# Draft Water Resources Management Plan 2024

## Section 6 – Allowing for Risk & Uncertainty, and Baseline Supply-Demand Balance

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## Background and Introduction

In this section we present our baseline supply-demand balance position for each of our six Water Resource Zones (WRZs). As we have taken an adaptive planning approach, we do not have a single supply-demand balance profile, and instead have nine profiles of supply-demand balance for each WRZ.

An immediate and increasing supply-demand deficit is evident in the London and WRZs. All other WRZs start in a position of surplus, with later deficits appearing in all zones under some future scenarios.

In the shorter term, increasing deficits are caused by population growth and a need for us to provide a higher level of drought resilience.

In the longer term, deficits are driven by the impacts of climate change and licence reductions that may be required to protect the environment.

6.1 Uncertainties are inherent within many aspects of water resources planning. Trying to establish supply capability under '1 in 500-year' drought conditions, predicting how many people will live within our supply area and how much water they will use, and determining the impact that climate change will have on the likelihood and severity of drought events all involve significant uncertainty. It is important that these uncertainties are acknowledged and incorporated into the planning process so that we do not either carry excessive risk or become too conservative and over-invest. In water resources planning, uncertainty is generally handled through the calculation of Target Headroom, defined as, ***"The minimum buffer that water companies are required to maintain between supply and demand in order to account for current and future uncertainties in supply and demand.[1]"***

6.2 We use a statistical technique called Monte Carlo analysis to examine the uncertainty associated with different components of our supply-demand balance, and to bring these together to give an appropriate allowance which accounts for the various uncertainties that we have assessed.

6.3 In this process, we examine the possible range of values (termed distribution) that different elements of our supply and demand forecasts could take. We examine the uncertainty around both the supply and demand side forecasts and bring these together to understand the range of uncertainty in our plan. We then choose a single allowance (Target Headroom) to allow for an appropriate amount of this uncertainty.

6.4 Neither our Target Headroom allowance nor our tolerance for risk are fixed over time. Some components of our forecast have varying uncertainty over time (for instance, predicting what the population will be in 2075 is more uncertain than predicting what the population will be in 2030) and so we must account for this. We have a greater tolerance for risk in the long term than in the short term because we have an ability to invest and adapt in the longer term.

6.5 Our approach to Target Headroom calculation has changed somewhat since WRMP19. The main changes have been brought about to fit with our improved adaptive planning approach. The use

[1] UKWIR, WRMP19 - Risk Based Planning Methods Guidance, 2016

of adaptive planning involves considering different pathways of future uncertain components, and to explicitly consider different pathways while adding an extra buffer for uncertainty may be more conservative than is really necessary. As such, we have taken an approach, aligned with WRSE, which removes uncertainties from Target Headroom as we explicitly considered different scenarios of uncertain factors in our adaptive plan.

6.6 This section describes the approaches taken in assessing the different supply-side and demand-side uncertainties which we are faced with, before describing how different uncertainties have been brought together to develop profiles of Target Headroom. We then present our baseline supply-demand balances for all of our WRZs.

## Key Guidance and Methodology Documents

6.7 There are several documents which detail methods that can be applied when assessing Target Headroom. There is no single prescribed methodology for Target Headroom calculation, with different methods being applicable when different planning methodologies are adopted.

6.8 The primary guidance documents referred to in the development of our Target Headroom profiles are:

- Environment Agency, April 2022, Water Resources Planning Guideline (WRPG): This document sets out the key requirements for the development of our Target Headroom allowances, including key inclusions, exclusions, and methodological stipulations. Section 7 is of particular note
- Environment Agency, Supplementary Guidance Notes. There is no supplementary guidance note which details approaches to be taken in calculating Target Headroom. However, several supplementary guidance notes reference uncertainty and detail where it would/would not be appropriate to account for something in Target Headroom, including:
  i. Supplementary Guidance – Stochastics: Uncertainty inherent in generation and use of stochastic datasets can be incorporated into headroom
  ii. Supplementary Guidance – 1 in 500: Uncertainty associated with estimating 1 in 500-year Deployable Output (DO) can be captured within Target Headroom
  iii. Supplementary Guidance – Climate Change: Climate Change uncertainty should be incorporated into Target Headroom assessment
  iv. Supplementary Guidance – Outage: Outage allowance should be considered separately from Target Headroom, and care should be taken to avoid double-counting
  v. Supplementary Guidance – Leakage: Uncertainty associated with not meeting AMP7 leakage targets should not be incorporated into Target Headroom
  vi. Supplementary Guidance – Adaptive Planning: Where adaptive planning techniques are applied, the application of Target Headroom should be carefully considered to ensure no omission, but also no double counting

6.9 The Environment Agency's WRPG does not set out methods that should be used when assessing Target Headroom. Instead, methods are set out in UKWIR guidance documents:

- UKWIR, 2016, WRMP19 Methods – Risk-based Planning: This document describes different approaches that can be taken in water resources planning which deal with uncertainty in explicit ways. It describes how Target Headroom allowances should be incorporated when applying different risk-based planning approaches
- UKWIR, 2002, An Improved Methodology for Assessing Headroom: This document sets out the Monte Carlo approach which is most commonly used in Target Headroom assessment

6.10 An important change between WRMP19 and dWRMP24 has been the focus on regional groups in water resource planning. Thames Water is part of the Water Resources South East (WRSE) regional group. WRSE has developed an approach to Target Headroom calculation, with the aim of alignment between the water companies in WRSE.

## Key Changes Between WRMP19 and dWRMP24

6.11 There have been a number of changes that have taken place between the publication of our WRMP19 and dWRMP24 which have influenced the calculation of Target Headroom. These include changes in guidance, new methods, and changes in our understanding.

### Adaptive Planning

6.12 We, as part of WRSE, are taking an 'Adaptive Planning' approach in our Water Resources Planning for dWRMP24. This adaptive approach means that we will not have a single 'Plan' for the next 50+ years, because the level of uncertainty present over that period would make a single, fixed plan highly inefficient and/or unsuitable. Instead, we will set out investment to solve short-term supply-demand balance risks, and then will have longer-term alternative pathways which will set out what investment would be most efficient under different future scenarios (e.g. the actions that we would take and investments we would make should the OxCam corridor be developed would be different should this project not go ahead). We will monitor factors such as population growth to establish which pathway we are following and invest accordingly.

6.13 This adaptive approach contrasts with our WRMP19, which took a multi-metric approach, but which was mainly based on solutions for single supply-demand balance profiles. Adaptive planning is used to ensure a plan which is efficient and resilient across a wide range of possible futures.

6.14 Our adaptive planning approach involves using supply-demand balance 'branches' (also referred to as 'pathways', 'scenarios', or 'situations'). We will initially consider a single supply-demand balance 'branch' (to reflect that we can only have a single investment plan in the short-term) but will later consider multiple supply-demand balance branches which will explore different pathways associated with key uncertain components of our supply-demand balance. This will allow us to define investments which are required in the short-term, as well as those which are low-regrets solutions across a range of uncertain futures, while deferring investments which may be suitable in more/less severe future supply-demand balance trajectories.

6.15 WRSE has set out an approach to Target Headroom calculation approach which aligns with the adaptive approach taken. This approach focuses on ensuring that uncertainties are not double counted when taking an adaptive approach, while also ensuring that uncertainties are not omitted.

6.16 Adopting the WRSE Target Headroom approach means that we have defined different 'types' of Target Headroom, which include/exclude different uncertain components.

### Requirement to Determine a '1 in 500-year' Deployable Output

6.17 The WRPG sets out the requirement that our baseline sources should be available such that our supply system has a 0.2% annual chance of failure caused by drought. In this circumstance, 'failure' is defined as a need for emergency drought orders.

6.18 Water companies have historically assessed the capability of their sources subject to a 'worst historical' drought condition, i.e. the DO of a source/group of sources would have been calculated such that the yield of the source/group of sources is that which would have been feasible during the 'worst' drought on record. The benefit of a 'worst historical' assessment is that this involves the use of a measured record (i.e. a weather/flow/groundwater level record in which we can be fully confident), but the downside is that it limits assessment of supply capability to a small number of events (and so means that potential system vulnerabilities may be omitted from consideration).

Environment Agency Guidance accepts that the determination of a '1 in 500-year' DO figure involves a large amount of uncertainty and suggests that Target Headroom allowances should incorporate uncertainty around assessment of 1 in 500-year DO.

6.19 We have undertaken an uncertainty assessment for our 1 in 500-year DO estimate which incorporates a greater range of uncertainties than our WRMP19 assessment, reflecting the different uncertainties present in estimating a 1 in 500-year DO.

## Methodology and Approach

6.20 Before describing how uncertainties associated with individual components of our supply and demand forecasts have been assessed, a brief introduction to the methods used is given in this section. The methods used are described in more detail in a later section, but an initial high-level summary is useful to give context to the component-level uncertainties which are explained in the following sections.

6.21 We use the method set out in UKWIR's 2002 methodology, *An Improved Methodology for Assessing Headroom*, and have adapted this method to incorporate adaptive planning concepts. While this method was developed twenty years ago, it is still considered an acceptable method to use.

6.22 Our calculation of Target Headroom uses Monte Carlo simulation. Distributions are defined for different uncertain components of the supply-demand balance and random sampling is used to draw values from these distributions, aggregating values associated with different uncertain components to give a view of the total uncertainty.

6.23 Rather than being represented by deterministic values, Monte Carlo sampling allows uncertain values to be represented by probability distributions. An example of a probability distribution is shown in Figure 6 - 1; it shows a probability density function (pdf). A pdf tells you the probability (value on the y-axis) that a random sample from the probability distribution will equal the corresponding value on the x-axis. The data in is purely illustrative, but you could suppose the x-axis represents the volume of water produced by a single borehole in Ml/d. The bar along the top (from left to right) shows there is a 5% chance that the borehole produces less than 58.9 Ml/d, a 90% chance it produces between 58.9 and 141.1 Ml/d and a 5% chance it produces more than 141.1 Ml/d.

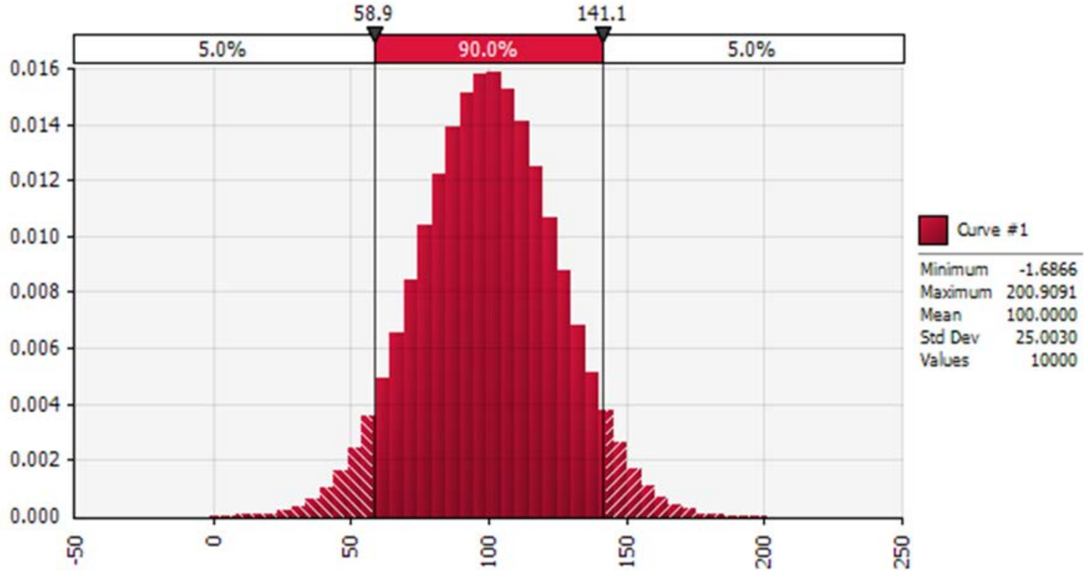


Figure 6 - 1: An example distribution that could be used in Headroom modelling

6.24 Monte Carlo analysis allows for consideration of many individual uncertain variables. Many variables can be defined using probability distributions that can subsequently be selected from using pseudo-random numbers, in order to give different aggregate outcomes, allowing for the influence of different uncertainties on an overall problem to be established.

6.25 An example of aggregating different uncertainties together is detailed next. If we have two independent uncertainties to consider, we can consider these together to determine the aggregate uncertainty. If uncertain component 1 has a 50% value of taking the value -4 and a 50% value of taking the value +4, while uncertainty 2 has equal chances of taking the values -2, 0, 1, and 2, random sampling from these distributions using 10 iterations may give the following outputs shown in Table 6 - 1.

| Iteration | Uncertainty 1 | Uncertainty 2 | Total |
|---|---|---|---|
| Iteration 1 | -4 | 1 | -3 |
| Iteration 2 | 4 | 0 | 4 |
| Iteration 3 | 4 | -2 | 2 |
| Iteration 4 | 4 | 0 | 4 |
| Iteration 5 | -4 | 1 | -3 |
| Iteration 6 | -4 | 2 | -2 |
| Iteration 7 | 4 | 2 | 6 |
| Iteration 8 | -4 | -2 | -6 |
| Iteration 9 | -4 | 1 | -3 |
| Iteration 10 | 4 | 0 | 4 |

**Table 6 - 1: An example of pseudo-random sampling being used to determine the aggregate impact of different uncertain variables**

6.26 The distribution of values can then be explored, for example by putting them in order, Table 6 - 2.

| | Value |
|---|---|
| Smallest | -6 |
| | -3 |
| | -3 |
| | -3 |
| | -2 |
| | 2 |
| | 4 |
| | 4 |
| | 4 |
| Largest | 6 |

**Table 6 - 2: Example Output from Monte Carlo Sampling**

6.27 Interpreting these values, we could say that our sampling suggests that there is a 90% chance that the total value will be less than 4, or a 40% chance that the value is greater than 2. Typically, we would undertake hundreds or thousands of Monte Carlo iterations using a computer, in order to fully explore the impact of consideration of multiple uncertainties.

6.28 In water resources planning, we define distributions of uncertain components of the supply-demand balance around 'central' forecast values, and sample individual component uncertainties to investigate the probability of achieving supply-demand balance. For example, we may use deterministic forecasts to say that we have a 20 Ml/d supply-demand surplus in a given year of the planning period, but could say that, in order to be 95% sure of having a surplus, we should allow for an extra 15 Ml/d Target Headroom buffer (leaving a supply-demand surplus of 5 Ml/d).

6.29 Once calculated and a risk profile agreed, Target Headroom is added to the forecast of demand and compared with the water available for use (WAFU) to establish the baseline supply demand balance.

### Uncertain Components Considered

6.30 The following components are considered within Target Headroom modelling:

- S4 – Bulk Imports (not relevant for Thames Water): Where there is uncertainty over the amount available for import, it is important that this is accounted for
- S5 – Gradual pollution of sources: Some sources may have yields which are at risk from pollution over time. Until it is realised, the timing and impact of pollution may not be known, and so uncertainty distributions can be used
- S6 – Accuracy of supply-side data: DO assessments involve uncertainty due to the consideration of extreme drought events. S6 uncertainty involves estimating the uncertainty that has resulted from DO assessments. With the requirement to consider '1 in 500-year' DO, S6 uncertainty should incorporate uncertainty with determining '1 in 500-year' drought events and the yield of sources during such events
- S8 – Uncertainty of impact of climate change on source yields: The impact that climate change will have on source yields is uncertain (e.g. some climate change projections suggest a wetter future, while others suggest a significantly drier future)
- S9 – Uncertain output from new resource developments. This component is typically included for the 'Final Plan Target Headroom' assessment, rather than the 'Baseline Target Headroom' assessment. It relates to the uncertainty associated with the outputs of new source developments (e.g. a source may be expected to have a future yield of 10 Ml/d, but could yield anywhere between 8 and 12 Ml/d – the +/-Ml/d uncertainty could be considered within headroom)
- D1 – Accuracy of sub-component data. Consumption data on which demand forecasts are based is uncertain, leading to uncertainty in overall demand prediction. The most important source of data in this regard is distribution input (DI) flow meter measurements; errors in flow measurement give rise to uncertainty
- D2 – Demand forecast variation. Arises from the risk that actual demand will depart from the dry year demand forecast used for the supply-demand balance due to uncertainties associated with growth in household and non-household sectors and water efficiency behaviour
- D3 – Uncertainty of impact of climate change on demand. Arises from uncertainties regarding the estimates of climate change impacts on demand
- D4 – Uncertain outcome from demand management measures. This component is typically included in the 'Final Plan Target Headroom' assessment, rather than the 'Baseline Target Headroom' assessment. The volume of reductions in demand that planned demand management measures may achieve is generally uncertain, and the date by which such demand reductions are realised even more so

## Adaptive Planning

6.31 The approach of identifying individual uncertain components and combining these to assess an overall supply-demand balance uncertainty is still valid when using adaptive planning methods.

6.32 In 'traditional' single pathway (non-adaptive) supply-demand balances the impact of all uncertainties is considered throughout the planning period.

6.33 However, in adaptive planning, it might be considered double counting to include Target Headroom allowances for uncertain components which are considered within explicit 'pathways'. For example, when different future pathways of climate change impact are considered, it would be double counting to also add on an additional buffer associated with climate change uncertainty.

6.34 WRSE has moved to a root and branch type adaptive planning approach in the form of situation trees. A situation tree combines discrete forecasts which are combined to provide different root and branch pathways. This shown in Figure 6 - 2, below.

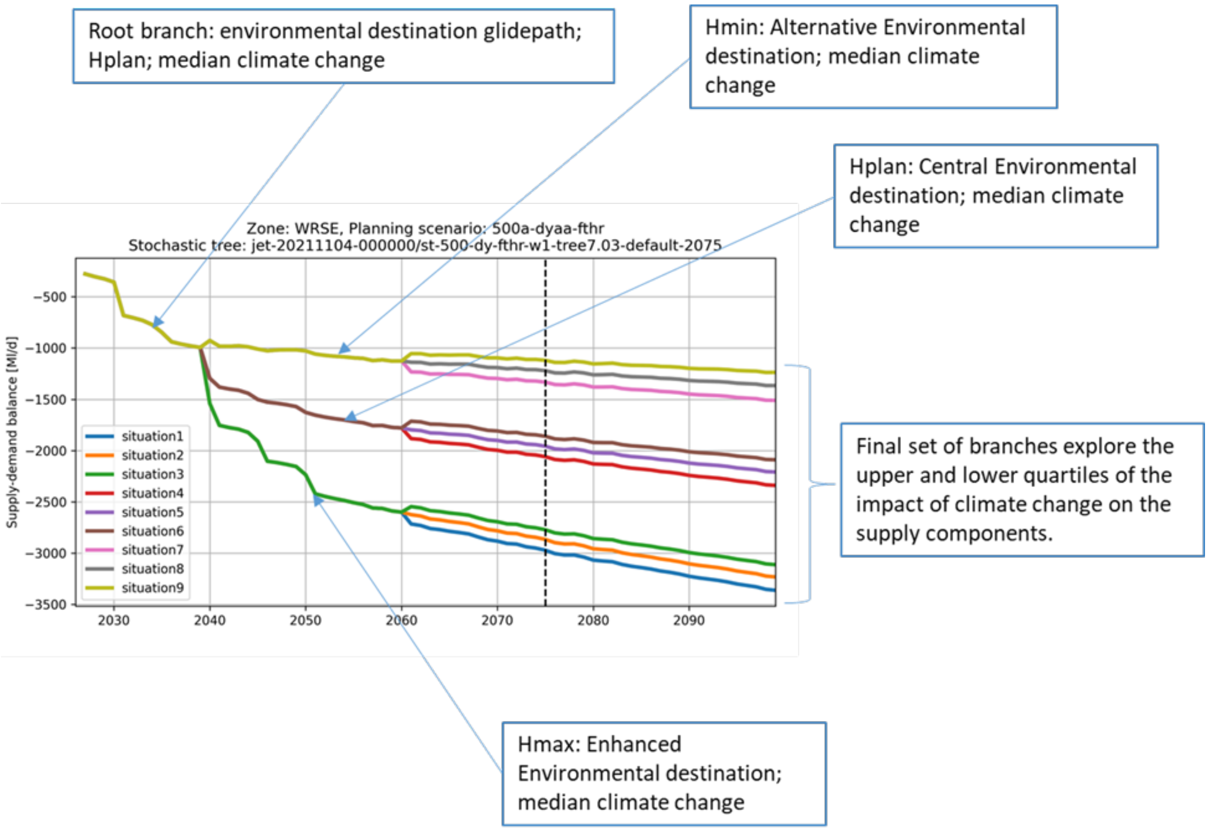


Figure 6 - 2: Example branched supply-demand balance (Source – WRSE)

6.35 Aligned with the WRSE group, we have implemented a target headroom calculation approach which excludes different uncertain components through the planning period, in order that we do not double count aspects of uncertainty.

## Supply-side Uncertainty

6.36 This section details the distributions used to describe different uncertain components of our supply forecast. As described in the previous section, supply-side uncertainty will be combined with demand-uncertainty to give an overall Target Headroom value.

6.37 The components of supply-side uncertainty which are investigated as part of our headroom assessment are:

- S5 – Gradual Pollution of Sources (causing a reduction in abstraction)
- S6 – Accuracy of supply-side data
- S8 – Uncertainty of impact of climate change on source yields
- S9 – Uncertain output from new resource developments (Final Plan Target Headroom only)

6.38 S1 (Vulnerable surface water licences), S2 (Vulnerable groundwater licences), S3 (Time-limited licences) are not included in our assessment due to exclusions set out in the WRPG. We have not included the S4 component (Bulk imports/exports) because bulk supply imports/exports make up a small proportion of our water available for use, and are subject to contractual agreements, and as such we consider that the risk posed by uncertainty around imports/exports is minimal.

6.39 Regarding the S5 (Gradual Pollution of Sources) component, we have reviewed the risk posed by gradual pollution to our groundwater sources and have confirmed that there are no issues to include at this stage. This is due to installation or planned installation of suitable treatment for nitrates and cryptosporidium. We have reviewed our assessment of the risk posed by gradual bromate pollution in North London at our Northern New River Well (NNRW) sources. The source of the bromate pollution is a former bromine chemicals factory at Sandridge, now redeveloped as a housing estate. The presence of bromate in the water pumped from the NNRW has meant that abstraction from these wells has had to be reduced in the past, in order to meet water quality standards. In 2005, a scavenging remediation scheme was implemented in conjunction with Affinity Water from one of their groundwater sources. This was done to assist remediation of the bromate plume in the chalk aquifer and also to manage the concentration of bromate reaching the NNRW sources. Previously, uncertainty around the DO caused by this bromate contamination focussed on whether Affinity Water's Hatfield scavenge pumping would continue to operate at a significant enough rate to support management of bromate at the NNR Wells. This type of uncertainty was considered in planning WRMP19, as well as WRMP14, on the basis that the future operation of Hatfield was uncertain beyond the end of a Remediation Notice (RN) served on the polluters by the Environment Agency. Further remediation through the Hatfield scavenge pumping (and other actions) has now been secured, reducing this risk. In addition, the trial of a reduced Echemical treatment dose of the bromate contaminated groundwater abstracted at Hatfield has seen a significant and sustainable improvement in Hatfield abstraction rate to 4 Ml/d. As a result, consideration of the uncertainty on the NNR Wells DO associated with Hatfield abstraction is no longer appropriate. It is now considered more appropriate to assess bromate data uncertainty in quantifying the bromate impact on the NNR Wells DO. By establishing conservative maximum bromate concentrations which could reasonably be expected during drought, it has been shown that through the normal operational practice of blending NNR groundwater with river water in the Lee Valley, there is an insignificant impact on the DO of the NNR Wells. The predicted reduction in DO from the NNR Wells as a result of bromate contamination would range from 0.3 Ml/d to 1 Ml/d over a 4-month period, which equates to only a 0.2 Ml/d loss to the average DO across a simulated 12-month period. As a result of this conservative assessment, it is concluded that there is no significant data uncertainty nor loss of DO that requires incorporation within the target headroom model and so this component of supply-side uncertainty has been removed from our dWRMP24 Target Headroom assessment.

6.40 The S9 (Uncertain output from new resource developments) component is only considered in our Final Plan Target Headroom assessment. Since no new resources are considered as part of our baseline, this component does not have an impact on our baseline Target Headroom. A brief introduction to our Final Plan Target Headroom method is given later in this section.

### S6 – Accuracy of Supply-side Data

6.41 Uncertainty associated with data and models used in our assessment of DO leads to uncertainty in our DO estimate. This is particularly the case now that our calculations of DO are based on assessing a '1 in 500-year' DO.

6.42 We have not updated the assessment of DO uncertainty associated with our groundwater sources since WRMP19. For each groundwater source, the governing constraint on DO is known (e.g. a source's yield may be limited by licence, infrastructure, or hydrological yield) and this leads to different reasonable bounds of uncertainty to be considered. For example, a source with a DO which is governed by licensed quantities will have a relatively small uncertainty around its DO (the only uncertainty being around measurement of quantities), while a source with a DO which is governed by hydrogeological yield will have more considerable uncertainty due to the need to consider/measure/model what groundwater levels during extreme drought events may be, and then derive a yield during drought dependent on groundwater levels that are seen. Table 6 - 3 shows the parameters used to define distributions of DO uncertainty associated with groundwater sources with different yield constraints.

| Constraint | Distribution Used | Min (if Triangular) / Standard Deviation (if Normal) - % | Mode (if Triangular) / Mean (if Normal) - % | Max (if triangular) - % |
|---|---|---|---|---|
| Infrastructure | Triangular | -2 | 0 | 1 |
| Licence | Normal | 0 | 0.3 | |
| Hydrogeological Yield | Triangular | -2 | 0 | 10 |

Table 6 - 3: Parameters Used in Groundwater Source Uncertainty Assessment

6.43 We include an allowance for uncertainty associated with the yield of the North London Artificial Recharge Scheme (NLARS). This scheme abstracts water from a number of boreholes in the Lee Valley and discharges to the raw water system including from some boreholes to the New River and in some cases directly to reservoir. The nature of the scheme is to abstract water from the confined aquifer where output will decrease over time. Improved information on borehole performance, together with better information about the aquifer state of storage allowed an updated view of NLARS output at AR16. There remains a risk around what the scheme may actually be capable of during a drought thus two further scenarios of the output from NLARS have been evaluated to assess the risk around NLARS. The impact of the modified output from NLARS for the two alternative scenarios was evaluated by inputting this data into WARMS2 and comparing with the value of DO before the change. The risk is assessed to be in the range 15-17 Ml/d, and so an allowance for NLARS uncertainty is made by defining a triangular distribution with a minimum of 0 Ml/d, a most likely value of 15 Ml/d, and a maximum of 17 Ml/d.

6.44 For our surface water sources, we have updated the methods used to assess DO uncertainty, because we felt that our existing estimates were inadequate for capturing '1 in 500-year' DO uncertainty.

6.45 In WRMP19, we included an allowance of +/-2% (using a triangular distribution with a minimum of -2%, a mode of 0%, and a maximum of 2%) for surface water DO uncertainty within our Target Headroom modelling. Considering the scale of uncertainty which we have observed when assessing 1 in 200-year DO for WRMP19 and now 1 in 500-year DO for WRMP24, we feel that +/-2% for surface water DO uncertainty is insufficient to capture the risk of overestimating or underestimating the DO contribution of our surface water abstractions.

6.46 We have assessed the influence of different uncertainties which feed into our DO assessments, using a consistent framework across all of our surface water sources. The factors that we have considered in our assessment are:

1) The representativeness of the historical record, and the associated uncertainty of using a '1 in X year' DO. This component serves as a proxy for considering uncertainty associated with 'stochastic' weather records
2) The use of hydrological models
3) Uncertainty associated with quantifying hydrological extremes
4) Uncertainty associated with operational risks, including:
    a) Requirements to stop abstraction due to poor water quality
    b) Requirements to stop abstraction due to other operational constraints not considered in DO assessments (e.g. low levels)
    c) The potential that emergency restrictions may be imposed earlier (or later) than assumed in DO assessments

6.47 All of these uncertain factors have been considered as being independent of one another.

6.48 The first three elements noted have uncertainty assessments which are based on analysis of measured and/or modelled datasets. Uncertainty associated with operational risks (factors which impact our operations, but which are not captured in either our DO or outage assessments) are based on expert judgement.

6.49 For each of the surface water sources considered, each of these components has been considered in the context of what impacts WRZ DO as some zones have a DO which is governed by long-duration drawdown of reservoirs, while other zones have a surface water DO which is driven by extreme low flows (e.g. run-of-river sources without bankside storage). We have undertaken assessments for the uncertainty associated with assessments of DO from the following sources:

- London WRZ - Lower Thames abstractions, feeding Lower Thames reservoirs
- London WRZ - River Lee abstractions, feeding Lee Valley reservoirs
- SWOX WRZ – Farmoor abstraction, feeding Farmoor reservoirs

- Kennet Valley WRZ – Fobney run-of-river abstraction
- Guildford WRZ – Shalford run-of-river abstraction

6.50 The results of this assessment are reported as cumulative distribution functions (CDFs), which are then resampled from in our overall Target Headroom assessment (in a similar way to outputs from our demand uncertainty assessment).

6.51 Results from this assessment (Table 6 - 4) show that we have considered the risk that we may have overestimated (negative contribution to Target Headroom – negative value in Table) or underestimated (positive contribution to Target Headroom – positive value in Table) DO.

| | 5th Percentile | 25th %ile | Median | 75th %ile | 95th %ile |
|---|---|---|---|---|---|
| London - Thames | -12.0 | -2.7 | 2.7 | 4.8 | 18.0 |
| London – Lee | -1.2 | -0.1 | 0.1 | 0.3 | 1.2 |
| SWOX – Farmoor | -5.9 | -0.1 | 1.6 | 4.1 | 23.0 |
| KV – Fobney | -0.8 | -0.3 | 0.1 | 0.5 | 4.8 |
| Guildford - Shalford | 0 | 0.1 | 0.2 | 0.4 | 0.6 |

**Table 6 - 4: Results from assessment of 1 in 500-year Annual Average surface water DO uncertainty (% of WRZ DO)**

6.52 These results suggest that the previous allowance of +/-2% of source DOs was insufficient for considering 1 in 500-year DO uncertainty.

6.53 We have assessed the uncertainty around ‘1 in 100-year’ and ‘1 in 200-year’ DO estimates, as well as ‘1 in 500-year’ DO estimates. Our planned Level of Service (for Level 4 restrictions) is initially 1 in 100-year, transitioning to 1 in 200-year in the early 2030s, and then transitioning to 1 in 500-year resilience by 2040. As such, our Target Headroom profiles account for 1 in 100-year DO uncertainty initially, then 1 in 200-year in the 2030s, and 1 in 500-year from 2040 onwards.

6.54 The enhanced assessment that we have undertaken to establish the risk around surface water DO has encompassed more aspects than our previous assessments. This has given us a greater level of confidence that our assessments have covered a reasonable range of unknown factors. In turn, this has led us to increase our risk tolerance, due to a reduced presence of ‘unknown unknowns’.

### S8 – Uncertainty of Impact of Climate Change on Source Yields

6.55 Climate change is expected to lead to changes in patterns and frequencies of drought and other extreme weather events. While the general expected pattern is that summers will be drier and hotter and winters wetter and warmer, the degree and scale of these impacts, and the impact on the likelihood of extreme drought events, is very uncertain.

6.56 Climate change will impact our drought risk both through temperature impacts (hotter temperatures leading to higher potential evapotranspiration, drying out soils) and precipitation impacts (changes in rainfall patterns).

6.57 The latest climate change projections for the United Kingdom, from the Met Office, known as UKCP18, have been used in our assessment of supply-side climate change impacts.

6.58 This section does not describe all work that has been done to assess the impact of climate change on our supplies (see Appendix U for a full description), and instead focuses on how these results have been used in assessing the uncertainty around the 'central' impact of climate change.

6.59 Our climate change modelling has involved perturbation of samples of the stochastic climate record, running our hydrological and hydrogeological models using these perturbed records, using flows and groundwater yields from these model runs as inputs to our water resources models, and using water resources model outputs to determine the impact of climate change perturbations on '1 in 500-year' DO for each WRZ.

6.60 We have assessed the uncertainty around '1 in 100-year' and '1 in 200-year' Climate Change DO Impact estimates, as well as '1 in 500-year' Climate Change DO Impact estimates. Our planned Level of Service (for Level 4 restrictions) is initially 1 in 100-year, transitioning to 1 in 200-year in the early 2030s, and then transitioning to 1 in 500-year resilience by 2040. As such, our Target Headroom profiles account for 1 in 100-year CC DO Impact uncertainty initially, then 1 in 200-year in the 2030s, and 1 in 500-year from 2040 onwards.

6.61 Detailed modelling has been undertaken for the 28 spatially coherent projections which form part of the UKCP18 dataset, using the RCP8.5 emissions scenario, for the 2060-80 timeslice. Appendix U details further work which has been undertaken to investigate the climate change impacts suggested by the probabilistic projections for our London WRZ, including different emissions scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5) and at different points in time (2030, 2050, 2070, and 2090).

6.62 In our supply forecast, we have taken the median climate change impact from our modelling results as our central impact of climate change on DO.

6.63 Our uncertainty assessment looks at the variance around the median climate change impact that is present in the rest of the model results. Our Target Headroom modelling includes the 28 individual CC scenario outputs for the year 2070. We have considered that each of these scenarios are equally likely to occur. Results in Figure 6 - 3 (London) and Figure 6 - 4 (SWOX) show that, for London, climate change could have up to 230 Ml/d more impact than our median impact suggests, or a 270 Ml/d less severe impact; for SWOX the results show that results could be anywhere from 20 Ml/d less severe than the median impact to 12 Ml/d more severe.

6.64 In each Monte Carlo iteration, for each WRZ, one of the 28 climate change scenarios is selected at random and the variance of the impact of that climate change scenario on DO around the central climate change DO impact is used. This impact is scaled through the planning period using the same scaling approach as is used to scale the central impact of climate change.

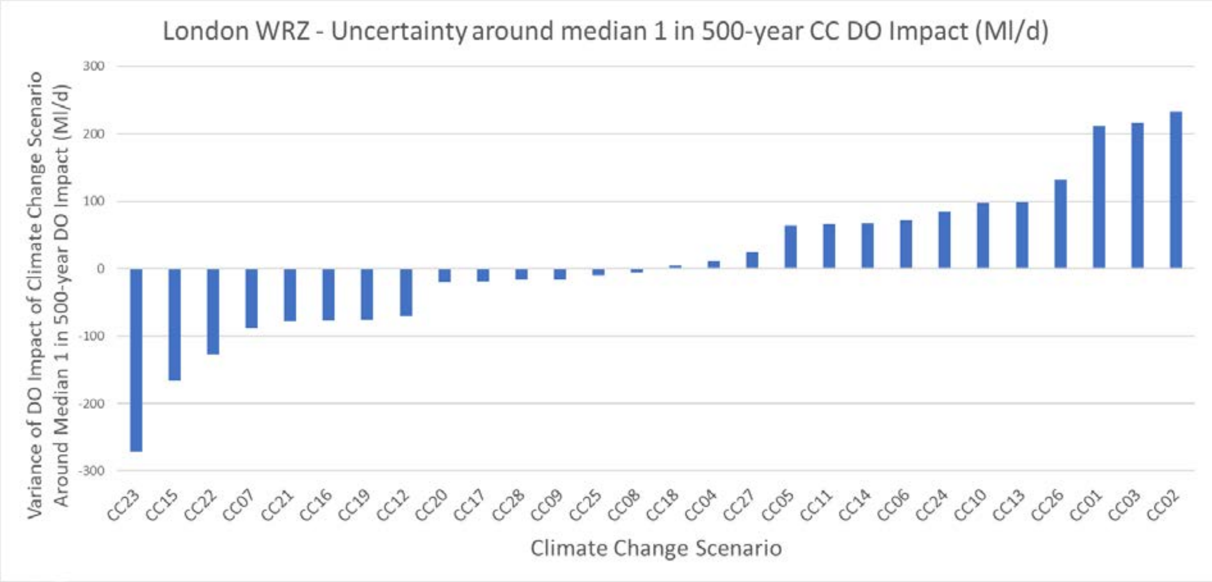


Figure 6 - 3: Variance of Climate Change Scenario DO Impacts Around Central Impact – London WRZ, 2070 (2060-80)

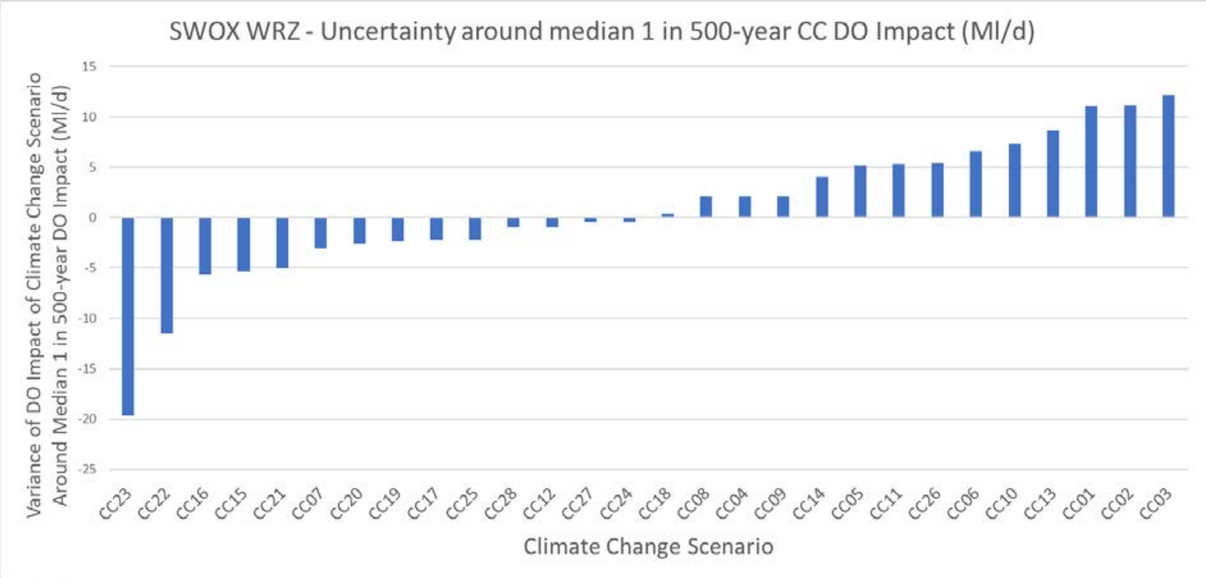


Figure 6 - 4: Variance of Climate Change Scenario DO Impacts Around Central Impact – SWOX WRZ, 2070 (2060-80), DYAA DO

## Demand-side Uncertainty

### Components of demand-side uncertainty

6.65 The demand-related headroom components identified in the methodology are as follows:

- D1 – Uncertainty in base year data
- D2 – Demand forecast variation
- D3 – Uncertainty of climate change on demand
- D4 – Uncertainty of demand management measures

6.66 We have undertaken analysis of demand uncertainty using Monte Carlo simulation to understand the uncertainty around the deterministic demand forecast. We describe this briefly in the "Demand uncertainty overview" section below, before examining the individual components D1 to D4.

6.67 The approach we have used is consistent with the current UKWIR guidance[2] which is recommended by the Environment Agency's WRPG.

### Demand Uncertainty Overview

6.68 Specialist software is used to calculate the uncertainty associated with the demand forecasts that are described in Section 3: Current and future demand for water. The demand forecasts produce a single value for demand for each year of the forecast period. Underpinning the demand forecast is a series of values which are considered the best estimate. Like any estimate, there is scope for uncertainty and analysis of these uncertainties is used to produce the demand uncertainty, that is then used in the calculation of Target Headroom. Monte Carlo simulation is used to understand how the uncertainties from input variables translate into uncertainty in the overall demand forecast. An overview of this is shown in Figure 6 - 5.

6.69 Each demand component shown in orange is assigned a probability distribution according to the information available. Most of the uncertainty ranges around these components have been estimated based on studies where possible, and expert judgment or opinion where little information is available. Where judgment/opinion has been used output values have been examined to ensure that the uncertainty range is reasonable.

6.70 Traditionally, we have not considered uncertainties around leakage because the outturn value is, to a degree, within our management control to deliver. This does not mean there is no uncertainty. Weather, particularly cold winters, can cause metal pipes to contract and fracture, therefore increasing leakage. Furthermore, we have more than 30,000km of buried water network and, whilst we invest considerable effort in understanding and modelling how it deteriorates over time, it is not an exact science.

[2] UKWIR, WRMP 2019 Methods – Risk Based Planning, Appendix D7, (16/WR/02/11), 2016.

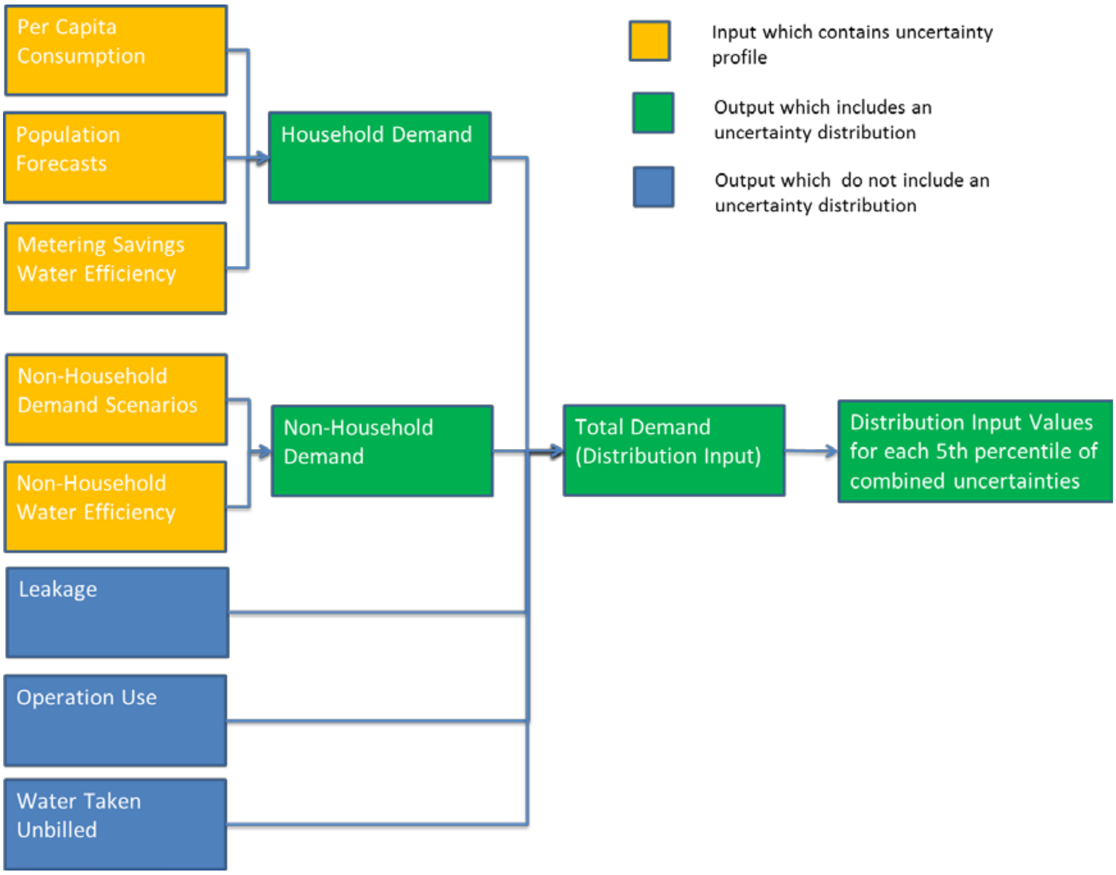


Figure 6 - 5: Overview of analysis of uncertainty in demand forecasts

6.71 Uncertainty distributions for the following outputs are not included for demand components shown in blue in Figure 6 - 5.

6.72 Leakage – For standard leakage management activities we consider the uncertainty in terms of the cost it will take for us to meet or out-perform our leakage target in each year through a mix of activities including finding and fixing leaks as they break out and replacing our old iron pipes with new plastic pipes. We do not include uncertainties in this "base" leakage in Headroom.

6.73 Operational use and demand from our properties – This component reflects the water we use in operational activity such as flushing mains for water quality reasons or water used at out sites or offices for sanitation purposes. Similarly to leakage the outturn value for this component is, to a large degree, within our management control to deliver. Therefore the same logic applies around the inclusion of uncertainty in future forecasts. Note that these values are not actually forecast and are assumed to be constant at base year values over the planning period. As such the uncertainty around this output is part of the base year measurement uncertainty described in D1 – Uncertainty in Base Year Data. Additionally, the total volume of this category is approximately 1% of total DI and therefore any reasonable uncertainty estimates around forecast values would be unlikely to have a material impact on the results of this analysis.

6.74 Water taken illegally or unbilled – These values are not actually forecast and are assumed to be constant at base year values over the planning period. As such the uncertainty around this output is part of the base year measurement uncertainty. Additionally, the total volume of this category is approximately 1% of total DI and therefore any reasonable uncertainty estimates around forecast values would be unlikely to have a material impact on the results of this analysis.

### D1 – Uncertainty in Base Year Data

6.75 The actual DI supplied in the base year is used as base data to support the forecast of demand for the 80-year planning period. DI is measured by meters, typically located at the outlet of a water treatment works. These meters are subject to a statutory verification programme, but there is still uncertainty about the results they record. This uncertainty is reflected in the calculation of the water balance as part of the annual performance report to Ofwat.

6.76 Here we have used the same uncertainty distribution for base year DI used as part of the water balance calculation. Base year DI is a random variable with a normal distribution where the mean is equal to the deterministic estimate of base year DI and the standard deviation is equal to 1.02%[3].

6.77 Uncertainty is also estimated around the uplift from the base year recorded value of DI to reflect the planning scenario in use[4]. This uplift reflects the weather and operational circumstance of the base year may have been more (or less) favourable than would be expected to be the case in a year typical of the planning scenario, i.e. a dry year. For example, in London the recorded DI in the base year was 2,080.7 Ml/d. The weather in the base year was assessed to have suppressed demand below what it would have been in dry year conditions. An uplift of 24.6 Ml/d is applied to convert DI to the value expected if conditions in the base year had been equal to dry year conditions.

6.78 There is uncertainty about the accuracy of the recording of conditions in the base year, the assessment of conditions in the dry year and the impact of those conditions on DI. Therefore we apply an uncertainty to the value of the uplift used. Because it is impossible to validate the accuracy of the uplift directly[5] we use expert judgement to set the uncertainty distribution used to reflect uncertainty around the uplift.

6.79 The value of the uplift in the deterministic forecast is our best estimate and therefore we believe is also the most likely value. We do not have any reason to believe that the distribution is likely to be skewed and therefore we have used a normal distribution to characterise the uncertainty around the uplift. We chose to set standard deviation for the distribution at 5% of the value of the deterministic uplift value. This resulted in a distribution which best matched the expectation of a number of experts.

6.80 The impact of the uncertainty around base year estimates is then set to the sum of both uncertainty distributions less the deterministic value of the base year DI in dry year conditions[6].

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[3] This is based on a 95% confidence interval for reported DI being +/- 2% and 95% confidence interval for a normal distribution being +/- 1.96 standard deviations. The 2% divided by 1.96 equals a standard deviation of 1.02%.
[4] E.g. Dry Year Annual Average basis for London.
[5] There is no opportunity to actually replicate the base year circumstances (population, customer water use behaviour, etc.) in dry year weather conditions.
[6] Because of the properties of normal distributions this results in a normal distribution with a mean of zero and a standard error of the square route of the sum of the squared standard errors of the original distributions. For example, standard error of the distribution of the impact of uncertainty around the base year estimate is equal to the square root of the sum of 1.02% of the measured DI squared and 5% of the deterministic uplift value squared.

### D2 – Demand Forecast Variation

6.81 The sources of demand forecast variation considered in the Demand Uncertainty Model are as shown in the list below. Each is discussed in a separate section which follows below:

- Household per capita consumption (PCC)
- Household population
- Non-household demand

### Household PCC uncertainty

6.82 Household PCC is the average volume of water used by each person in a household. Typically it is reported in units of litres per head per day (l/h/d). PCC is a measure of customers' water use behaviour. In this section the PCC discussed is the baseline[7] value, meaning that it is the value prior to any demand management activity we might deliver to influence the value.

6.83 PCC uncertainty is calculated by using the household demand forecasting model produced by Artesia Consulting[8]. The demand forecasting model uses a multiple linear regression approach, which produces standard errors around each of the input values that indicate uncertainties and can be used to simulate confidence intervals around the central PCC forecast. The uncertainties related to the Artesia final model are illustrated in Figure 6 - 6, which shows that uncertainty in model coefficients alone translates to a PCC uncertainty range of +/- 3.4%. It also shows that the number of adults and size of property are the key variables. This approach and the setup of the model are explained further in Section 3: Current and future demand for water (Household water use) and Appendix F: Household water demand modelling (Section 20 - uncertainties). This Section 20 discusses uncertainties where base year, model coefficients, property types and population uncertainties are combined to show impacts on WRZ consumption in Ml/d.

[7] For example, progressive metering or water efficiency Smarter Home Visits.
[8] Section 3: Current and future demand for water (Household water use) and Appendix F: Household water demand modelling (Section 20 - uncertainties).

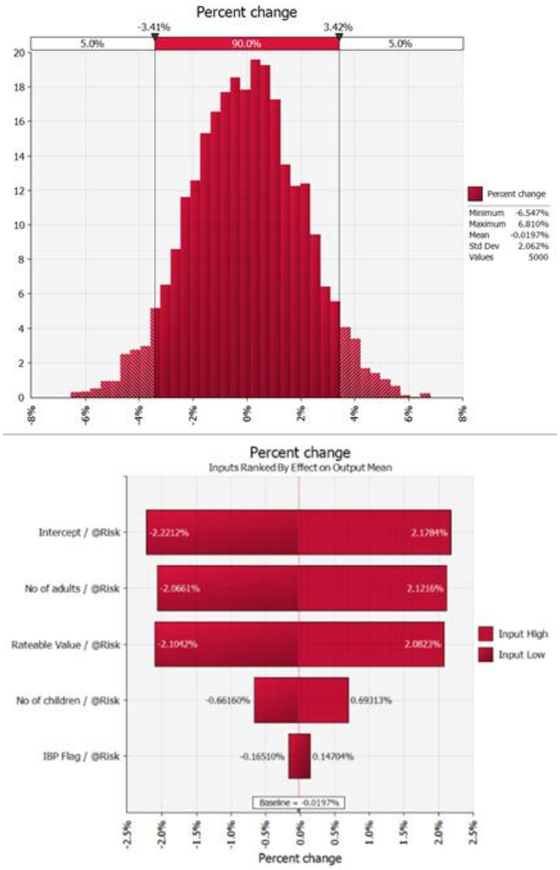


Figure 6 - 6: Illustration of PCC model coefficient uncertainty on PCC (percentage) and sensitivity to input variables

6.84 An 80% confidence interval for forecasts of household PCC produced by applying the household demand forecasting model are used as inputs to the demand uncertainty model. The limits of this confidence interval along with the expected value used in the deterministic demand forecast are used to characterise a PERT probability density function for household PCC for each year of the planning problem. Figure 6 - 7 shows the expected value, and the 10th percentile and 90th percentile values which form the 80% confidence interval for household PCC.

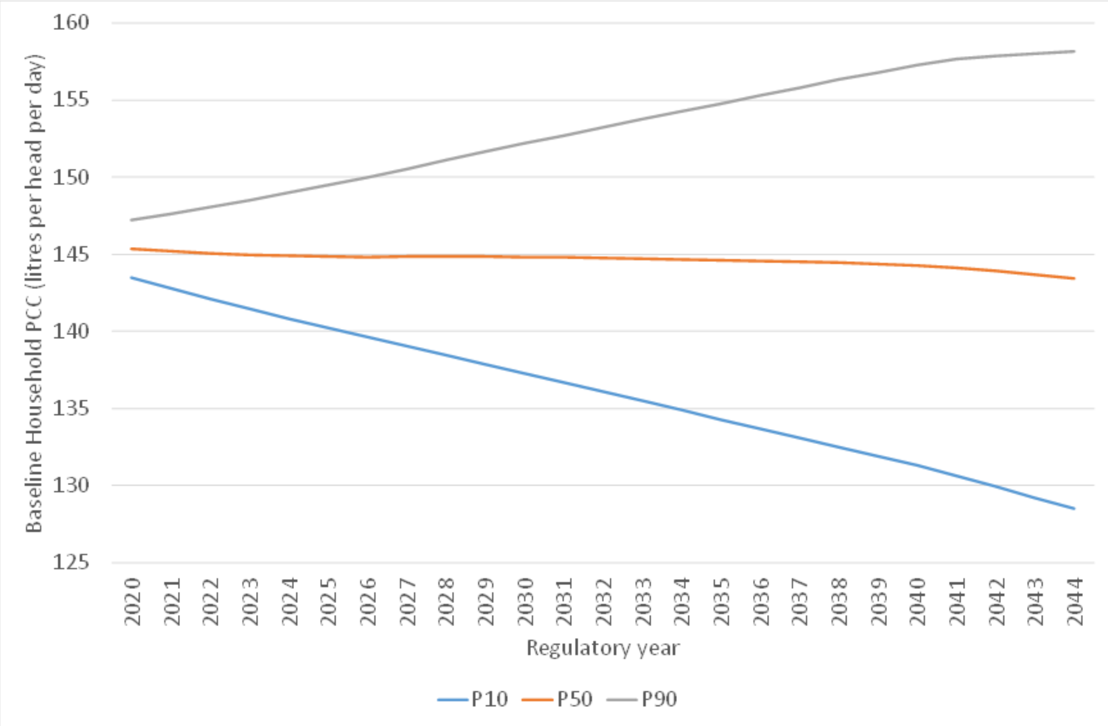


Figure 6 - 7: Baseline household PCC results from demand forecasting model

### Household population uncertainty

6.85 The household population we serve is a key factor in forecasting demand. Population is the result of a myriad of uncertain components including, birth rates, death rates and net migration. Each of these components is influenced by a range of underlying factors such as macro-economic growth. As such it is easy to see why there is uncertainty in the forecast of population.

6.86 As discussed in Section 3 for this round of planning we have procured multiple growth forecasts. Given this we feel we have a range of forecasts which adequately reflect the uncertainty around likely future growth, and we have used these in our uncertainty analysis. We use three forecasts in the calculation of the uncertainty; the maximum, minimum and plan-based scenarios. The maximum scenario is the forecast which has the highest growth in households in the final year of the forecast, 2100. Conversely, the minimum scenario uses the forecast which has the smallest increase in the number of households in the final year of the forecast. The plan-based forecast is used as the most likely forecast due to the emphasis placed on this forecast within the WRPG.

6.87 While preparing the uncertainty distributions it was noted that the plan-based forecasts are in the short term high growth, in some cases exceeding growth predicted in the maximum scenario.

### Non-household demand

6.88 Unmeasured non-household demand is a comparatively small component of total non-household demand, approximately 3%. We believe that measured and unmeasured non-household demand for water will tend to be well correlated as both are primarily driven by regional macro-economic factors. Therefore, we have assumed that the uncertainty distribution for measured non-household demand can be applied proportionately to unmeasured non-household demand.

6.89 The deterministic forecast for non-household demand was produced by Artesia Consulting. As part of that work, using the same methodology and varying future macro-economic projections, they also produced lower and upper forecasts for measured non-household demand in each year.

6.90 We have fitted a triangular probability density function using the deterministic forecast as the most likely value and the upper and lower forecasts as minimum and maximum parameters. Figure 6 - 8 shows the values used to fit uncertainty distributions.

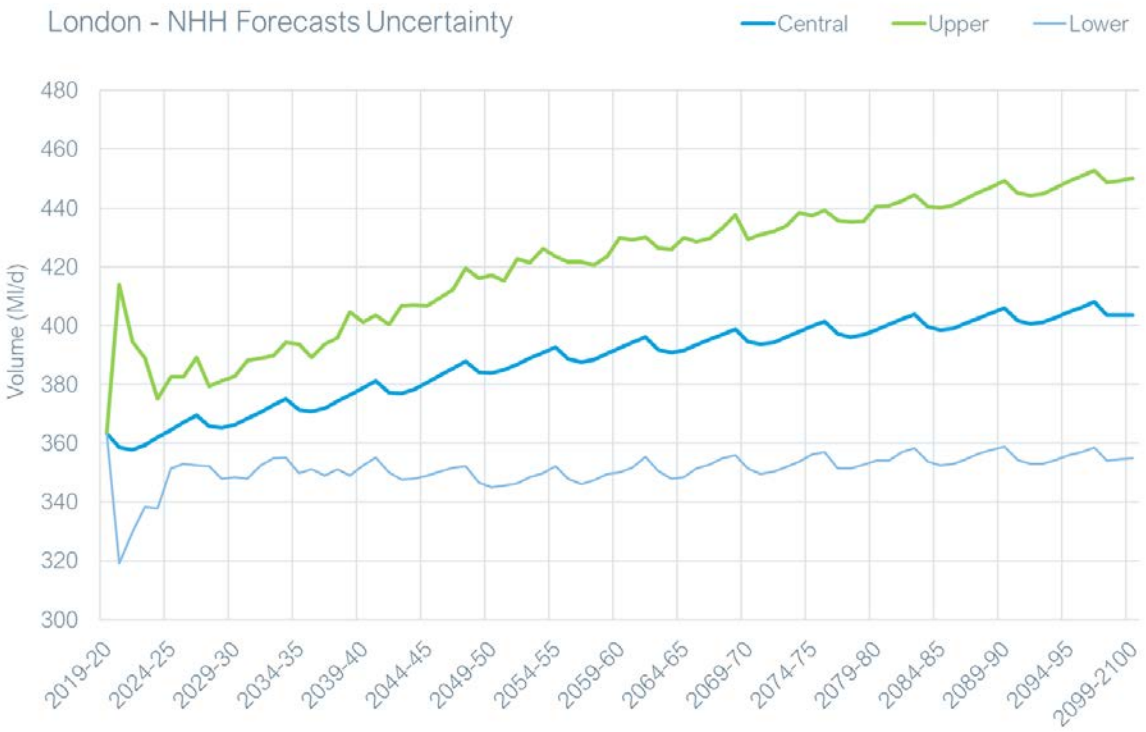


Figure 6 - 8: Measured non-household demand forecast uncertainty

## D3 – Impact of climate change on demand

6.91 HR Wallingford carried out a study[9] to estimate the likely impacts of climate change upon household demand. Climate change effects are only considered for domestic water use. More information regarding the effects of climate change on demand can be found in Section 3: Current and future demand for water. The climate change ranges are summarised in Figure 6 - 9 for DYAA and Figure 6 - 10 for DYCP.

6.92 No allowance has been included for non-household demand based on the findings on the UKWIR report 13/CL/04/12 “Impact of climate change on water demand” which stated:

[9] HR Wallingford, EX6828 Thames Water Climate Change Impacts and Water Resource Planning. Thames Water Climate Change Impacts on Demand for the 2030s, 2012

*'It was concluded that, except in the case of agriculture and horticulture in South East Water area, there is inadequate consistent evidence to justify making any allowance for climate change impacts on non-household demand.'*

6.93 The low, mid and upper scenarios presented in these figures are 10th percentile, 50th percentile and 90th percentile forecasts for the impact of climate change on demand. We have used these data points to fit a normal probability density function for each year in the planning period.

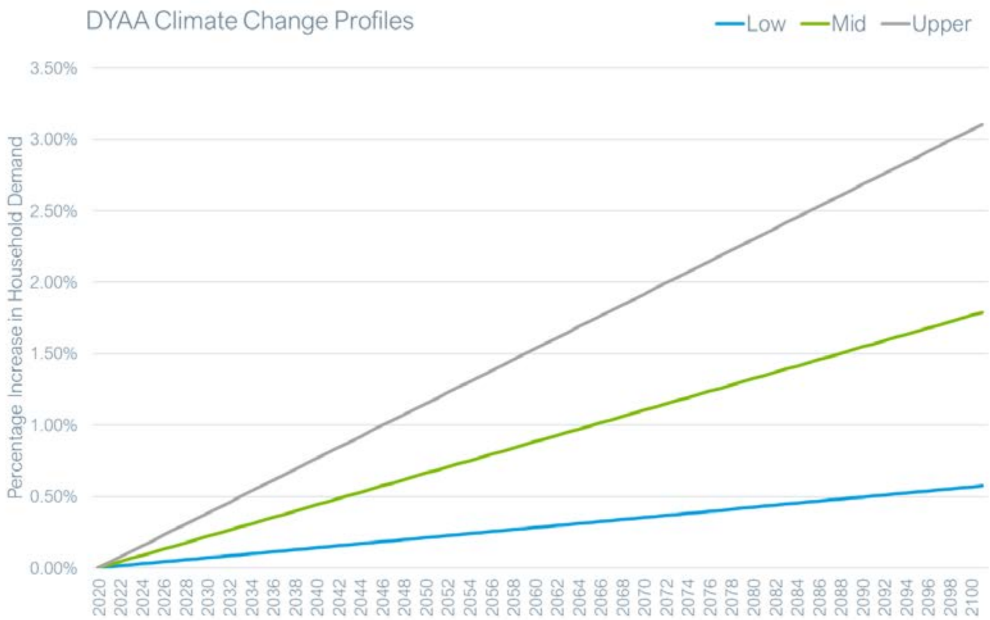


Figure 6 - 9: Impacts of Climate Change on DYAA Demand

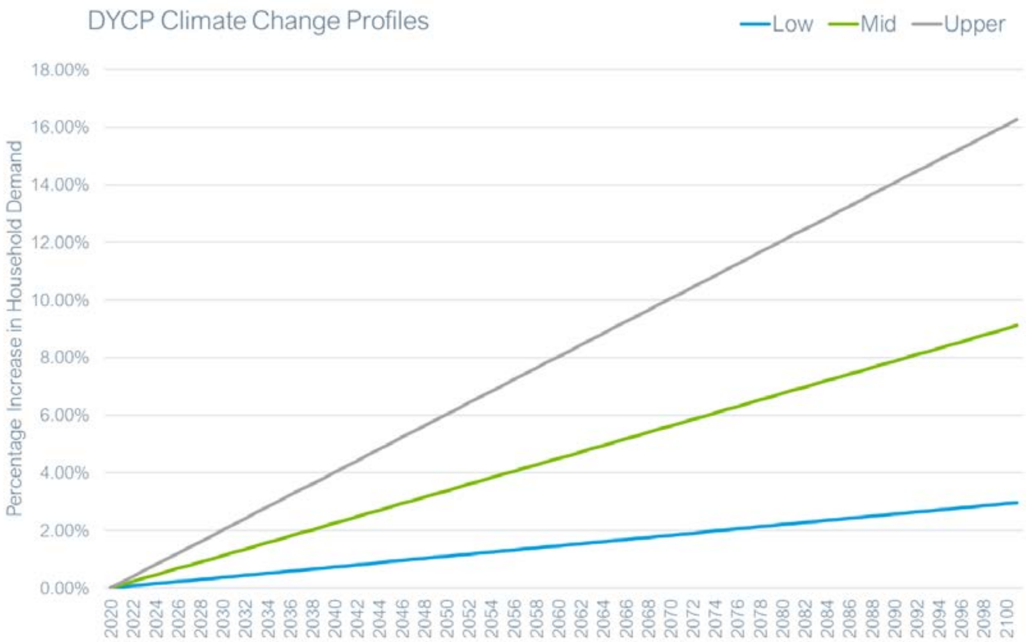


Figure 6 - 10: Impacts of Climate Change on DYCP Demand

## D4 – Uncertainty of demand management measures

6.94 Only a small amount of demand management is present within baseline target headroom which relates to planned demand activity for AMP7. This component is, therefore, not included in our baseline Target Headroom assessment.

### Metering savings

6.95 The central estimate for progressive metering savings has been revised since WRMP19 based on the data collected from the delivery and subsequent monitoring of our progressive metering programme (PMP). Data from a sample of more than 100,000[10] households were used in a report produced by Artesia Consulting. The results of the analysis were controlled for the primary influencing factors:

- Housing type
- Occupancy
- Ethnicity

| WRZ | Unit | Upper estimate | Most likely | Lower estimate |
|---|---|---|---|---|
| London | % | 111 | 100 | 85 |
| Thames Valley | % | 111 | 100 | 85 |

Table 6 - 5: Progressive metering saving uncertainty parameters

6.96 Based on the Artesia Consulting analysis a value of 13.0% represents the most likely saving from this activity. Due to time constraints for investment modelling uncertainty estimates around the central saving estimate were not available at the time of running the target headroom model. Therefore, an estimate of uncertainty has been used based on judgement of +11% and -15% which will be used as upper and lower estimates for a 95% confidence interval for the most likely saving. These estimates will be updated for the revised draft WRMP based on further analysis by Artesia Consulting of the model used to produce the central value of 13%.

### Household and Non-household Water Efficiency

6.97 The uncertainty for water efficiency savings is based on a study of the activity carried out in AMP6. The results of this study are presented in Table 6 - 6 The upper and lower estimates are used as a 95% confidence interval for the most likely saving. This has been used to fit a PERT distribution.

| WRZ | Unit | Upper estimate | Most likely | Lower estimate |
|---|---|---|---|---|
| London | % | 114 | 100 | 86 |
| Thames Valley | % | 114 | 100 | 86 |

Table 6 - 6: Water efficiency savings uncertainty parameters for households and non-household

[10] 8,567 households which have been measured and a control group of 1,000 properties from the unmeasured domestic water use study

### Leakage

6.98 In line with supplementary guidance[11] no uncertainty has been included for leakage activity in AMP7. However uncertainty will be applied to the final plan leakage programmes.

6.99 We have retained our leakage uncertainty estimate for final planning from WRMP19. These estimates suggested a moderate to low likelihood of not meeting planned targets for additional activities and a small chance of exceeding targets. Therefore, a simple triangular distribution was used with the 'most likely' value of 100% of the planned benefits, a minimum of 80% and a maximum of 105%.

### Government Led Savings

6.100 Government led savings (GLS) refers to policy measures undertaken by the UK Government that would be expected to result in reductions to water use, primarily household customers. For example, measures such as water labelling or minimum standards for water fittings would be included within this category.

6.101 GLS are not included within the baseline but are used within final planning scenarios. These savings are particularly uncertain as there is, at the time of writing, no Government commitment to introduce measures which would deliver these savings. To reflect this a wide range of uncertainty has been included using a triangular distribution with the parameters shown in Table 6 - 7.

| WRZ | Unit | Upper estimate | Most likely | Lower estimate |
|---|---|---|---|---|
| London | % | 105 | 100 | 60 |
| Thames Valley | % | 105 | 100 | 60 |

Table 6 - 7: Government-led Savings Assumptions

### Coronavirus Uncertainty

6.117 The long-term impacts of changes brought about by the Coronavirus pandemic are currently highly uncertain. Artesia consulting reported within their study "Understanding changes in household water consumption associated with Covid-19" that to understand how domestic water use patterns will change as a result of the Covid-19 pandemic will:

*"require long term monitoring with both qualitative and quantitative data to know whether the changes in dynamics reflected during this lockdown reflect only a temporary disruption, or represent a longer-term change to the patterns and rhythms of the everyday practices that underpin and influence domestic and garden water use."*

6.118 We have not included any additional demand for water within our deterministic demand forecasts, but we do consider it appropriate to include an allowance within demand uncertainty. Therefore, we have used a triangular distribution with the parameters shown in Table 6 - 8.

[11] Water resources planning guideline supplementary guidance – Leakage 2 September 2020

| WRZ | Unit | Upper estimate | Most likely | Lower estimate |
|---|---|---|---|---|
| London | % | 103 | 101 | 100 |
| Thames Valley | % | 103 | 101 | 100 |

Table 6 - 8: Uncertainty around long-term changes in demand brought about by coronavirus pandemic

## Model Outputs

6.134 Climate change is the most important Headroom theme, but total demand side uncertainty is the second most important and a significant part of the plan. For Baseline Headroom both base uncertainty (D1) and population uncertainty (part of D2) are key components. Most uncertainty in future DI is due to uncertainty in population forecasts; over 40% of the variance in DI in 2044 is due to the population forecast alone. Introducing uncertainties for demand management measures (D4) for the final planning results increases the magnitude of uncertainty (by a maximum ca. 1% of DI) but population uncertainty remains the dominant factor.

6.135 The output from the model, which is then used in the headroom model, is a table with a demand value for each 5th percentile. A graphical representation of the output can be seen in Figure 6 - 11. Results from the baseline model run are used as input into the headroom model to form an initial view of Target Headroom for the baseline forecasts.

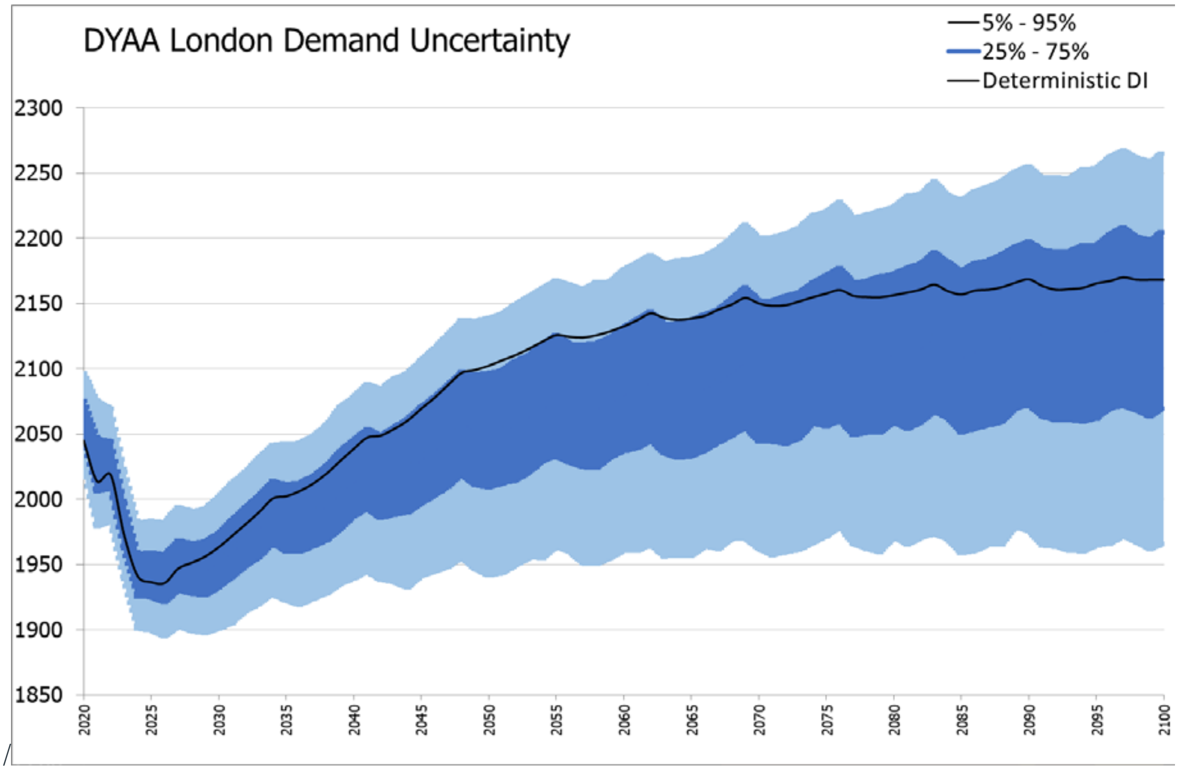


Figure 6 - 11: Baseline demand forecast uncertainty spread – London WRZ

## Bringing Uncertainties Together – Baseline Target Headroom Modelling

6.136 As described above, we have defined distributions associated with different uncertain components of our supply-demand balance according to evidence and/or expert judgement.

6.137 We use all of the component-level uncertainties as inputs to our holistic Target Headroom assessment.

6.138 In some cases, we use individual component-level uncertainty distributions as direct inputs to our Target Headroom model (e.g. we define a discrete distribution associated with supply-side climate change uncertainty inputs). In other cases, we use cumulative distribution functions (CDFs) as inputs to our Target Headroom models, and use software functionality which allows us to sample from a probability distribution function that underlies a given CDF.

6.139 Our Monte Carlo Target Headroom modelling samples values from the different input distributions and adds uncertainties together to derive samples of total uncertainty.

6.140 We then look at all of the total sampled uncertainty values that have been calculated and take the 'Xth' percentile of all values calculated, with the value 'X' depending on our risk tolerance.

### Adaptive Planning – Exclusion of 'Double Counted' Components

6.141 WRSE's Regional Plan (and so Thames Water's WRMP24) is a fully adaptive plan. This is in contrast to our WRMP19, which took a multi-metric approach, but which was mainly based on solutions for single supply-demand balance profiles. Adaptive planning is used to ensure a plan which is efficient and resilient across a wide range of possible futures. The explicit consideration of uncertain components within an adaptive plan would mean that accounting for all uncertain components within Target Headroom would result in double counting (e.g. a 'standard' Target Headroom calculation would include an allowance for population growth uncertainty – it may be considered double counting to include a buffer to account for population growth uncertainty if an adaptive planning framework is applied which considers different pathways for future population growth).

6.142 WRSE has written a document which details the approach that it requests companies adopt when determining Target Headroom profiles.

6.143 The key facet of the WRSE approach is the submission of multiple target headroom profiles, which are used to avoid double counting uncertainties within an adaptive planning framework.

6.144 The WRSE plan will start with a single 'root' branch, in which required actions to ensure a supply-demand balance which conforms with requirements set out in the WRPG will be set out (e.g. the demand forecast will be based on Local Authority Plan forecasts). At this stage, a 'Full' Target Headroom profile is appropriate, because no uncertain components have been explicitly considered (i.e. the supply-demand balance profile at this point is a 'central' profile).

6.145 The WRSE plan will then branch on different uncertain components, first into three branches, and then each of the three branches will be split into three further branches, leading to a total of nine branches in the long term. WRSE may consider different timing for branches within programme appraisal. The uncertain supply-demand balance components which are branched on are:

- Population Growth, i.e. the regional plan considers a wide range of plausible future demand forecasts

- Environmental Destination (DO impact of future sustainability reductions)
- Climate Change

6.146 These uncertain factors were chosen as they are the largest time-variant uncertain components of the supply-demand balance.

6.147 The WRSE Target Headroom approach sets out that it would be considered to be double counting to account for uncertainty within Target Headroom for any component which has been branched upon in the adaptive plan. As such, different 'types' of Target Headroom have been calculated, and when branches are made the Target Headroom profile used in determining the supply-demand balance is altered.

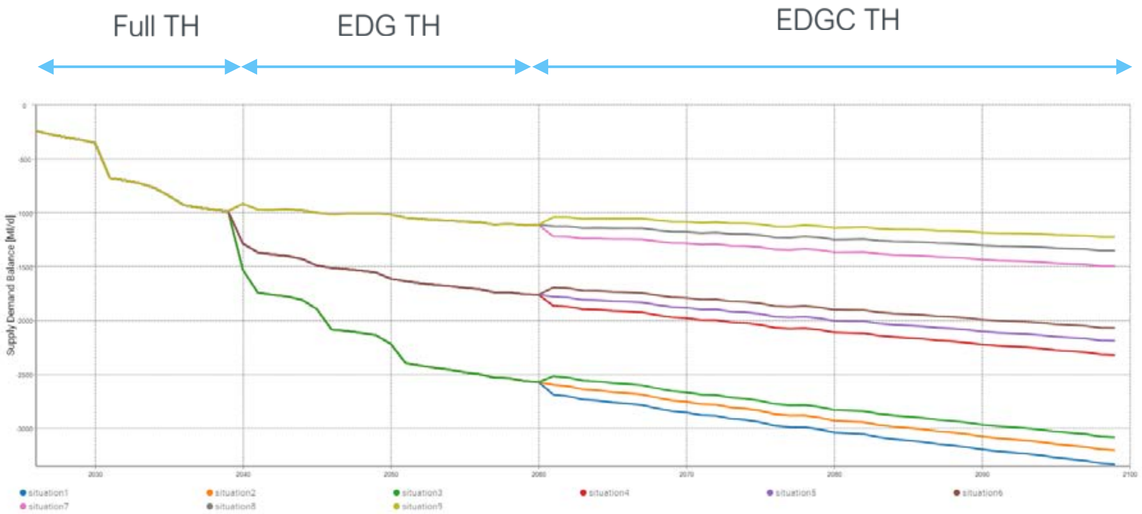


Figure 6 - 12: Different 'Types' of Target Headroom Used Across the Planning Period

6.148 WRSE described the forms of Target Headroom as:

- Full – Target Headroom considering all uncertainties, to be used in the 'root' branch
- EDG – Target Headroom, excluding any uncertainty associated with Environmental Destination or Growth projections, to be used after the first branch point
- EDGC – Target Headroom, excluding any uncertainty associated with Environmental Destination, Growth, or Climate Change projections, to be used after the second branch point

6.149 We have not included uncertainty associated with vulnerable licences within Target Headroom (excluded, as per WRPG), and has not assessed the change in supply-side uncertainty associated with reduced DO under future Environmental Destination scenarios. As such, only the removal of growth and climate change have been considered in our modified Target Headroom profiles. In this document, the Target Headroom profiles are thus described as:

- TH – Full Target Headroom, incorporating all uncertain components
- THEG – Target Headroom, Excluding uncertainty associated with population Growth

- THEGC – Target Headroom, Excluding uncertainty associated with population Growth and Climate change

6.150 We will always branch on demand uncertainty before climate change uncertainty, because growth uncertainty will be manifested (and observable) on a shorter timescale than climate change (i.e. in 2030 or 2035 we will be able to see whether population growth has followed the 'Local Plan' forecasts, but we will not be able to determine whether we are on course for climate to change to have severe or benign impacts.

6.151 The calculation of TH involves all supply-side and demand-side uncertainties that have been outlined in the preceding sections.

6.152 The calculation of THEG involves all supply-side uncertainties; demand-side uncertainty profiles are used which exclude uncertainty associated with growth.

6.153 The calculation of THEGC involves all supply-side uncertainties apart from uncertainty associated with climate change impacts. Demand-side uncertainty profiles which exclude uncertainty associated with both climate-change impacts and growth are used.

6.154 In our supply-demand balances, we have adopted a THEG profile from the beginning of the planning period, rather than using a 'Full' Target Headroom assessment from the beginning of the planning period. When we measure demand uncertainty around our main, local authority plan-based demand forecast, it has a negative skewing effect on Target Headroom. Including this negative skew does not seem in the spirit of planning for a local authority plan-based demand forecast. If we were to measure demand uncertainty as being centred on the plan-based forecast, we would account for additional uncertainty on top of what is a relatively high demand forecast, which seems excessive. As such, we have excluded growth uncertainty from our Target Headroom profiles throughout the planning period.

### Risk Tolerance Profile

6.155 Our Target Headroom model gives outputs which give a Target Headroom for each year of the plan, subject to a given risk tolerance. For example, if we are willing to accept 20% risk in a given year, we could end up with a Target Headroom in a given WRZ of 20 Ml/d, while if we were willing to accept 30% risk, we may end up with 10 Ml/d. A lower risk tolerance implies a greater buffer being necessary between supply and demand.

6.156 The key features of the risk profile that we deemed appropriate were:

- Initially, a relatively low risk tolerance should be taken. It would, however, be reasonable to take more risk than at WRMP19 due to the increased appreciation of supply-side risks that has been included
- This low risk tolerance should be maintained until 1 in 200-year resilience is relatively secure
- It would be inappropriate to suggest significant investment be made on the basis of future uncertainties, and so a higher degree of risk tolerance is appropriate further into the future

6.157 These factors align with the guidance set out in the WRPG:

> *"You should consider the appropriate level of risk for your plan. If target headroom is too large it may drive unnecessary expenditure. If it is too small, you may not be able to meet your planned level of service. You should accept a higher level of risk further into the future. This is because as time progresses the uncertainties will reduce and you have time to adapt to any changes."*

6.158 The risk tolerance profile adopted is shown in Table 6 - 9. Linear interpolation is used between these dates. Beyond 2050, a constant risk tolerance of 40% is used.

| Year | 2019/20 | 2024/25 | 2029/30 | 2034/35 | 2039/40 | 2044/45 | 2049/50 |
|---|---|---|---|---|---|---|---|
| WRMP19 | 5 | 10 | 15 | 20 | 25 | 29 | 29 |
| dWRMP24 | 15 | 15 | 15 | 21 | 30 | 35 | 40 |

Table 6 - 9: Risk Tolerance Profile Adopted in Target Headroom Modelling

6.159 The initial risk tolerance adopted is 15%; this is higher than WRMP19 due to the greater range of supply-side risks that have been considered. This initial value is maintained for longer than was the case for WRMP19, in order to provide a high degree of confidence that we will meet a 1 in 200-year Level of Service in the relatively near term.

6.160 The risk tolerance is then increased rapidly between the early 2030s and 2040 (15% to 30%), in order than the selection of a large option to deliver 1 in 500-year resilience is not driven by an excessive Target Headroom forecast. The value is then further reduced in the long-term to reflect an increased risk tolerance and ability for investments to adapt to long-term uncertainties.

### Minimum Threshold

6.161 We have applied a de-minimis of 3% of base-year DI for Target Headroom, in order to ensure that a minimum buffer between supply and demand will exist at all points in our plan.

## Final Plan Target Headroom Approach

6.162 In the WRSE Target Headroom approach document, WRSE recommended that Baseline Target Headroom profiles should include uncertainty associated with options set out in the WRSE emerging plan. We do not consider that submitting 'Final Plan' Target Headroom profiles in place of Baseline Target Headroom profiles is appropriate, and feel that we could be criticised by regulators or stakeholders for over-accounting for uncertainty if including allowances for Final Plan uncertainty within our Baseline.

6.163 The WRSE approach describes an iterative planning process that it wishes to avoid:

- Baseline TH is established
- Baseline TH is used to derive a supply-demand balance
- A plan is determined which satisfies supply-demand balance, incorporating this Baseline TH profile
- Final Plan TH is calculated (incorporating uncertainty associated with options present in the plan), which generally exceeds Baseline TH due to the larger number of uncertainties considered
- Final Plan supply-demand balance therefore shows a deficit
- Additional options are required to satisfy the additional supply-demand balance gap created
- Final Plan TH re-calculated, which exceeds the previously calculated Final Plan TH, and so on

6.164 The idea here would be to assume that the Final Plan Target Headroom as determined with options set out in the Emerging Plan would be sufficiently close to a Final Plan Target Headroom to avoid plan iterations.

6.165 While we do not consider that submitting Final Plan Target Headroom in place of Baseline Target Headroom is appropriate, we do agree that avoiding an iterative planning process is a good idea. As such, we have devised a different approach to consideration of Final Plan Target Headroom which we believe will avoid this iterative process.

6.166 We intend to carry out a Final Plan Target Headroom analysis between our draft and revised draft WRMP24 submissions, including uncertainty associated with options which are selected, and have used generic uncertainty distributions suggested by WRSE. We have adapted our Baseline Target Headroom models, incorporating additional uncertainty components within our Monte Carlo sampling approach to account for the uncertainty associated with option delivery (e.g. we may find that demand management programmes yield more or less than the level of savings that we anticipate, or we may find that groundwater schemes yield more, or less, water than anticipated).

6.167 However, rather than alter our Baseline Target Headroom risk tolerance profile by default, we will instead infer the risk tolerance profile that would be determined if using the same Target Headroom allowance profile as in our Baseline supply-demand balance. If the inferred risk tolerance is less than an acceptable threshold we will not increase our Final Plan Target

Headroom to be above the Baseline Target Headroom profile. If the inferred risk tolerance is greater than an acceptable threshold we will increase our Final Plan Target Headroom and investigate additional options that may be needed.

6.168 Two examples are set out below to explain this. In the first example, if, in a given year of the plan, we had Risk Tolerance vs Target Headroom relationships (Baseline and Final Plan) as shown below, and in this year of the plan our Baseline Target Headroom Risk Tolerance was 10%, we would have had a Baseline Target Headroom allowance of 200 Ml/d. When looking at the Final Plan Risk Tolerance vs Headroom allowance relationship, a 200 Ml/d allowance would give us a 'Final Plan Risk Tolerance' of 30%. With this value being below 50% (an assumed acceptable threshold), we would deem this acceptable.

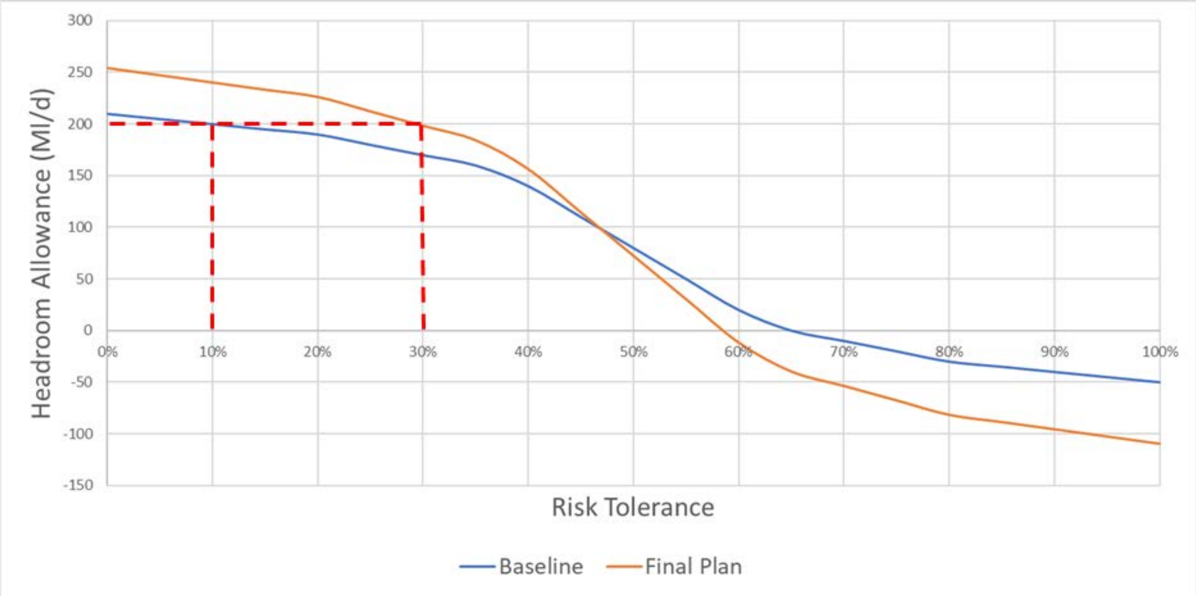


Figure 6 - 13: Final Plan Target Headroom – Example 1

6.169 In the second example, below, a 200 Ml/d Target Headroom allowance (a 10% Baseline Risk Tolerance) would imply a Final Plan Risk Tolerance of more than we would deem unacceptable, with the acceptability threshold linked to our Level of Service. We would, in this case, increase our Final Plan Target Headroom to be equal to the 50th percentile Final Plan Target Headroom, i.e. around 220 Ml/d from the Figure below and would investigate whether additional options would be needed.

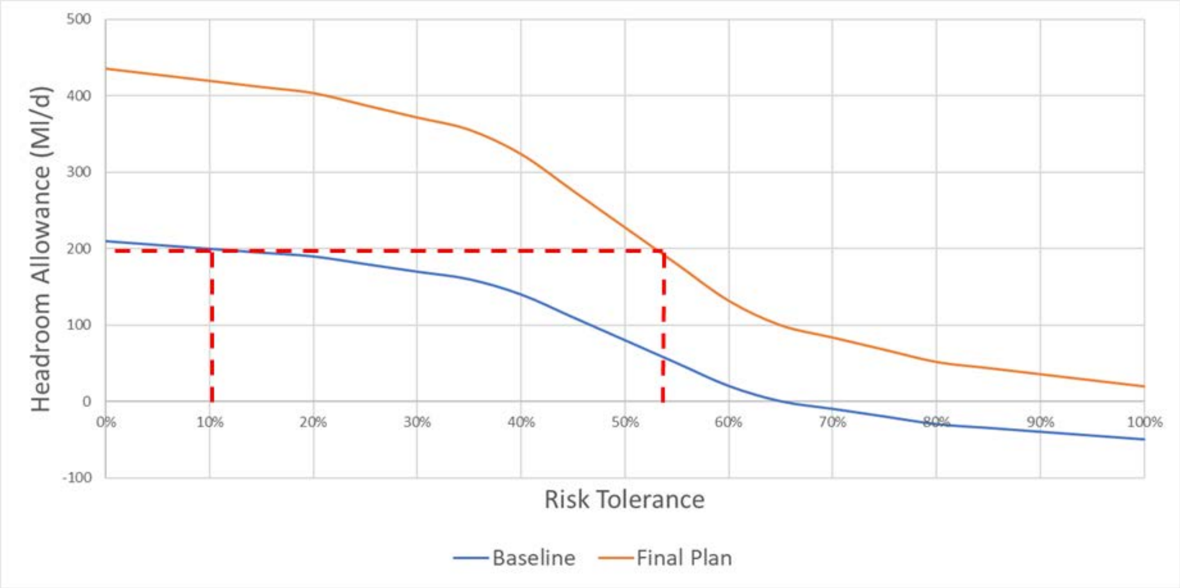


Figure 6 - 14: Final Plan Target Headroom – Example 2

## Results of Baseline Target Headroom Assessment

6.170 In this section, the Target Headroom profiles produced for each of our WRZs for each planning scenario are set out. When reviewing these figures, please bear in mind that 'THEG' profiles are used in our Baseline Supply-demand Balance until 2035, with 'THEGC' profiles used from then on. For each WRZ, for each planning scenario, an estimate has been made of the relative contribution of different uncertain components to overall Target Headroom.

### London DYAA


Figure 6 - 15: London DYAA Target Headroom Profiles

6.171 Compared to WRMP19, we are initially including a larger Target Headroom allowance, driven by the inclusion of a greater range of 'base year' risks on the supply side. As is usual, our Target Headroom grows over the first few years of the planning period, reflecting uncertainty around forecast demand and a low tolerance for risk in the short term. We maintain a low tolerance (and so relatively high Target Headroom allowance) for risk until our 1 in 200-year resilience will be secure, in the early 2030s. We then reduce our Target Headroom allowance during the 2030s in order that we do not drive investment due to long-term uncertainty.

6.172 In the long term, our Target Headroom allowance is reduced compared to WRMP19, reflecting an increased risk tolerance due to the adaptive approach that we are taking.

6.173 Table 6 - 10 shows that base-year supply-side uncertainty is the main component of Target Headroom throughout the planning period.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 60% | 57% | 63% | 78% |
| Climate Change Supply-Side | 15% | 20% | N/A | N/A |
| Demand-Side | 25% | 24% | 37% | 22% |

Table 6 - 10: Contribution of Different Uncertainties Towards Target Headroom – London

## SWOX DYAA

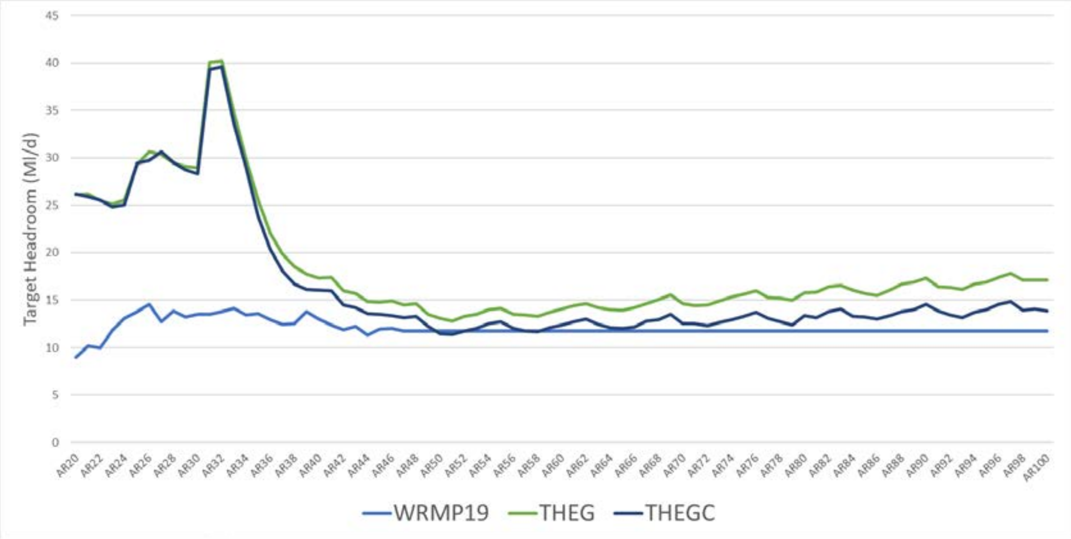


Figure 6 - 16: SWOX DYAA Target Headroom Profiles

6.174 As with London, our SWOX DYAA Target Headroom allowance is initially larger than at WRMP19, reflecting the inclusion of a greater range of base-year risks. In the longer term, our SWOX DYAA Target Headroom allowance is approximately the same as that used in WRMP19.

6.175 Table 6 - 11 shows that base-year supply-side uncertainty (i.e. uncertainty associated with DO assessment) is the main source of uncertainty for SWOX.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 72% | 70% | 66% | 76% |
| Climate Change Supply-Side | 6% | 8% | N/A | N/A |
| Demand-Side | 22% | 21% | 34% | 24% |

Table 6 - 11: Contribution of Different Uncertainties Towards Target Headroom – SWOX DYAA

## SWOX DYCP

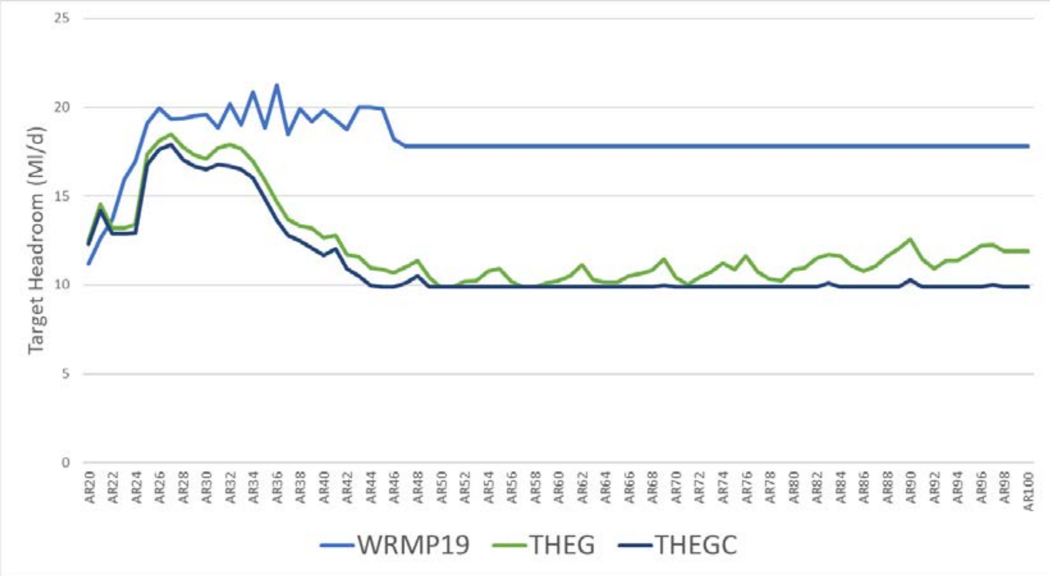


Figure 6 - 17: SWOX DYCP Target Headroom Profiles

6.176 In the short-term, our SWOX DYCP Target Headroom profile is relatively close to that which was used in WRMP19. DYCP Target Headroom has not seen the same short-term increase due to the different driver of DYCP DO (treatment capacity) compared to DYAA DO (water availability over a drought period).

6.177 Table 6 - 12 shows that demand-side uncertainty is the main contributor towards SWOX's DYCP Target Headroom.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 23% | 22% | 26% | 32% |
| Climate Change Supply-Side | 8% | 11% | N/A | N/A |
| Demand-Side | 69% | 66% | 74% | 68% |

Table 6 - 12: Contribution of Different Uncertainties Towards Target Headroom – SWOX DYCP

## SWA DYAA

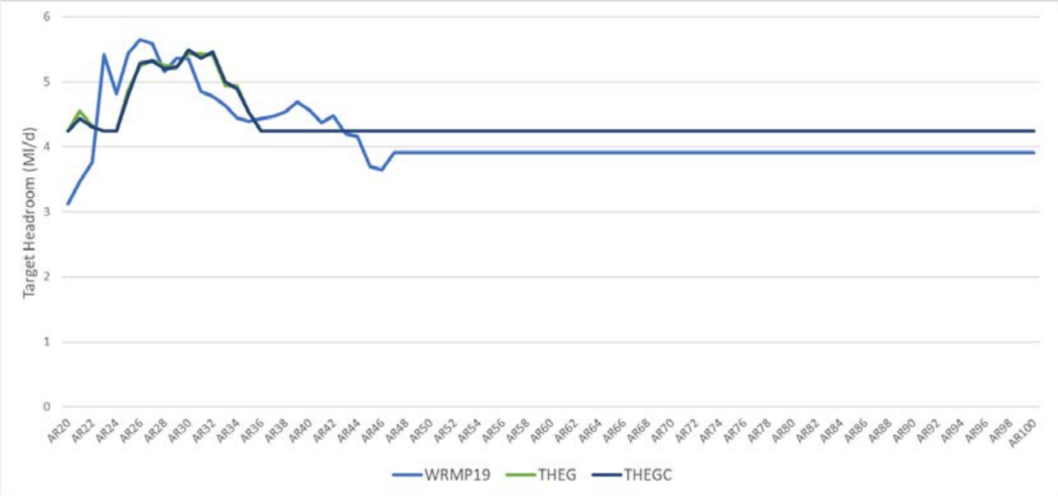


Figure 6 - 18: SWA DYAA Target Headroom Profiles

6.178 The uncertainty profile for the SWA DYAA planning scenario is broadly similar to that used at WRMP19. The influence of climate change on the SWA WRZ is relatively small, and so the THEG and THEGC profiles are very close.

6.179 Table 6 - 13 shows that demand uncertainty is the main contributor towards SWA's DYAA Target Headroom profile.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 24% | 21% | 18% | 20% |
| Climate Change Supply-Side | 1% | 1% | N/A | N/A |
| Demand-Side | 75% | 77% | 82% | 80% |

Table 6 - 13: Contribution of Different Uncertainties Towards Target Headroom – SWA DYAA

## SWA DYCP

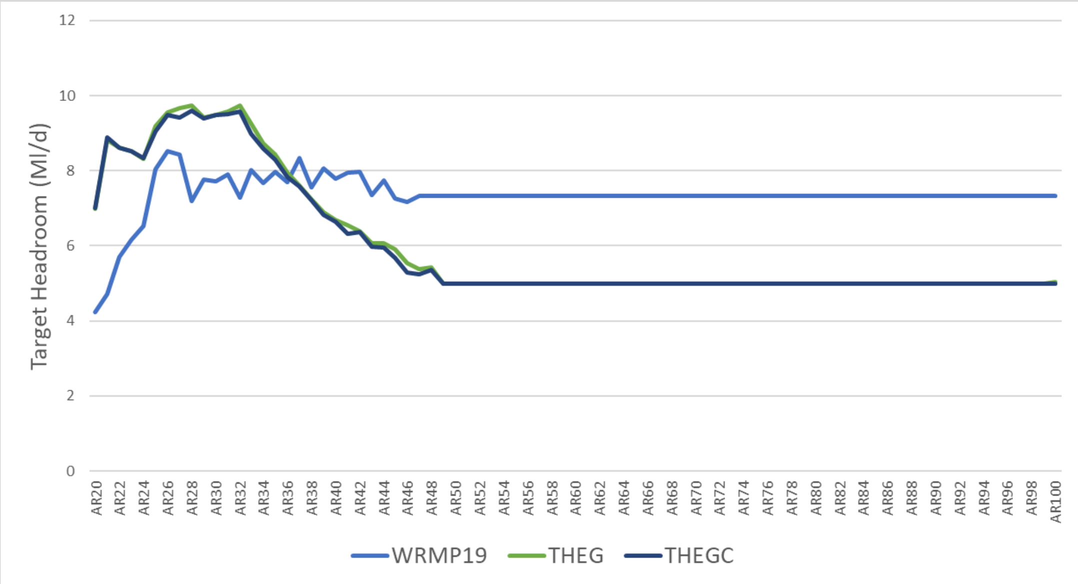


Figure 6 - 19: SWA DYCP Target Headroom Profiles

6.180 The SWA DYCP Target Headroom profile is initially slightly greater than was used at WRMP19. In the long-term, our Target Headroom allowance is smaller than was used at WRMP19.

6.181 Table 6 - 14 shows that demand uncertainty is the main contributor towards SWA's DYCP Target Headroom.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 30% | 29% | 28% | 34% |
| Climate Change Supply-Side | 1% | 1% | N/A | N/A |
| Demand-Side | 70% | 71% | 72% | 66% |

Table 6 - 14: Contribution of Different Uncertainties Towards Target Headroom – SWA DYCP

## Kennet Valley DYAA

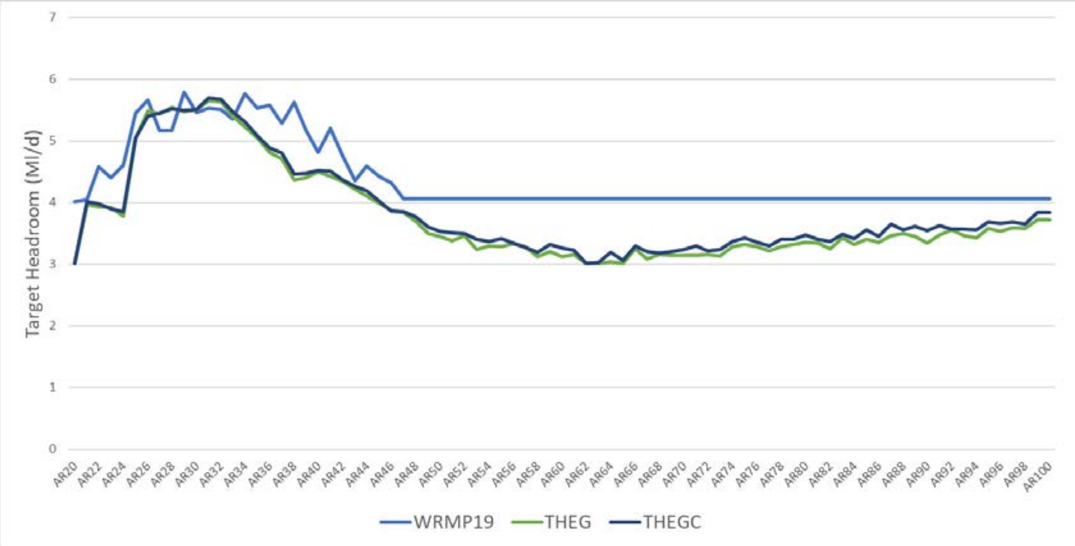


Figure 6 - 20: Kennet Valley DYAA Target Headroom Profiles

6.182 The Kennet Valley DYAA Target Headroom profile is relatively similar to that used in WRMP19.

Table 6 - 15 shows a fairly even split between base-year supply-side uncertainty and demand-side uncertainty as having contributed to KV's DYAA Target Headroom Profiles. The contrast between the Kennet Valley WRZ and other Thames Valley WRZs (which have a smaller base-year supply-side contribution) is likely due to the vulnerability of the Fobney run-of-river surface water source.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 45% | 42% | 41% | 47% |
| Climate Change Supply-Side | 1% | 1% | N/A | N/A |
| Demand-Side | 54% | 57% | 59% | 53% |

Table 6 - 15: Contribution of Different Uncertainties Towards Target Headroom – KV DYAA

## Kennet Valley DYCP

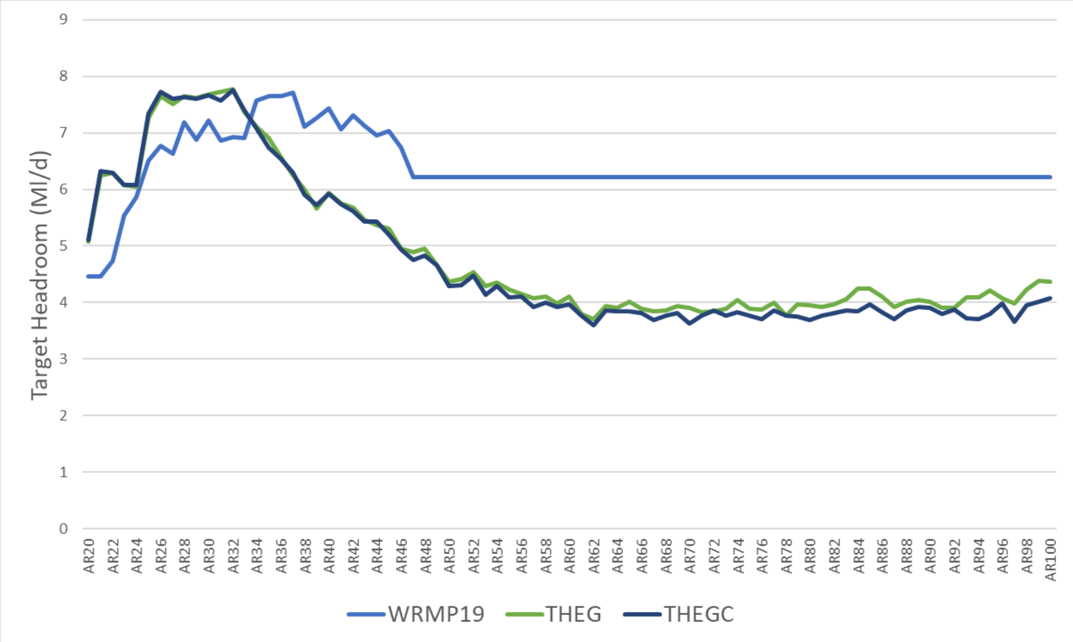


Figure 6 - 21: Kennet Valley DYCP Target Headroom Profiles

6.203 The Target Headroom profile adopted for the Kennet Valley DYCP scenario is broadly similar to that used at WRMP19, but with a lower allowance in the longer term.

6.204 Table 6 - 16 shows that demand-side uncertainty contributes most to Kennet Valley's DYCP Target Headroom profiles.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 35% | 33% | 34% | 41% |
| Climate Change Supply-Side | 1% | 2% | N/A | N/A |
| Demand-Side | 64% | 65% | 66% | 59% |

Table 6 - 16: Contribution of Different Uncertainties Towards Target Headroom – KV DYCP

## Guildford DYAA

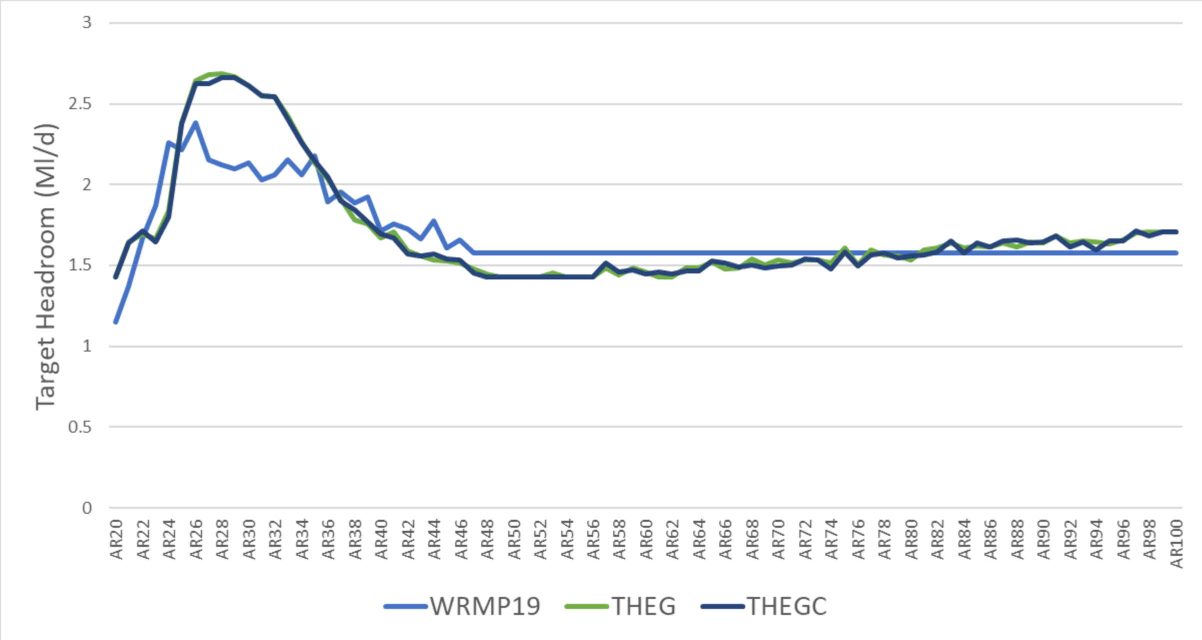


Figure 6 - 22: Guildford DYAA Target Headroom Profiles

6.205 The DYAA Target Headroom profile adopted for Guildford WRZ is broadly similar to that used in WRMP19.

6.206 Table 6 - 17 shows that demand-side uncertainty is the largest contributor towards Guildford's DYAA Target Headroom profiles.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 26% | 24% | 22% | 25% |
| Climate Change Supply-Side | 0% | 0% | N/A | N/A |
| Demand-Side | 74% | 76% | 78% | 75% |

Table 6 - 17: Contribution of Different Uncertainties Towards Target Headroom – Guildford DYAA

## Guildford DYCP

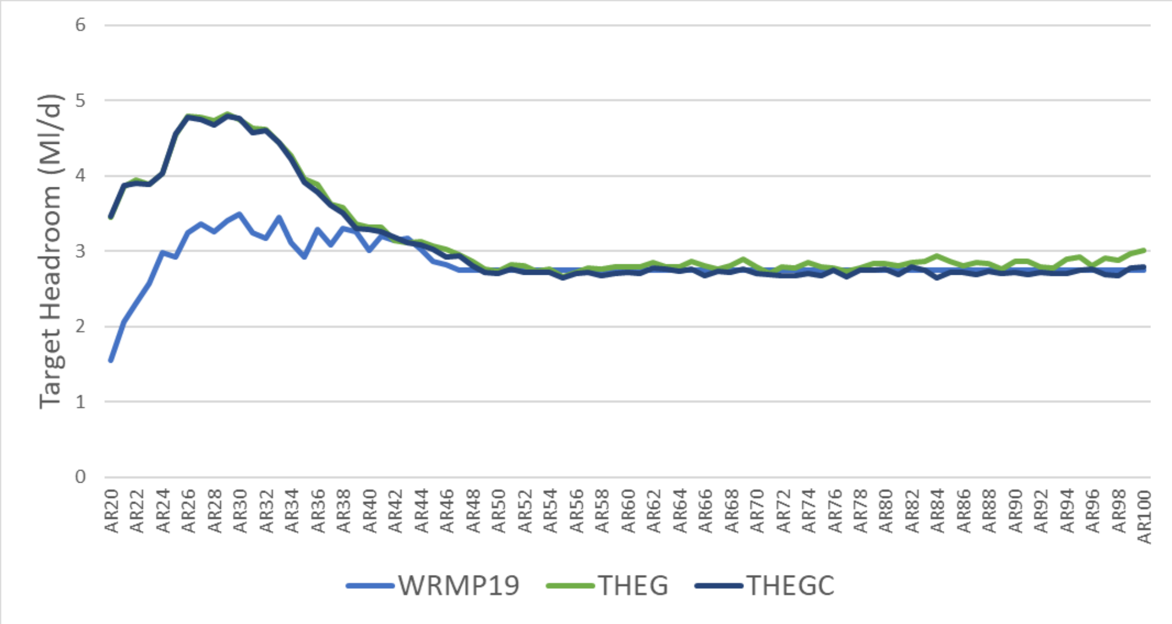


Figure 6 - 23: Guildford DYCP Target Headroom Profiles

6.207 The DYCP Target Headroom profile adopted for Guildford WRZ is broadly similar to that used in WRMP19, but with a higher allowance made in the shorter term.

6.208 Table 6 - 18 shows that demand-side uncertainty is the largest contributor towards Guildford's DYCP Target Headroom profiles.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 17% | 16% | 15% | 17% |
| Climate Change Supply-Side | 0% | 0% | N/A | N/A |
| Demand-Side | 83% | 84% | 85% | 83% |

Table 6 - 18: Contribution of Different Uncertainties Towards Target Headroom – Guildford DYCP

## Henley DYAA

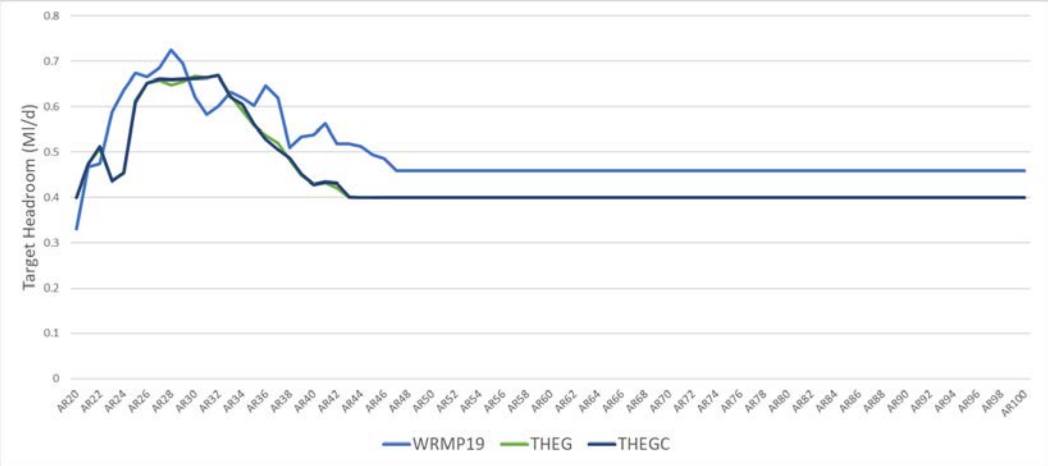


Figure 6 - 24: Henley DYAA Target Headroom Profiles

6.209 The Henley DYAA Target Headroom profile adopted is broadly similar to the profile used at WRMP19.

6.210 Table 6 - 19 shows that demand-side uncertainty is the largest contributor towards Henley's DYAA Target Headroom profiles.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 6% | 6% | 4% | 3% |
| Climate Change Supply-Side | 0% | 0% | N/A | N/A |
| Demand-Side | 94% | 94% | 96% | 97% |

Table 6 - 19: Contribution of Different Uncertainties Towards Target Headroom – Henley DYAA

### Henley DYCP

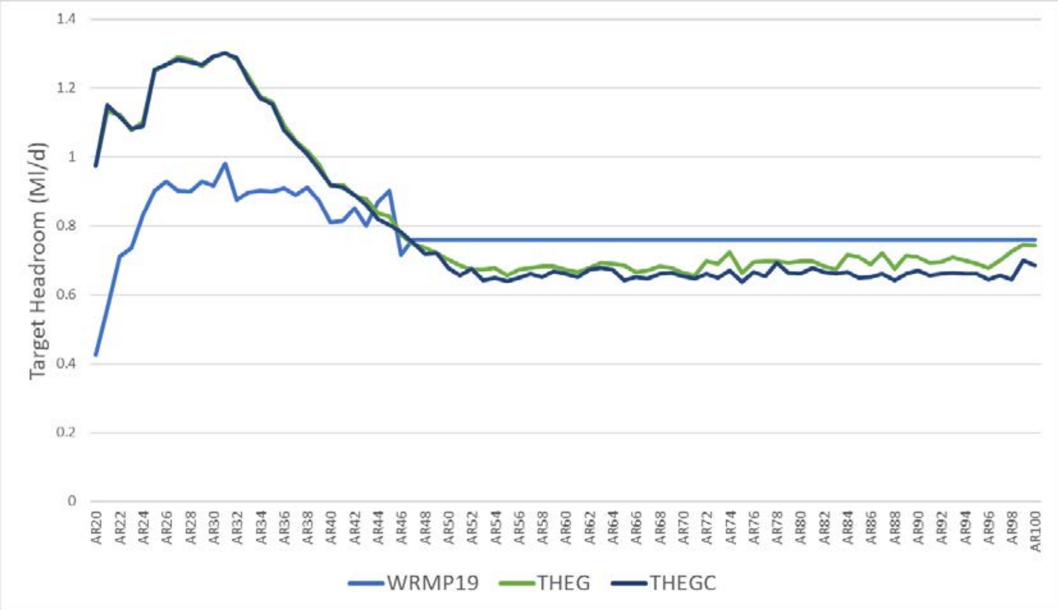


Figure 6 - 25: Henley DYCP Target Headroom Profiles

6.211 The Henley DYCP Target Headroom profile adopted is broadly similar to the profile used at WRMP19, though with an increased allowance in the short-term.

6.212 Table 6 - 20 shows that demand-side uncertainty is the largest contributor towards Henley's DYCP Target Headroom profiles.

| | 2025 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Base-year supply-Side | 5% | 5% | 4% | 4% |
| Climate Change Supply-Side | 0% | 0% | N/A | N/A |
| Demand-Side | 95% | 95% | 96% | 96% |

Table 6 - 20: Contribution of Different Uncertainties Towards Target Headroom – Henley DYCP

## Baseline Supply-Demand Balance

6.213 The baseline supply-demand balance position is defined as:

*The resulting supply-demand balance assuming no activity beyond the immediate AMP period other than that required to maintain leakage, or that required by law*

6.214 By comparing the profile(s) of unrestricted demand (Section 3: Current and Future Demand for Water) against the available supply (Section 4: Current and future water supply), plus an allowance for uncertainty as outlined earlier in this section, and accounting for future sustainability reductions (Section 5), supply-demand balance(s) are created.

6.215 A supply-demand balance highlights whether there is a "planning problem", i.e. a forecast deficit in any zone before significant intervention from the company. We test this for both the dry year annual average (DYAA) and average day peak week (ADPW, also referred to as Dry Year Critical Period, DYCP). It is possible that deficits may exist under one/both/neither condition(s); our plan must provide a solution to ensure supply-demand balance in both scenarios.

6.216 In this section we present baseline supply-demand balances for each of our WRZs. A full breakdown of the components of the forecast can be found in the Water Resources Management Plan tables.

6.217 Within the baseline presented in this section, we have assumed a Level of Service that changes over time, aligned with our expected Levels of Service. Our baseline includes a period (2025-2030) during which we would not impose emergency drought orders more often than once every one hundred years; there then follows a period during which we would not impose emergency drought orders more often than once every two hundred years (2031-2039), and then a period when we would not impose emergency drought orders more often than once every five hundred years.

6.218 Where there is an upwards step change in the resilience level in our plan, there will be a step down in the supply-demand balance. The reason for this is that we can reliably supply more water in less severe drought events. As we increase the level of resilience that we are aiming for, we will be able to rely on a smaller supply of water from our existing resources.

6.219 Our baseline in London and SWOX is presented slightly differently to WRMP19. In WRMP19 we assumed that Temporary Use Bans (TUBs) and Non-Essential Use Bans (NEUBs, also known as DD11 Drought Orders) were part of our baseline. These are now excluded from the baseline as shown in the Water Resources Management Plan tables. In this section we have presented a set of baseline supply-demand balances excluding TUBs, NEUBs and media campaigns, and a set of supply-demand balances which include these actions, to reflect the fact that we will certainly include these demand management actions within our WRMP.

6.220 We have excluded transfers to companies within the WRSE region from our baseline supply-demand balance, regardless of whether a contract exists for that transfer. The reason for this is that the WRSE plan has optimised transfers between WRSE companies. Transfers to those companies outside WRSE have been included within our baseline.

## Activity Within the Baseline Scenario

6.221 It is assumed that water resource activity included in our plan for the period 2020-2025 is delivered as has been set out in Section 3: Current and Future Demand for Water. Baseline activity beyond 2025 is restricted to the following levels:

- Leakage levels are assumed to be maintained
- Optant metering programme
- Societal changes and government-led efforts continue to reduce consumption, as described in Section 3: Current and Future Demand for Water

## Baseline Supply-Demand Balance and Adaptive Planning

6.222 In WRMP19, we formed single supply-demand balance profiles, using deterministic forecasts for supply, demand and target headroom. In WRMP24, we are adopting an adaptive planning approach, reflecting the highly uncertain exogenous factors which we need to plan for, and so will instead set out multiple supply-demand balance profiles.

6.223 The key uncertainties within our WRMP are:

- Population growth, and so the demand forecast
- The volume of sustainability reductions, set out in our 'Environmental Destination' scenarios
- The impact that climate change will have on our available supplies

6.224 These exogenous uncertainties are the factors that we will consider when building supply-demand balance scenarios. Our plan will be one which provides an efficient solution to a very uncertain future, rather than being a plan which focuses on providing an optimised solution for a given future.

6.225 The scenarios considered and branch points adopted are consistent across the WRSE regional group.

6.226 Our plan starts with a single supply-demand balance 'branch'. It starts off with a single branch, because we need to have a single plan for actions which need to be undertaken in AMP8. After AMP8, if appropriate to do so, we can consider having different investment programmes which are suitable for different future scenarios. For example, if we saw that population growth was following a low trajectory during AMP8, we may make different investments during AMP9 (2030-35) than if we saw that population growth was following a high trajectory. We have considered the magnitude of difference between different forecasts of uncertain factors over time, as well as the time at which we may be able to observe whether a more or less severe trajectory is being followed, as well as considering our allowances for uncertainty and the lead times associated with interventions, when considering when our supply-demand balance profiles should branch.

## Demand

6.227 The WRPG sets out that we should consider Local Authority plans of population and properties when developing our demand forecast. As such, our early and central supply-demand balances will use the Local Authority Plan demand forecasts.

6.228 Ofwat has released guidance regarding adaptive planning[12] which sets out that we should consider an ONS18 principal population forecast as a plausible low population forecast. As such, we have considered the demand forecast based on this population forecast within the lower branches of our supply-demand balance trees.

6.229 The OxCam growth corridor is an important factor which we should consider in our water resources planning. Developments associated with the OxCam corridor are not yet built into Local Authority plans, but would pose a material risk to our supply-demand balance should they materialise, particularly in our SWOX and SWA WRZs. As such, we have considered OxCam demand forecasts within the upper branches of our supply-demand balance trees.

6.230 Analysis of demand forecasts shows a material divergence between low and high population forecasts in the relatively short term; observation of population growth is also relatively simple. As such, we will impose an adaptive plan 'decision point' as early as possible, in 2030, and will 'branch' our supply-demand balances to consider different demand forecasts in 2035. The separation between 'decision point' and 'supply-demand balance branch point' avoids skewing investments towards more challenging branches.

### Environmental Destination

6.231 As is set out in Section 5, we have developed several scenarios of future licence reductions, known as 'Environmental Destination' scenarios, which may need to be implemented to protect and enhance ecology.

6.232 We do not yet have sufficient evidence to say whether ecological gain would be brought about by all of these licence reductions. Building an evidence base on which to make decisions regarding which sustainability reductions will need to be made in the future will be a key part of our WINEP plans for AMP8 and AMP9.

6.233 While there is material divergence between 'High' and 'Low' Environmental Destination scenarios, the Environment Agency has set out that licence reductions in these scenarios do not need to be made until 2050 at the latest, giving us time to conduct investigations and adapt our investment plans in the future.

6.234 Environmental Destination scenarios are the largest single uncertainty within our plan.

6.235 We will start out by assuming a 'Low' Environmental Destination trajectory (only assuming that sustainability reductions that have been identified as being fairly likely will be made) and have incorporated the Environment Agency's recently introduced 'Licence Capping' policy into this 'Low' Environmental Destination scenario (ensuring that double counting is avoided). There will be a 'decision point' at 2035, and a 'supply-demand balance branch point' at 2040, where our supply-demand balances will diverge in the Environmental Destination scenario that is followed.

### Climate Change

6.236 The impact that climate change will have on drought events is highly uncertain. Detecting which future climate trajectory we are following will not be possible in 'real-time' due to the uncertainty that exists over the impact of climate change on drought events in a given future emissions scenario, and so incorporating climate monitoring into our WRMP monitoring plan will not be

[12] 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

feasible. We do, however, feel it is important that we consider more and less severe future climate scenarios, to ensure that our plan is robust to a range of risks.

6.237 Aligned with other WRSE companies, we have conducted detailed modelling of 28 future climate projections. We have then supplemented this modelling with less detailed modelling of thousands of future climate projections. All WRSE companies are using the median result of the 28 future climate scenarios as the 'central' (or medium) climate change impact forecast within their WRMPs, the 6$^{th}$ climate scenario as a representative 'high' scenario (please note that it is the 6$^{th}$ scenario modelled, not the 6$^{th}$ most severe), and the 7$^{th}$ climate scenario as a representative 'low' scenario.

6.238 The 'high' (6$^{th}$) scenario is not the most severe that we have modelled and is instead approximately an upper quartile position within the range of scenarios that we have modelled. For our London WRZ, which is the most impacted by climate change, the 6$^{th}$ climate change scenario is the 7$^{th}$ most severe of the 28 scenarios modelled.

6.239 The 'low' (7$^{th}$) scenario is not the least severe climate change scenario. For our London WRZ, the 'low' scenario we are using is the fourth least severe scenario of the 28 that have been modelled.

6.240 The 6$^{th}$ and 7$^{th}$ climate scenarios were chosen by WRSE and were selected as scenarios which are consistently quite severe and not very severe, respectively, across the WRSE region.

6.241 We will start by following the 'median' climate change trajectory. There will be a 'decision point' at 2035, and a 'branch point' in 2040, at which point we will consider multiple climate change impact scenarios.

6.242 We would ideally have used a later branch point for climate change impact uncertainty, to reflect the difficulty and uncertainty associated with monitoring climate change impacts and the impact of climate change on drought likelihood and severity. However, computational constraints mean that we can have a maximum of two branch points (each branch point splitting into 3, giving 9 branches in total), and so we have chosen to 'branch' on climate change uncertainty at the same time as Environmental Destination scenarios.

### Supply-Demand Balance Profiles Shown

6.243 The scenarios associated with different uncertain factors have been combined to form a 'tree' of supply-demand balance. The scenarios ('branches) considered within the tree are shown in Table 6 - 21.

| Branch No. | 2025-30 | 2030-35 | 2035-40 | 2040-2100 |
|---|---|---|---|---|
| 1 | Local Plan<br>Demand<br>Median CC<br>Low ED | Local Plan<br>Demand<br>Median CC<br>Low ED | Local Plan +<br>OxCam Demand<br>Median CC<br>Low ED | Maximum Demand<br>Forecast<br>High CC<br>High ED |
| 2 | | | Local Plan +<br>OxCam Demand<br>Median CC<br>Low ED | Local Plan + OxCam<br>Demand<br>Median CC<br>Medium ED |
| 3 | | | Local Plan +<br>OxCam Demand<br>Median CC<br>Low ED | Local Plan + OxCam<br>Demand<br>Low CC<br>Low ED |
| 4 | | Local Plan<br>Demand<br>Median CC<br>Low ED | Local Plan Demand<br>Median CC<br>Low ED | Local Plan Demand<br>High CC<br>High ED |
| 5 | | | Local Plan Demand<br>Median CC<br>Low ED | Local Plan Demand<br>Median CC<br>Medium ED |
| 6 | | | Local Plan Demand<br>Median CC<br>Low ED | Local Plan Demand<br>Low CC<br>Low ED |
| 7 | | Local Plan<br>Demand<br>Median CC<br>Low ED | ONS18 Demand<br>Median CC<br>Low ED | ONS18 Demand<br>High CC<br>High ED |
| 8 | | | ONS18 Demand<br>Median CC<br>Low ED | ONS18 Demand<br>Median CC<br>Medium ED |
| 9 | | | ONS18 Demand<br>Median CC<br>Low ED | Minimum Demand<br>Forecast<br>Low CC<br>Low ED |

Table 6 - 21: Scenarios considered within situation 'tree' for WRMP24

6.244 In the following sub-sections we will show supply-demand balances for each of the nine branches considered within our adaptive plan for each of our WRZs.

6.245 We will also show, and describe in more detail, the balance of supply and demand in Branch 4, the pathway along which we describe our preferred programme.

6.246 In addition, in order to demonstrate the relative contribution of each uncertain factor, we will set out the values associated with different uncertain components at different points in the plan at 2060.

### London DYAA

6.247 The tables below show that all three main uncertainties contribute fairly significantly to uncertainty around London's future supply-demand balance but DO reduction due to Environmental Destination is the largest uncertainty.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 1888 | 2011 | 2133 | 2092 | 2147 |

Table 6 - 22: London DYAA Baseline Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | -147 | -97 | -34 |

Table 6 - 23: London DYAA Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -247 | -129 | -61 |

Table 6 - 24: London DYAA Environmental Destination Impact Scenarios

6.248 Figure 6 - 26 and Figure 6 - 28 show that London's baseline supply-demand balance starts in a position of deficit. It is important to note that this is only due to the removal of the benefits associated with media campaigns, TUBs and NEUBs, and that when these benefits are included we see our supply-demand balance start in a position of surplus, as shown in Figure 6 - 27 and Figure 6 - 29.

6.249 A deficit develops in our London WRZ before 2030 due to forecast demand increasing through AMP8, though at this point the deficit is modest, with a magnitude which demand management actions alone should be able to solve.

6.250 In 2031, the magnitude of the deficit grows significantly as we move to a '1 in 200-year' level of resilience (this change has a 120 Ml/d impact on our supply-demand balance). The deficit at this point is quite significant (around 200 Ml/d, after benefits of TUBs and NEUBs are accounted for), and we are likely to require new sources of water to ensure a supply-demand balance.

6.251 The variation in forecasts considered results in significant differences in the supply-demand challenge to be solved by 2040, with our least challenging and most challenging supply-demand positions being separated by around 300 Ml/d. This disparity in the need for investment by 2040, creates a significant adaptive planning problem, particularly when considering that many of our large supply options have lead times of between 8 and 15 years.

6.252 In 2040, our supply-demand balance is hit by the move to 1 in 500-year resilience. For our London WRZ, this impact is around 150 Ml/d in all scenarios, which can be seen in Figure 6 - 28.

6.253 The gaps between our different supply-demand balance forecasts continue to grow as the variation between demand forecasts, climate change impact forecasts, and environmental destination scenarios grows through the planning period. In our least challenging forecast, the planning problem that is posed does not grow substantially from 2040 onwards, while in the most challenging supply-demand balance forecast the deficit grows from around 300 Ml/d in 2040 to around 900 Ml/d in 2060.

6.254 In our forecast for scenario 4, our supply-demand balance once benefits from TUBs and NEUBs are accounted for is approximately -400 Ml/d in 2040, with the deficit growing to 420 Ml/d by 2050 and 540 Ml/d by 2060. The deficit by 2100 is around 680 Ml/d.

6.255 The significant jumps downwards in most of our supply-demand balance profiles in 2050 and 2060 are due to forecast licence reductions contained within our Environmental Destination forecasts.

6.256 The fact that Environmental Destination and Climate Change together pose a larger uncertainty than demand means that scenarios 1, 4, and 7 end up being those with the most severe supply-demand balance challenge to be overcome in the long term. The gaps of nearly 300 Ml/d by 2050 that exist between scenarios 7 and 9, and between scenarios 4 and 6, pose a challenge to our adaptive planning techniques and highlights that the 'High' Environmental Destination scenarios are likely to be the largest influence in our future investment plan for London.

6.257 When a like-for-like comparison is made with our forecast WRMP19 supply-demand balance, as can be seen in Table 6 - 25, we begin the planning period in a significantly better position than our WRMP19 Baseline supply-demand balance. This is due to the significant demand management programme that is being undertaken during AMP7. This improved position is maintained through the 2020s and 2030s. The move to 1 in 500-year resilience creates a point of difference between our WRMP19 and WRMP24 supply-demand balances, and the impact of this change is to bring our WRMP24 baseline supply-demand balance very close to our WRMP19 forecast. Over the longer term, sustainability reductions forecast in our Environmental Destination forecast leave us with a larger supply-demand balance problem to overcome than was forecast in WRMP19, though a reduced long-term growth forecast means that this difference is not as large as the DO reductions present in our Environmental Destination forecasts.

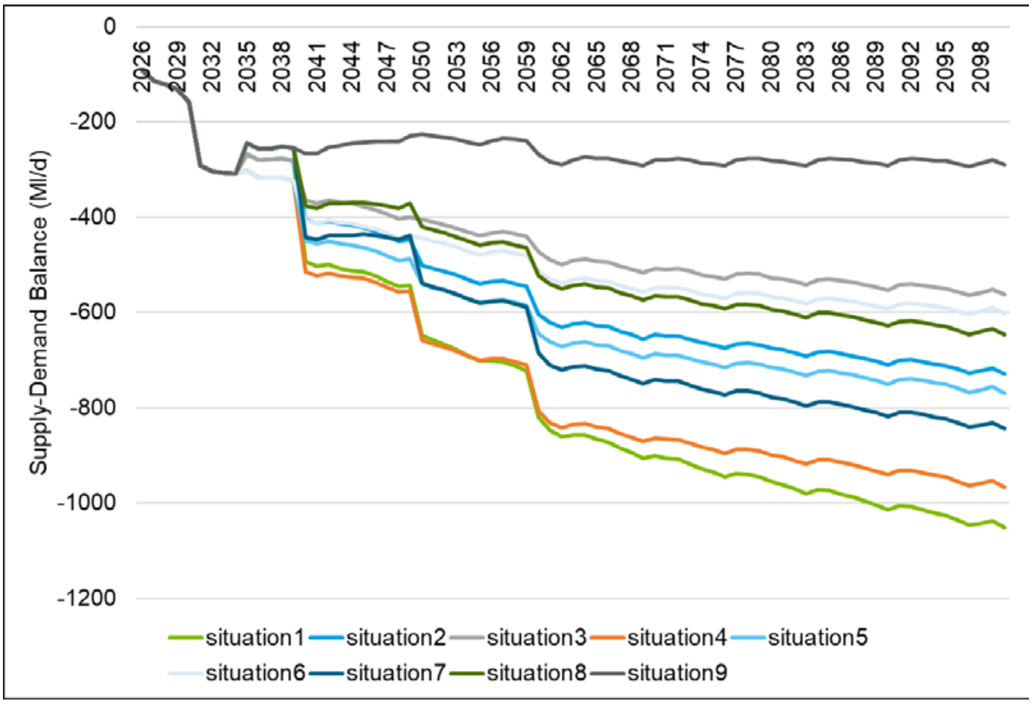


Figure 6 - 26: Supply-demand Balances of 9 Branches for London DYAA Scenario

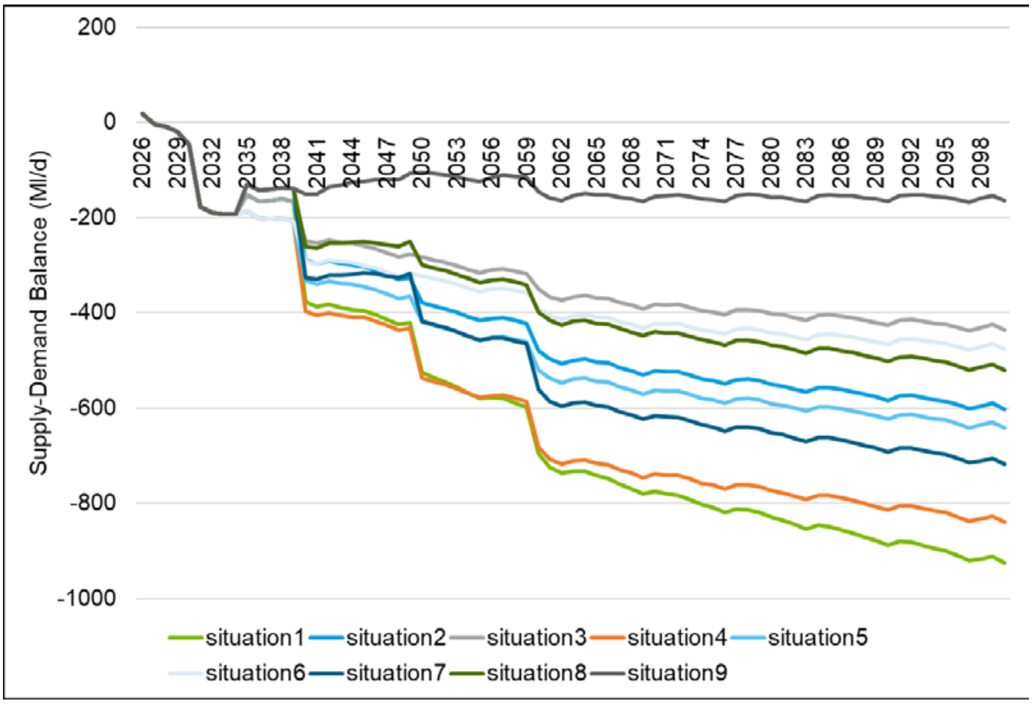


Figure 6 - 27: Supply-demand Balances of 9 Branches for London DYAA Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

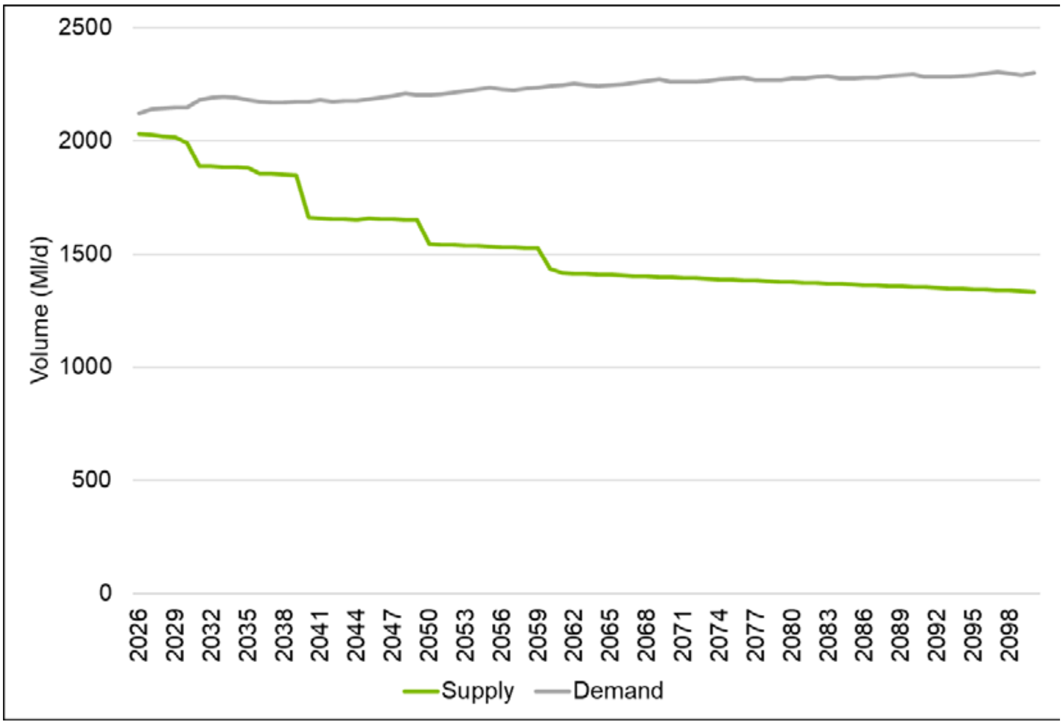


Figure 6 - 28: Baseline Supply-demand Balance for Situation 4, London DYAA

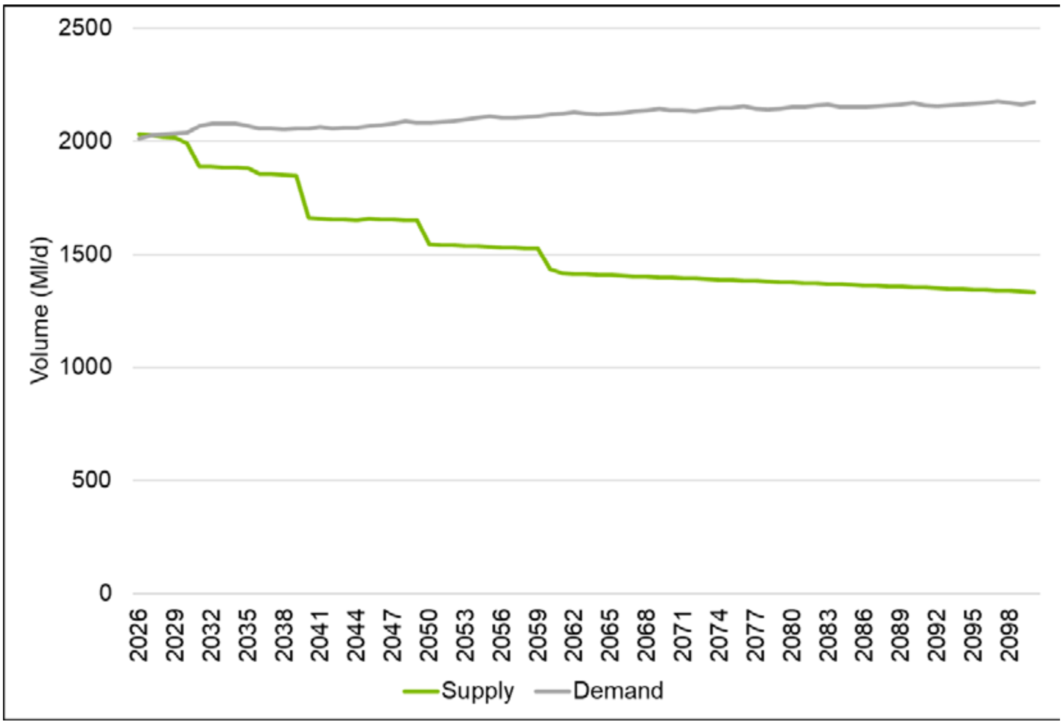


Figure 6 - 29: Baseline Supply-demand Balance for Situation 4, London DYAA, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | -153 | -195 | -362 | -531 | -623 |
| WRMP24 | +19 | -46 | -409 | -762 | -840 |

Table 6 - 25: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for London WRZ DYAA. Note: In order to provide a like-for-like comparison, benefits associated with Media Campaigns, TUBs and NEUBs are included for WRMP24

## SWOX DYAA

6.258 The tables below show that Environmental Destination and demand are the largest uncertainties associated with SWOX's DYAA supply-demand balance.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 265 | 276 | 296 | 300 | 315 |

Table 6 - 26: SWOX DYAA Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | -11.5 | -6.9 | -4.7 |

Table 6 - 27: SWOX DYAA Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -59 | -32 | -13 |

Table 6 - 28: SWOX DYAA Environmental Destination Impact Scenarios

6.259 Figure 6 - 30 and Figure 6 - 32 show that SWOX is forecast to begin in a position of deficit for the DYAA planning scenario. It is important to note that this is only due to the removal of the benefits associated with media campaigns, TUBs, and NEUBs, and that when these benefits are included we see our supply-demand balance start in a position of surplus, as shown in Figure 6 - 31 and Figure 6 - 33.

6.260 We see a surplus in SWOX during AMP8, but a transition to deficit during the early 2030s, when we move to 1 in 200-year resilience.

6.261 When our supply-demand balances branch into three, we see a moderate gap of around 20 Ml/d between the most and least favourable supply-demand balances.

6.262 When our supply-demand balances branch into 9, we see a much more significant variation between future supply-demand balance positions, particularly after 2050 when Environmental Destination DO reductions are accounted for. The gap between the most challenging and least challenging supply-demand balances is almost 100 Ml/d by 2050, which equates to around a third of the supplies in the zone at present. As was the case for London, branches 1, 4, and 7 are the most challenging in the long term. The scale of difference between scenarios 4 and 6 is notable, with a gap of around 50 Ml/d from 2050 onwards. This again shows that the 'High' Environmental Destination scenario is likely to have a major influence on our adaptive solution, because the long-term planning problem is made very severe by needing to account for this potential future.

6.263 In our forecast for scenario 4, we see deficits, when accounting for benefits from TUBs and NEUBs of 16 Ml/d after our move to 1 in 200-year resilience, 29 Ml/d after moving to 1 in 500-year resilience, 72 Ml/d after Environmental Destination DO reductions are accounted for, and 86 Ml/d by the end of the planning period.

6.264 When compared to our WRMP19 baseline supply-demand balance our initial position, our initial supply-demand balance is initially slightly improved due to our AMP7 demand programme. A demand forecast which grows more quickly than our WRMP19 forecast means that this initial gap is closed by 2030, and as this increased growth and 1 in 500-year resilience are accounted for we have a 37 Ml/d greater planning problem by 2045 than was forecast in WRMP19. The size of the baseline deficit forecast continues to increase above that forecast in WRMP19 in the longer term and as significant licence reductions are accounted for.

6.265 As the next section will show, the influence of environmental destination, and the greater benefit that TUBs and NEUBs are assumed to bring during the 'critical period' mean that SWOX has become a zone where the DYAA planning scenario is the more challenging planning scenario, a change compared to WRMP19.

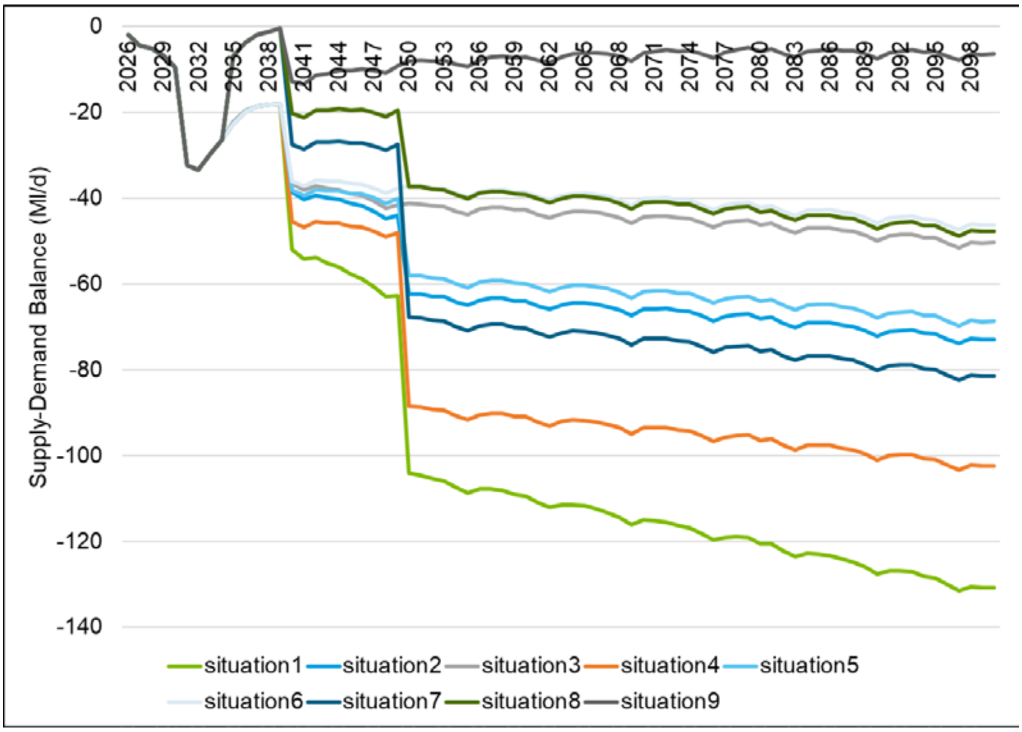


Figure 6 - 30: Supply-demand balances of 9 Branches for SWOX DYAA Scenario

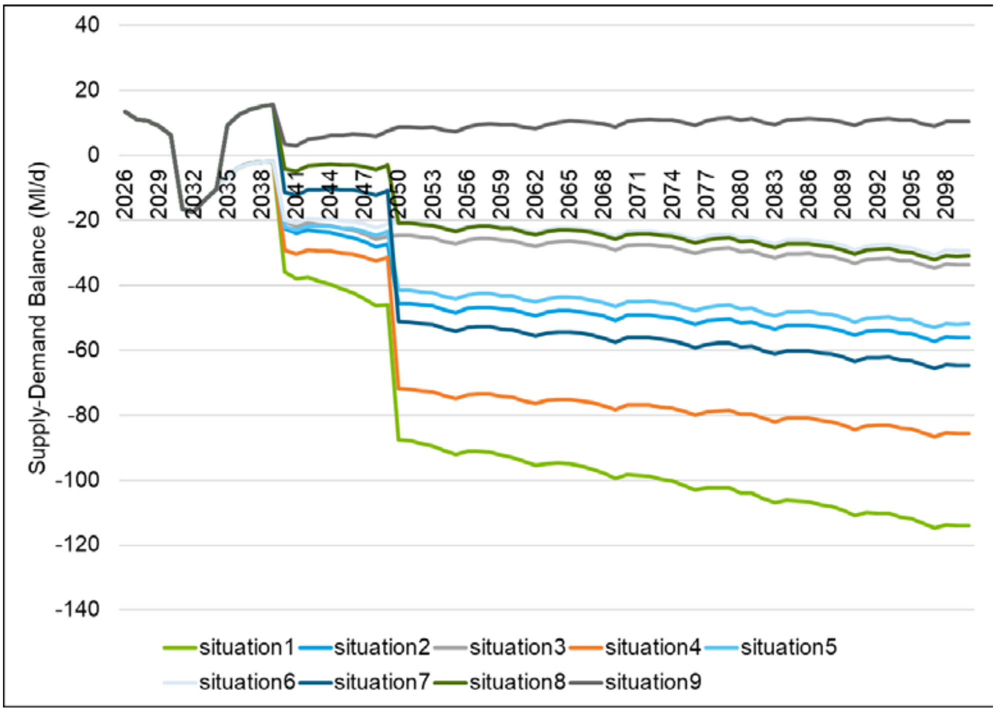


Figure 6 - 31: Supply-demand balances of 9 Branches for SWOX DYAA Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

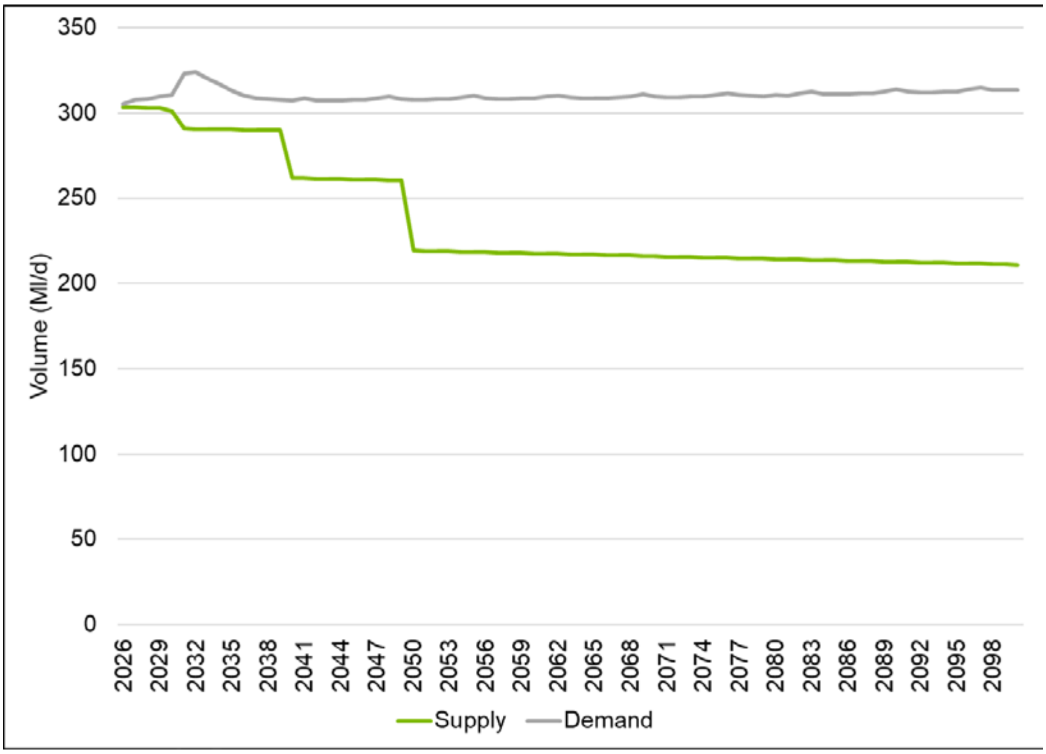


Figure 6 - 32: Baseline Supply-demand Balance for Situation 4, SWOX DYAA

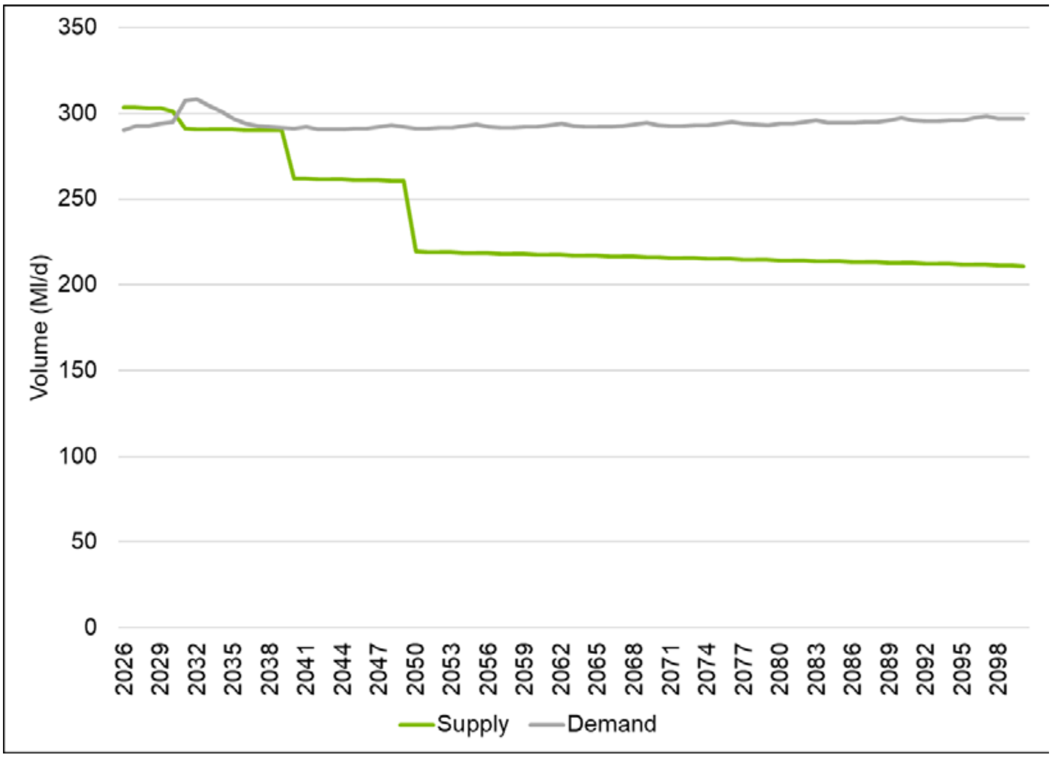


Figure 6 - 33: Baseline Supply-demand Balance for Situation 4, SWOX DYAA, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +9 | +6 | +8 | +9 | +4 |
| WRMP24 | +14 | +6 | -29 | -79 | -86 |

Table 6 - 29: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for SWOX WRZ DYAA. Note: In order to provide a like-for-like comparison, benefits associated with Media Campaigns, TUBs and NEUBs are included for WRMP24

## SWOX DYCP

6.266 The tables below show that demand is the most important future uncertainty for the SWOX WRZ's DYCP scenario.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 321 | 332 | 354 | 358 | 373 |

Table 6 - 30: SWOX DYCP Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | -3.8 | -3.5 | -0.5 |

Table 6 - 31: SWOX DYCP Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -23 | -18 | -13 |

Table 6 - 32: SWOX DYCP Environmental Destination Impact Scenarios

6.267 Figure 6 - 34, Figure 6 - 35, and Figure 6 - 36 show that the SWOX DYCP scenario beings in a position of surplus. This surplus is maintained until 2040 in all scenarios, or (almost) throughout the planning period in every scenario if the benefits of TUBs and NEUBs are accounted for.

6.268 Many of the future supply-demand balance scenarios for the SWOX DYCP scenario sit within a fairly narrow range, with the difference between the second-most challenging and second-least challenging scenarios being around 30 Ml/d. Scenarios 1 and 9 are significantly different to all other scenarios, with very high and very low demand forecasts being included in these scenarios respectively.

6.269 When compared with WRMP19, our reduced allowance for outage during the DYCP planning scenario and increased assessment of SWOX's DYCP DO, along with our AMP7 demand management programme, give us a significant improved supply-demand balance at the beginning of the planning period in branch 4. Sustainability reductions and a higher demand forecast in the Local Authority plan-based demand forecast result in a more challenging supply-demand position than WRMP19 in the long term. When the large benefit of TUBs and NEUBs in the DYCP scenario is accounted for, we see surplus throughout the planning period for the SWOX DYCP scenario.

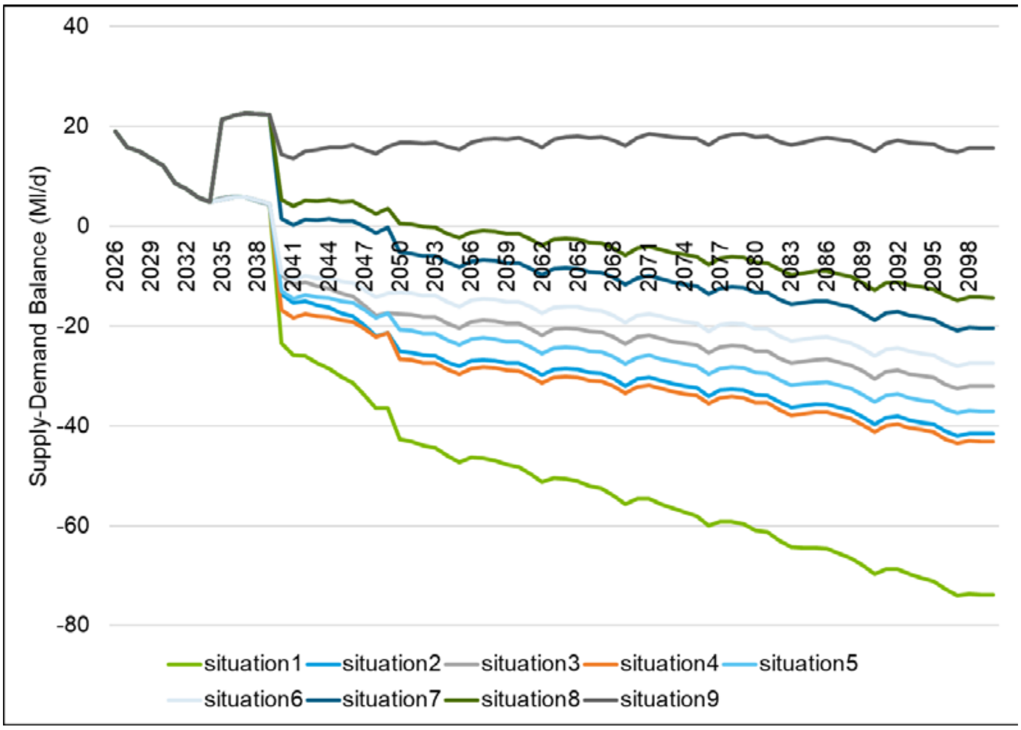


Figure 6 - 34: Supply-demand balances of 9 Branches for SWOX DYCP Scenario

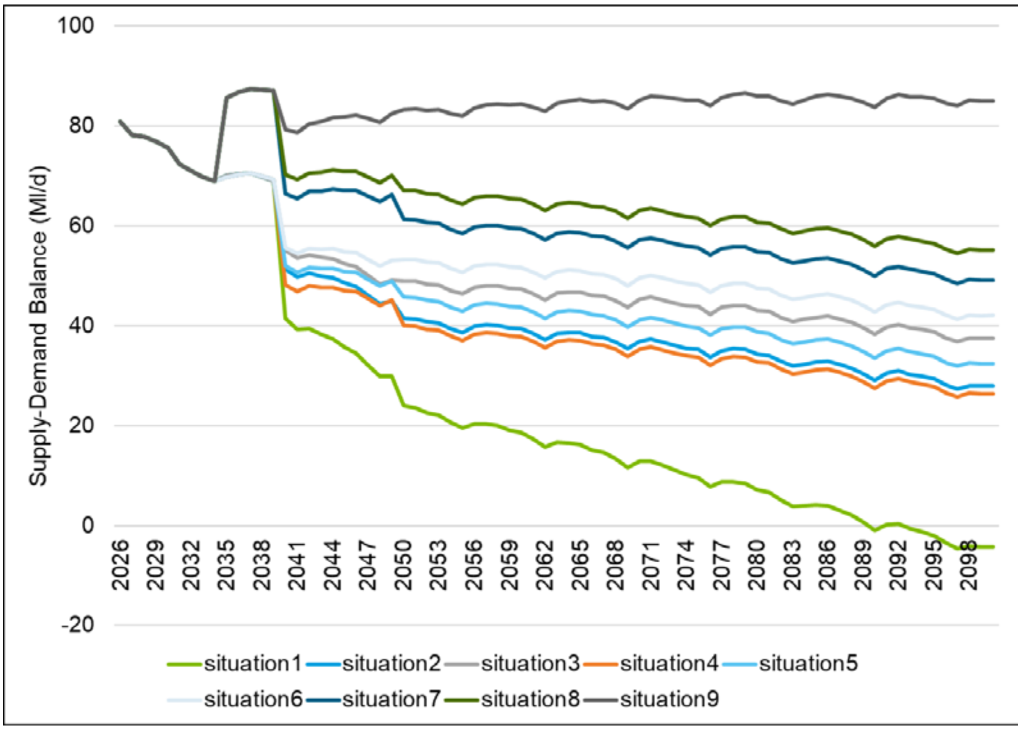


Figure 6 - 35: Supply-demand balances of 9 Branches for SWOX DYCP Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

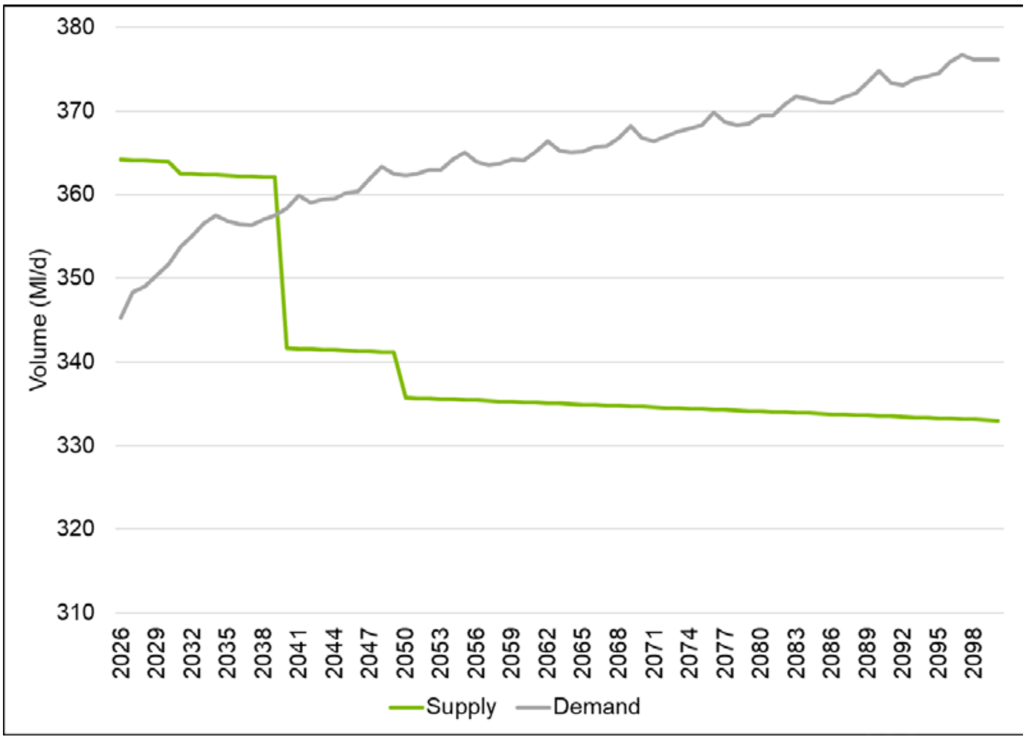


Figure 6 - 36: Baseline Supply-demand Balance for Situation 4, SWOX DYCP

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | -3 | -7 | -11 | -18 | -31 |
| WRMP24 | +19 | +12 | -19 | -34 | -43 |

Table 6 - 33: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for SWOX WRZ DYCP

### SWA DYAA

6.270 The tables below show that the High Environmental Destination scenario poses the largest source of uncertainty for the SWA DYAA supply-demand balance. Demand uncertainty also poses a fairly significant uncertainty, while the impact of climate change is small in all scenarios due to the WRZ's supplies being dominated by drought-resilient groundwater sources.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 136 | 142 | 155 | 159 | 170 |

Table 6 - 34: SWA DYAA Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | -0.4 | -0.2 | -0.1 |

Table 6 - 35: SWA DYAA Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -46.1 | -11.1 | -9.1 |

Table 6 - 36: SWA DYAA Environmental Destination Impact Scenarios

6.271 Our SWA DYAA planning scenario begins with a position of surplus which is maintained in all scenarios until 2040, or until 2050 if TUBs and NEUBs are accounted for.

6.272 Prior to DO reductions associated with Environmental Destination forecasts, the gap between different scenarios is modest, with a gap of around 20 Ml/d between the most and least challenging scenarios by 2040.

6.273 As with other zones, the 'High' Environmental Destination scenario results in scenarios 1, 4, and 7 being the most challenging in the long term. There is a gap of around 35 Ml/d between scenarios 4 and 6 from 2050 onwards. It is likely that no investment will be required in new sources in all scenarios apart from 'High' Environmental Destination scenarios.

6.274 Compared to WRMP19, scenario 4 begins with a reduced surplus, due to DO reductions. Sustainability reductions in 2040 and 2050 then leave this scenario with a larger planning problem than WRMP19 in the long term.

6.275 As with SWOX, the greater influence of Environmental Destination licence reductions on the DYAA scenario than DYCP and the larger benefits associated with TUBs and NEUBs in the DYCP scenario mean the DYAA planning scenario is likely to be more challenging than the DYCP scenario for SWA.

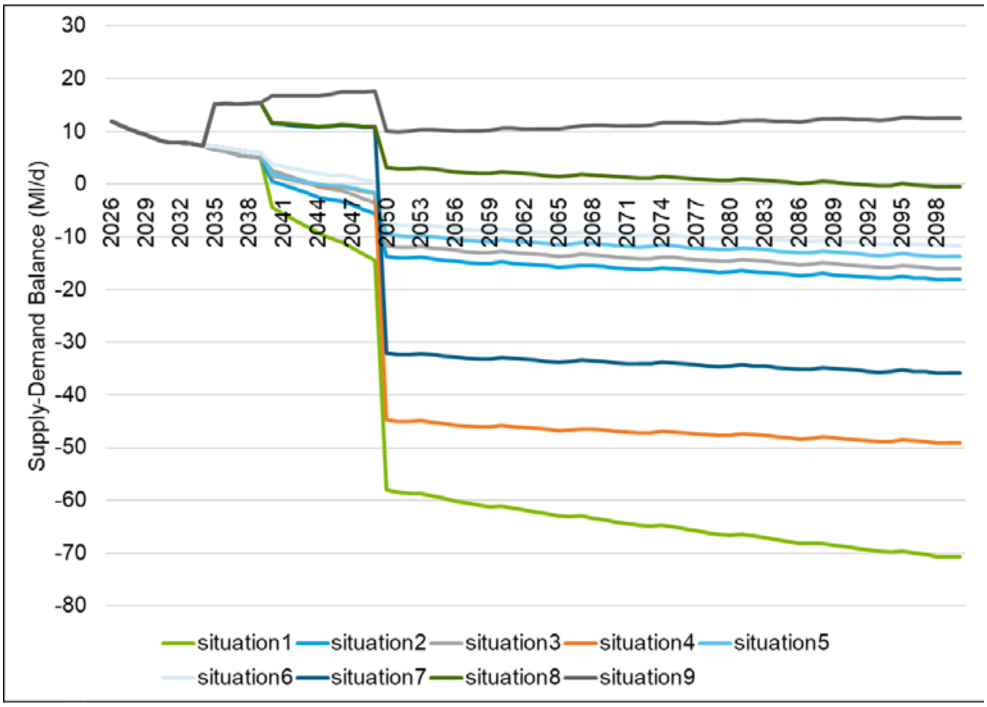


Figure 6 - 37: Supply-demand balances of 9 Branches for SWA DYAA Scenario

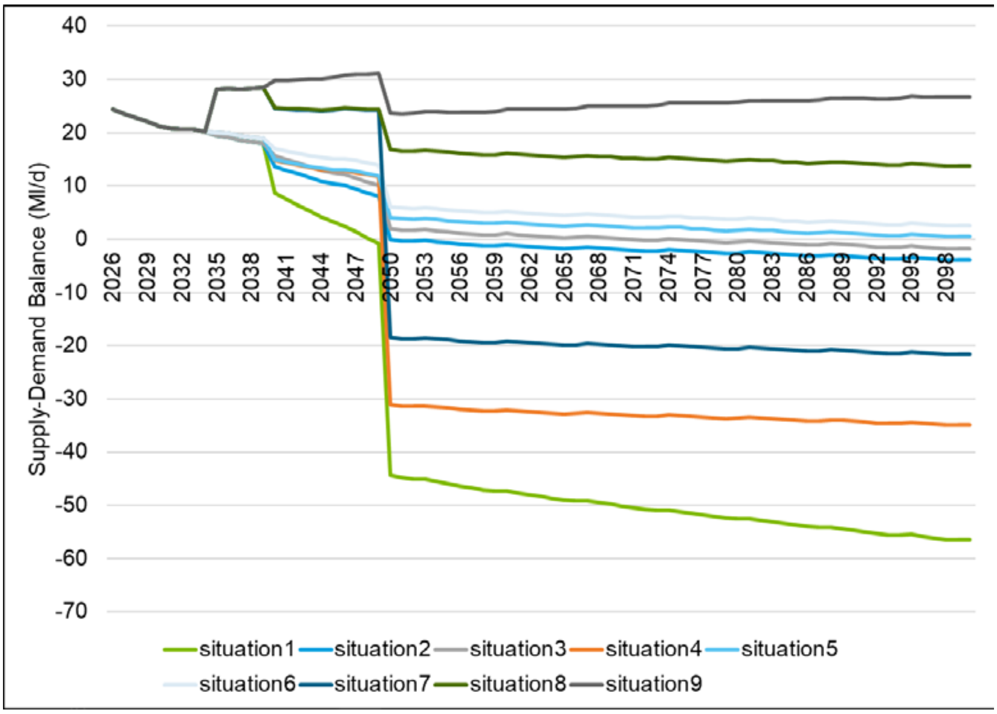


Figure 6 - 38: Supply-demand balances of 9 Branches for SWA DYAA Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

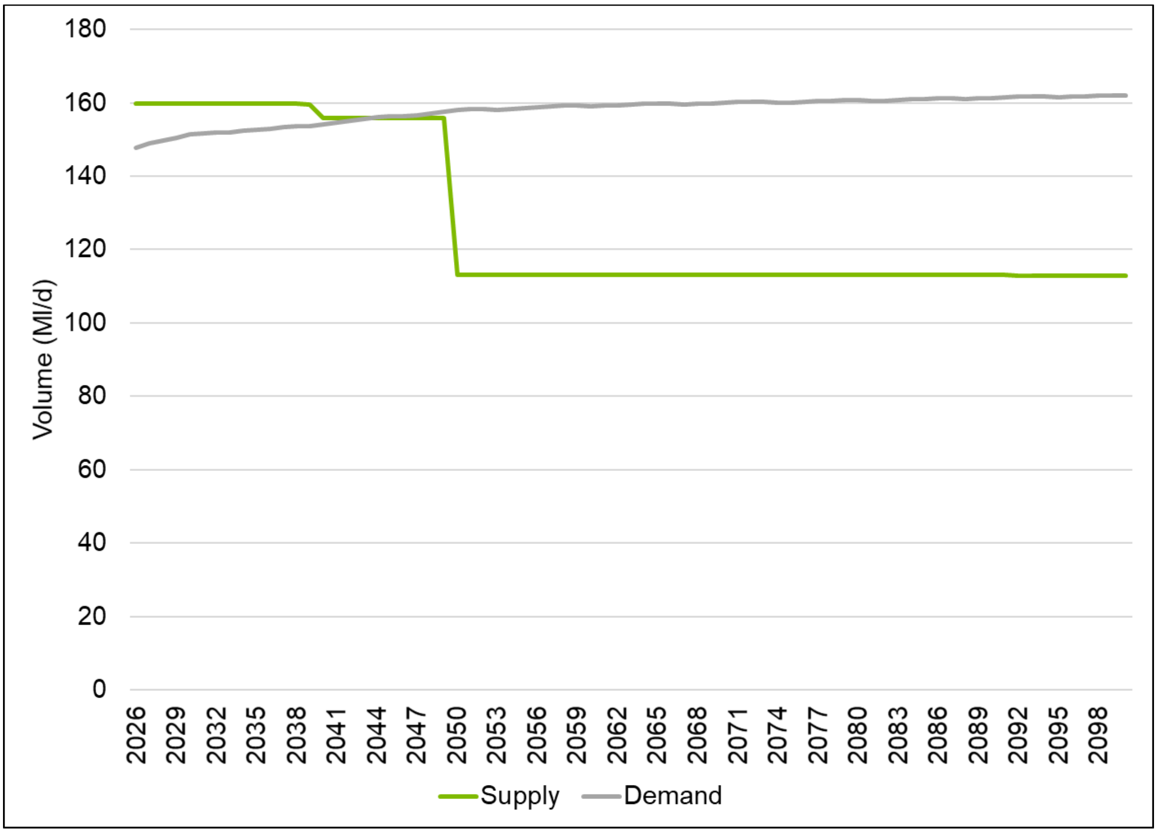


Figure 6 - 39: Baseline Supply-demand Balance for Situation 4, SWA DYAA

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +20 | +19 | +15 | +13 | +7 |
| WRMP24 | +12 | +8 | -0.5 | -47 | -49 |

Table 6 - 37: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for SWA WRZ DYAA

## SWA DYCP

6.276 The tables below show that the High Environmental Destination scenario and demand uncertainty pose significant uncertainty to the SWA DYCP supply-demand balance, while climate change impacts are minor.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 163 | 170 | 183 | 187 | 199 |

Table 6 - 38: SWA DYCP Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | -0.4 | -0.2 | 0 |

Table 6 - 39: SWA DYCP Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -44.6 | -15.8 | -13.8 |

Table 6 - 40: SWA DYCP Environmental Destination Impact Scenarios

6.277 Our SWA DYCP planning scenario begins with a position of surplus which is maintained in all scenarios until 2040, or until 2050 if TUBs and NEUBs are accounted for.

6.278 Prior to DO reductions associated with Environmental Destination forecasts, the gap between different scenarios is modest, with a gap of around 20 Ml/d between the most and least challenging scenarios by 2040.

6.279 As with other zones, the 'High' Environmental Destination scenario results in scenarios 1, 4, and 7 being the most challenging in the long term. There is a gap of around 30 Ml/d between scenarios 4 and 6 from 2050 onwards. It is likely that no investment will be required in new sources in all scenarios apart from 'High' Environmental Destination scenarios.

6.280 Compared to WRMP19, scenario 4 begins with an improved surplus, due to a reduced allowance for outage in the DYCP scenario. Sustainability reductions in 2040 and 2050 then leave this scenario with a planning problem that is much greater than was present in WRMP19 in the long term. When TUBs and NEUBs are accounted for, scenario 4 shows a position of surplus throughout the planning period.

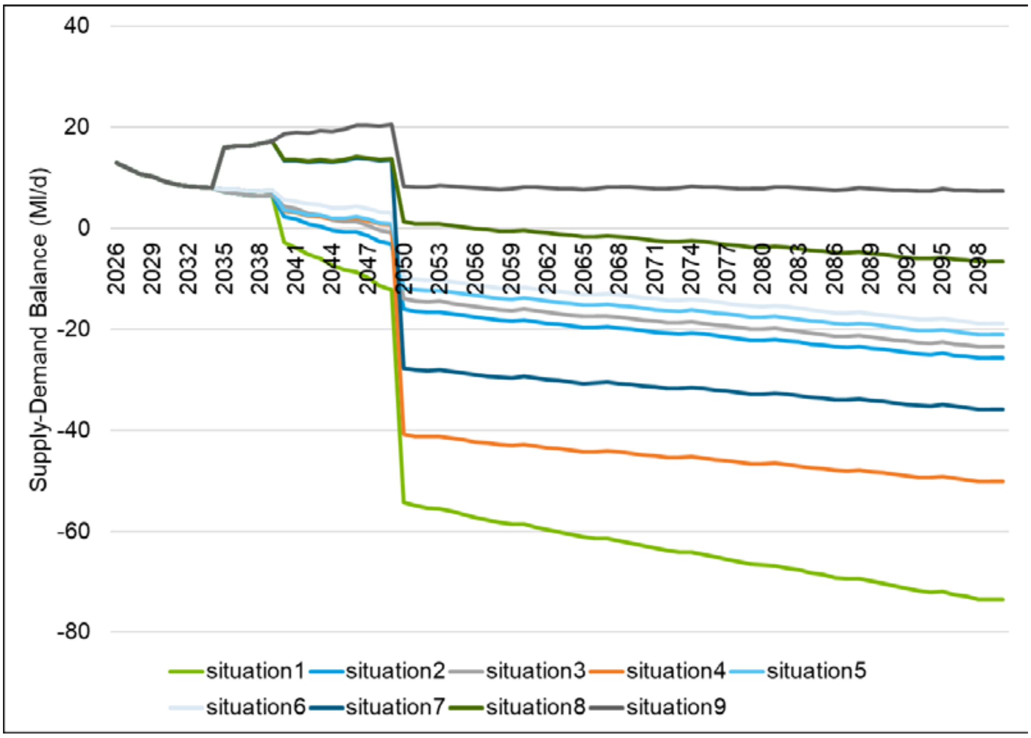


Figure 6 - 40: Supply-demand balances of 9 Branches for SWA DYCP Scenario

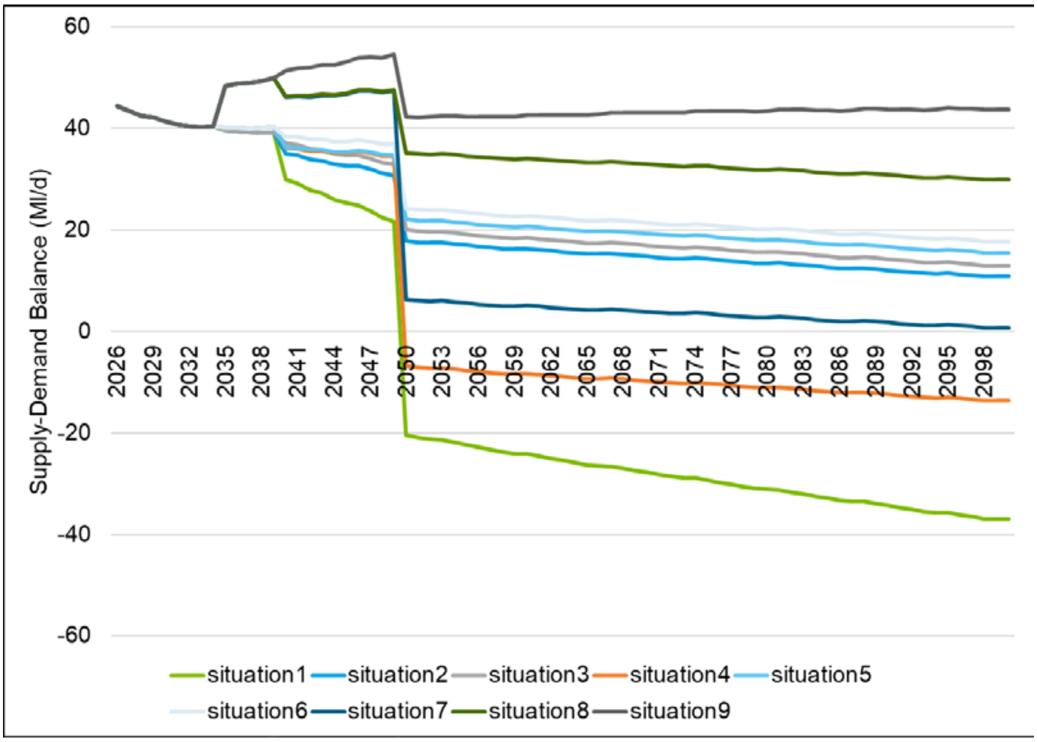


Figure 6 - 41: Supply-demand balances of 9 Branches for SWA DYCP Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

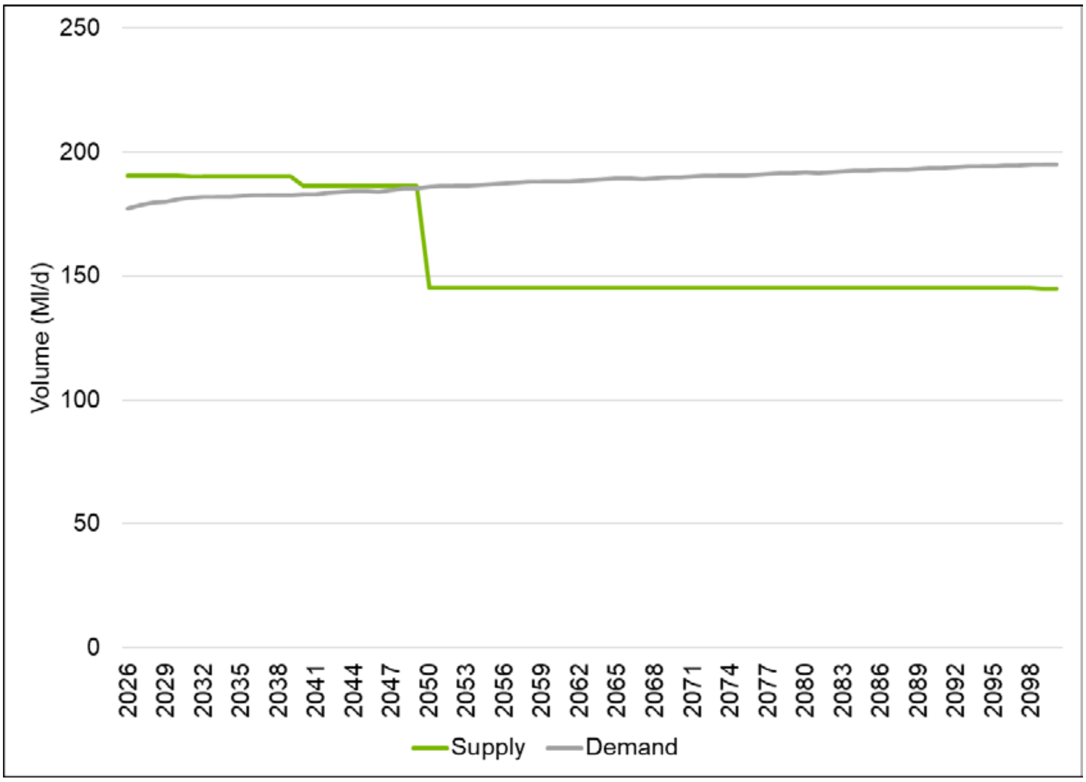


Figure 6 - 42: Baseline Supply-demand Balance for Situation 4, SWA DYCP

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +3 | +1 | -6 | -12 | -21 |
| WRMP24 | +13 | +9 | +2 | -45 | -50 |

Table 6 - 41: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for SWA WRZ DYCP

## Kennet Valley DYAA

6.281 The tables below show that Environmental Destination is the largest uncertainty for the Kennet Valley DYAA scenario, with demand uncertainty and climate change posing a smaller range of uncertainty.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 91 | 95 | 102 | 101 | 107 |

Table 6 - 42: Kennet Valley DYAA Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | -1.7 | -1.3 | -1.0 |

Table 6 - 43: Kennet Valley DYAA Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -29.4 | -6.6 | -6.6 |

Table 6 - 44: Kennet Valley DYAA Environmental Destination Impact Scenarios

6.282 The Kennet Valley DYAA scenario shows a position of surplus at the beginning of the planning period. Drops in the supply-demand balance can be seen in all scenarios at 2030 and 2040, due to the moves to 1 in 200-year and 1 in 500-year resilience respectively. The Fobney run-of-river source's DO is significantly reduced in severe drought conditions.

6.283 Differences between demand forecasts result in a moderate variance between different forecast supply-demand balance positions by 2040, with the gap between the most and least challenging positions being around 20 Ml/d by 2040.

6.284 Environmental Destination again results in a large gap between supply-demand balance forecasts in the long term. The gap between scenarios 4 and 6 is a little over 20 Ml/d by 2050. The scale of deficit in 'High' Environmental Destination scenarios is likely to result in a significant need for new sources in the zone.

6.285 When compared to WRMP19, situation 4 has a very similar starting supply-demand balance position. The impact of considering 1 in 500-year drought reduces the zone's DO significantly compared to our WRMP19 forecast, resulting in a much larger planning problem in the long term.

6.286 As with other zones, the greater influence of Environmental Destination licence reductions on the DYAA scenario than DYCP and the larger benefits associated with TUBs and NEUBs in the DYCP scenario mean the DYAA planning scenario is likely to be more challenging than the DYCP scenario for Kennet Valley.

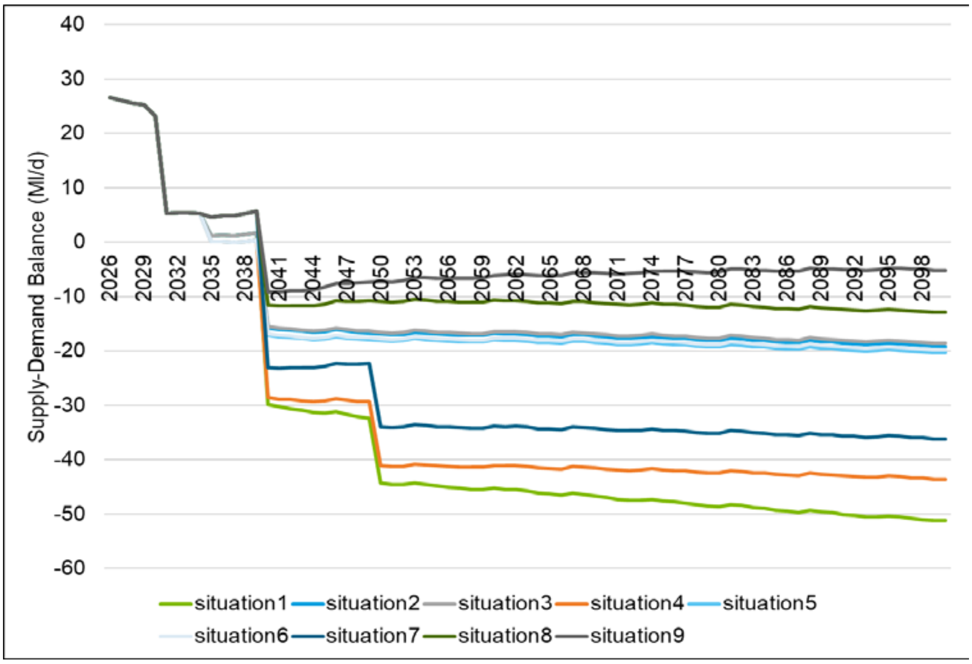


Figure 6 - 43: Supply-demand balances of 9 Branches for Kennet Valley DYAA Scenario

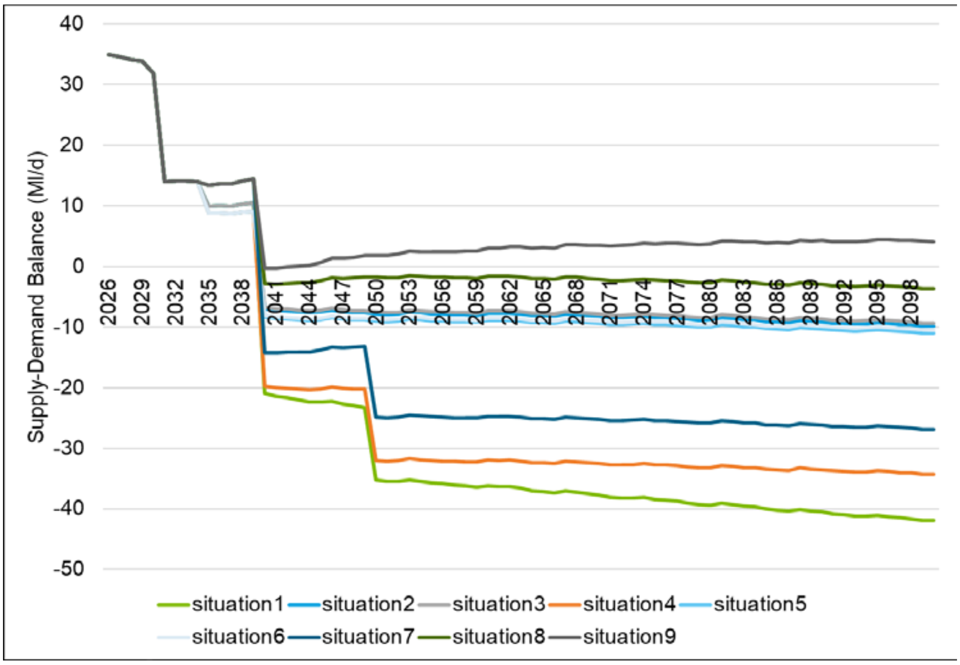


Figure 6 - 44: Supply-demand balances of 9 Branches for Kennet Valley DYAA Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

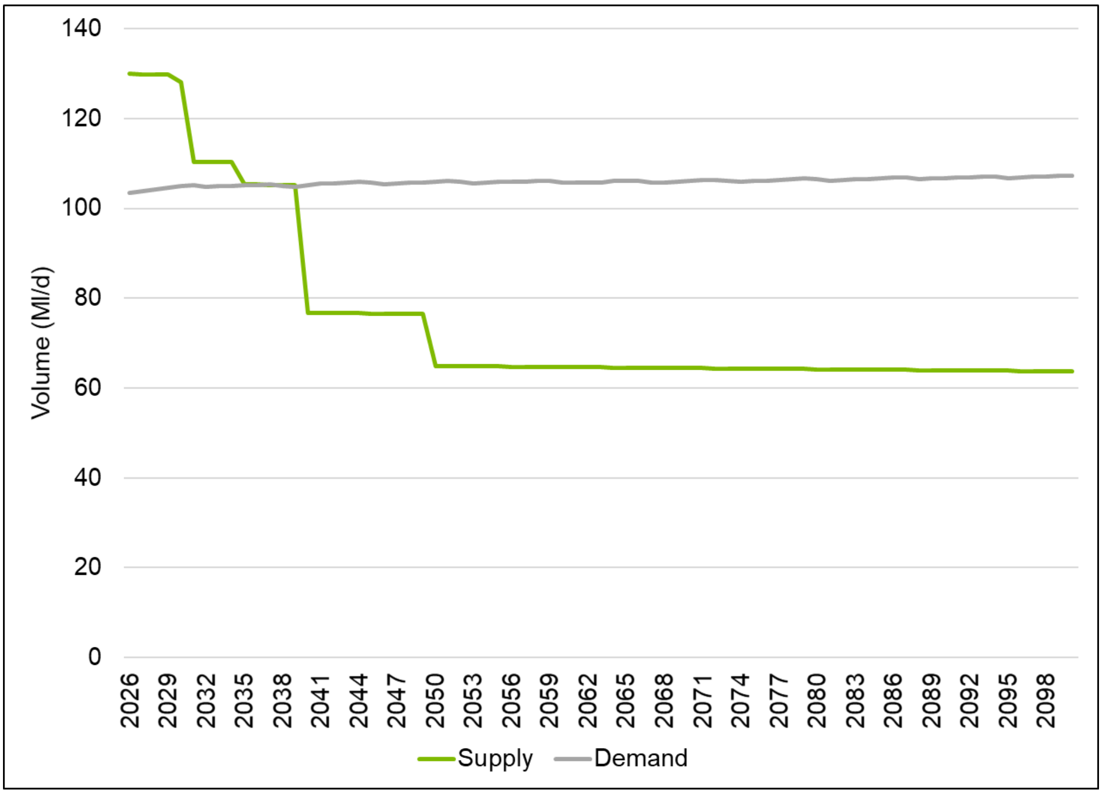


Figure 6 - 45: Baseline Supply-demand Balance for Situation 4, Kennet Valley DYAA

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +28 | +26 | +24 | +21 | +16 |
| WRMP24 | +27 | +23 | -29 | -42 | -44 |

Table 6 - 45: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for Kennet Valley WRZ DYAA

### Kennet Valley DYCP

6.287 The tables below show that Environmental Destination is the largest uncertainty for the Kennet Valley DYCP scenario, with demand uncertainty and climate change posing a smaller range of uncertainty.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 109 | 113 | 121 | 119 | 125 |

Table 6 - 46: Kennet Valley DYCP Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | -1.4 | -0.9 | -0.5 |

Table 6 - 47: Kennet Valley DYCP Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -30.3 | -6.6 | -6.6 |

Table 6 - 48: Kennet Valley DYCP Environmental Destination Impact Scenarios

6.288 The Kennet Valley DYCP scenario shows a position of surplus at the beginning of the planning period. Drops in the supply-demand balance can be seen in all scenarios at 2030 and 2040, due to the moves to 1 in 200-year and 1 in 500-year resilience, respectively. The Fobney run-of-river source's DO is significantly reduced in severe drought conditions.

6.289 Differences between demand forecasts result in a moderate variance between different forecast supply-demand balance positions by 2040, with the gap between the most and least challenging positions being around 20 Ml/d by 2040.

6.290 Environmental Destination again results in a large gap between supply-demand balance forecasts in the long term. The gap between scenarios 4 and 6 is a little over 20 Ml/d by 2050.

6.291 When compared to WRMP19, situation 4 has a slightly improved starting supply-demand balance position. The impact of considering 1 in 500-year drought reduces the zone's DO significantly compared to our WRMP19 forecast, resulting in a much larger planning problem in the long term, including the appearance of deficits where our WRMP19 forecast surplus throughout the planning period.

6.292 As with other zones, the larger benefits associated with TUBs and NEUBs in the DYCP scenario mean the DYAA planning scenario is likely to be more challenging than the DYCP scenario for Kennet Valley.

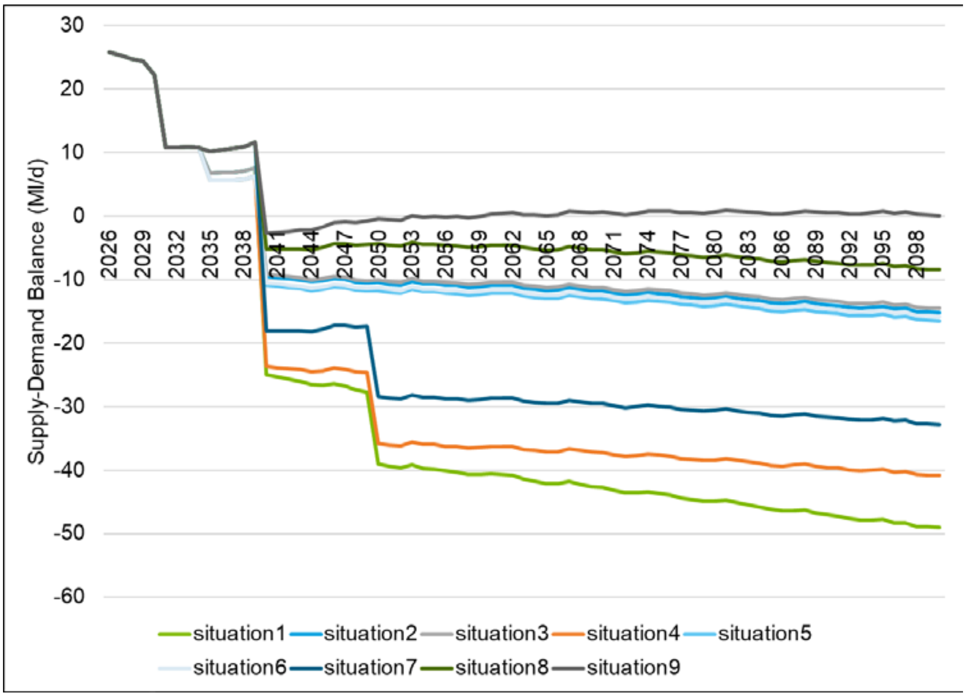


Figure 6 - 46: Supply-demand balances of 9 Branches for Kennet Valley DYCP Scenario

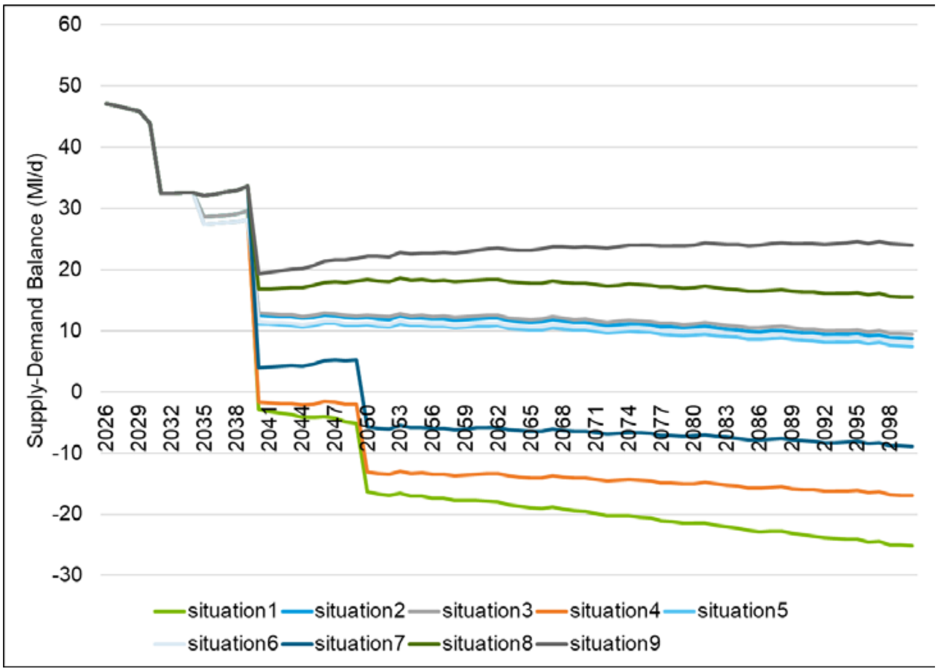


Figure 6 - 47: Supply-demand balances of 9 Branches for Kennet Valley DYCP Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

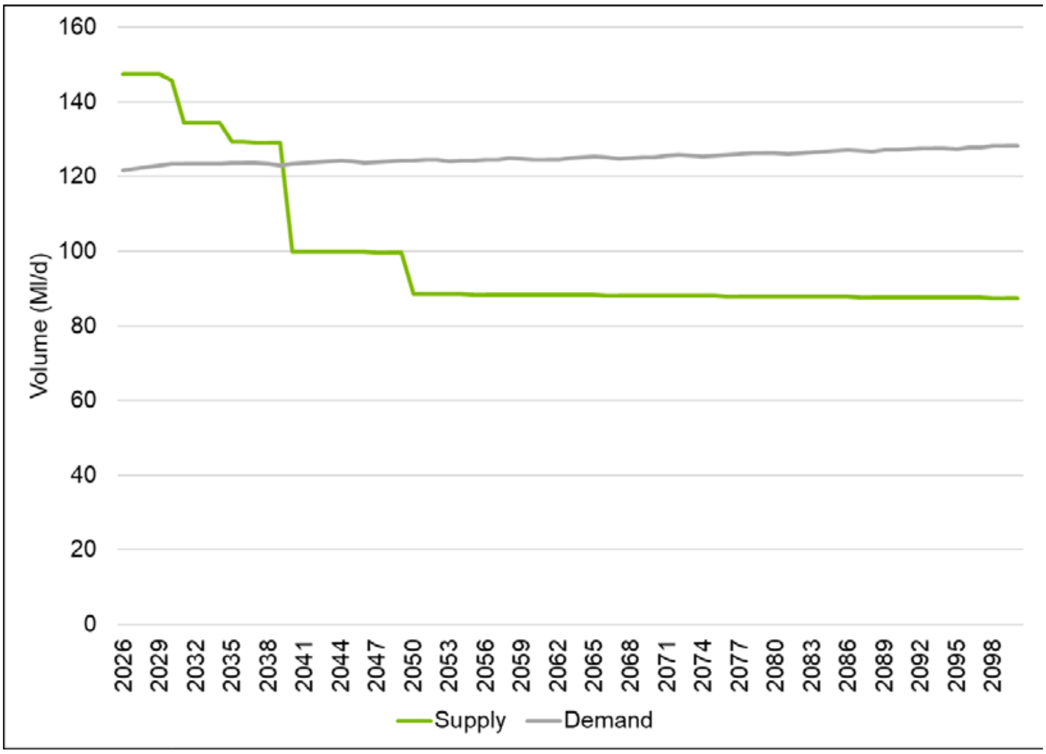


Figure 6 - 48: Baseline Supply-demand Balance for Situation 4, Kennet Valley DYCP

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +18 | +16 | +12 | +8 | +1 |
| WRMP24 | +26 | +22 | -24 | -38 | -41 |

Table 6 - 49: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for Kennet Valley WRZ DYCP

## Guildford DYAA

6.293 The tables below show that Environmental Destination poses by far the largest uncertainty to the future supply-demand balance, with the 'High' scenario resulting in almost half of the zone's DO being lost. In comparison, demand uncertainty is a relatively minor factor. Climate change does not pose a risk to the Guildford WRZ according to our analysis.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 40.9 | 42.6 | 47.2 | 47.2 | 47.3 |

Table 6 - 50: Guildford DYAA Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | 0 | 0 | 0 |

Table 6 - 51: Guildford DYAA Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -30 | -4.5 | -1.2 |

Table 6 - 52: Guildford DYAA Environmental Destination Impact Scenarios

6.294 The Guildford DYAA supply-demand balance starts in a position of surplus. There is little change in the supply-demand balance position, and little gap between different scenarios, until 2040, at which point the differences in demand and Environmental Destination forecasts give a larger variance.

6.295 Both with and without accounting for the benefits associated with TUBs and NEUBs, deficits are only present in scenarios 1, 4, and 7, again showing that the High Environmental Destination scenario will drive different investment decisions to all other scenarios.

6.296 When compared to WRMP19, scenario 4 starts in a slightly improved supply-demand balance position. This improved position is maintained until licence reductions are made under the High Environmental Destination.

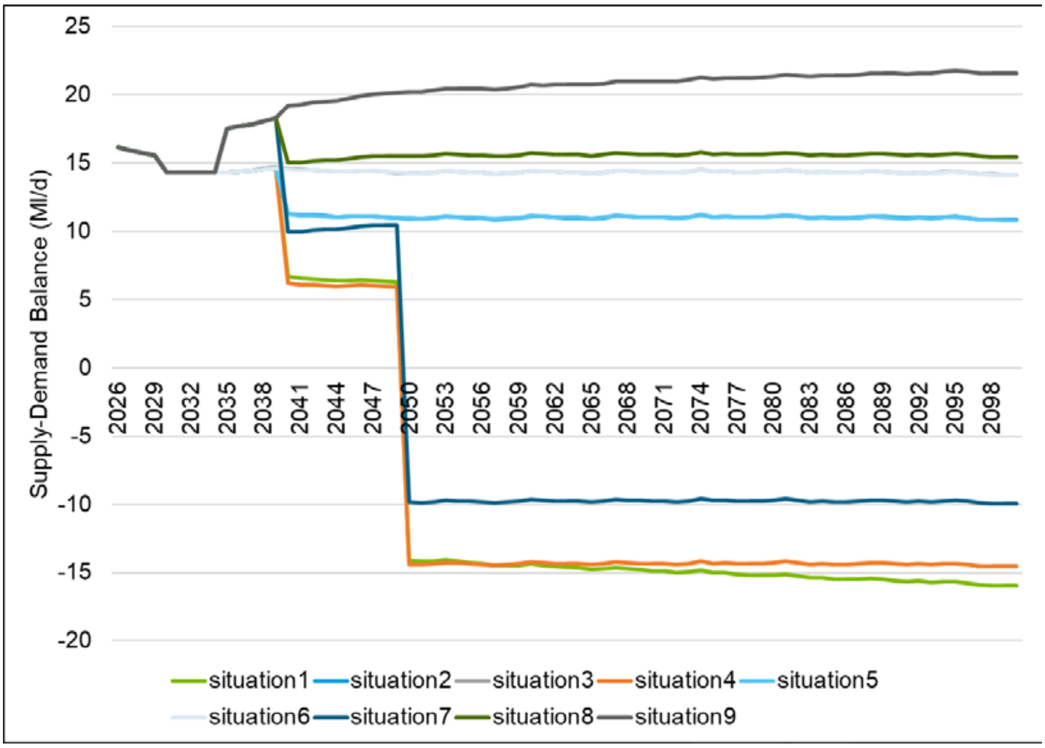


Figure 6 - 49: Supply-demand balances of 9 Branches for Guildford DYAA Scenario

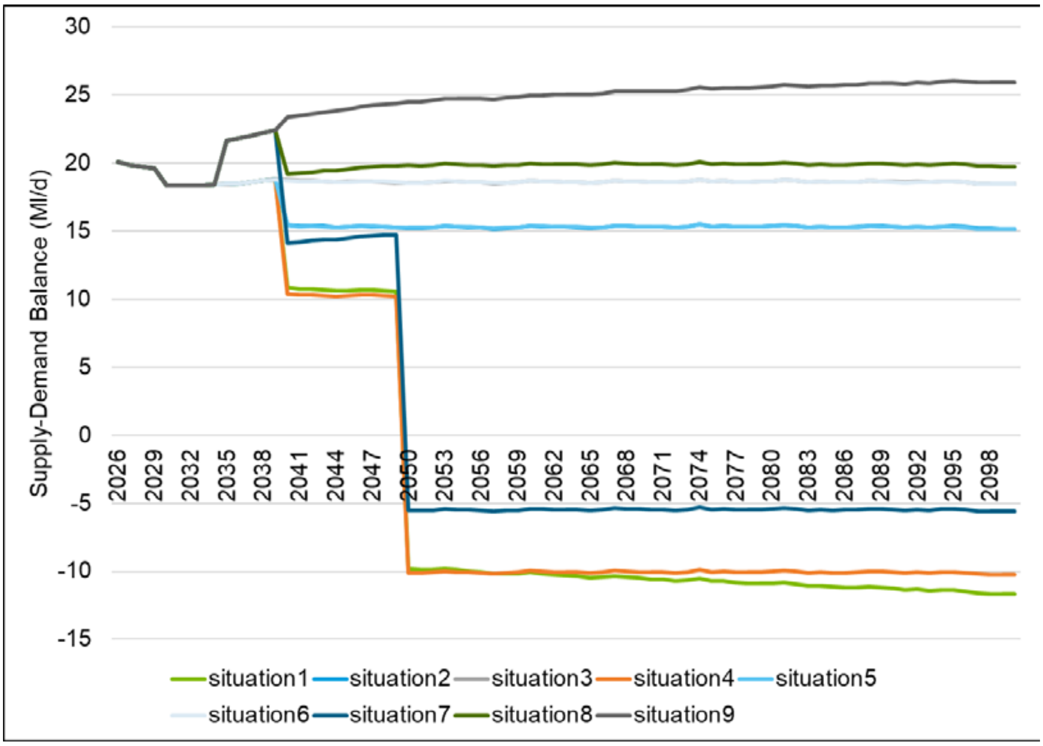


Figure 6 - 50: Supply-demand balances of 9 Branches for Guildford DYAA Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

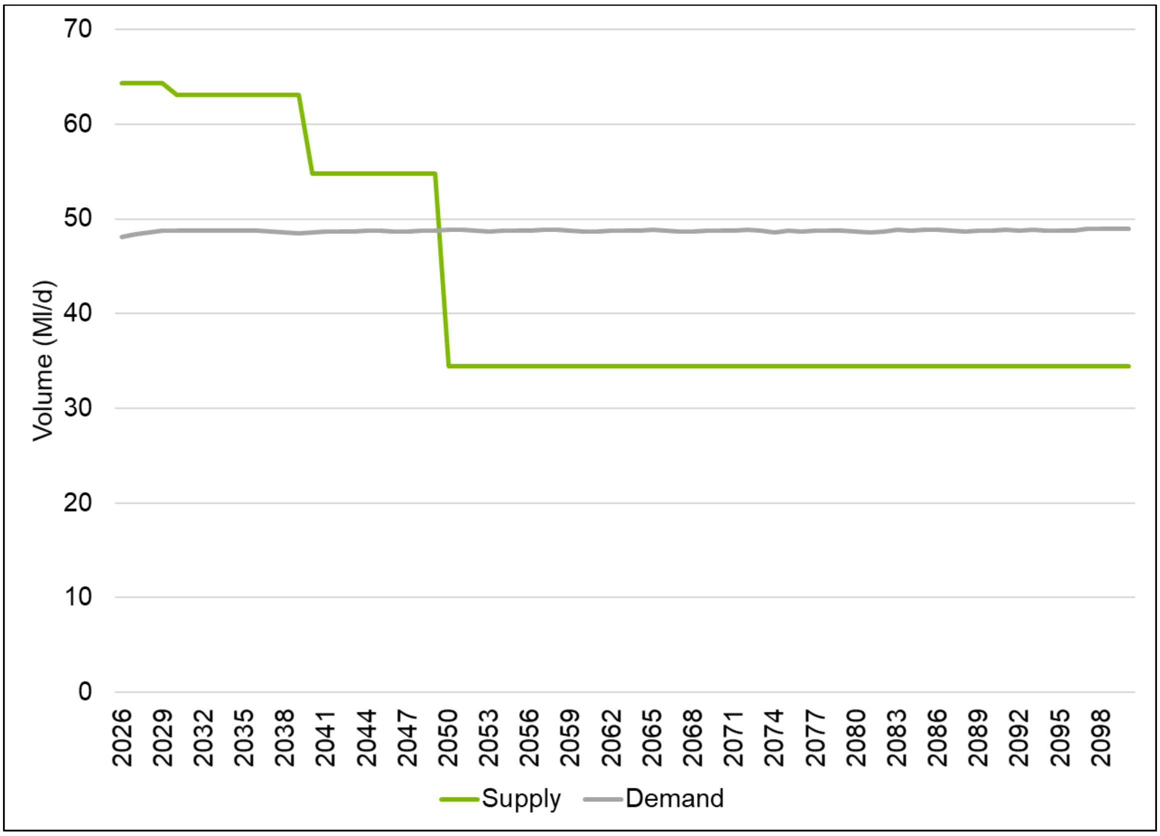


Figure 6 - 51: Baseline Supply-demand Balance for Situation 4, Guildford DYAA

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +12 | +11 | +8 | +7 | +6 |
| WRMP24 | +16 | +14 | +6 | -14 | -15 |

Table 6 - 53: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for Guildford WRZ DYAA

## Guildford DYCP

6.297 The tables below show that Environmental Destination poses by far the largest uncertainty to the future supply-demand balance. In comparison, demand uncertainty is a relatively minor factor. Climate change does not pose a risk to the Guildford WRZ according to our analysis.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 54.3 | 56.1 | 60.8 | 60.9 | 61.3 |

Table 6 - 54: Guildford DYCP Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | 0 | 0 | 0 |

Table 6 - 55: Guildford DYCP Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -28.2 | -5.3 | 0 |

Table 6 - 56: Guildford DYCP Environmental Destination Impact Scenarios

6.298 The Guildford DYCP supply-demand balance starts in a position of surplus. There is little change in the supply-demand balance position, and little gap between different scenarios, until 2040, at which point the differences in demand and Environmental Destination forecasts give a larger variance.

6.299 Without accounting for the benefits associated with TUBs and NEUBs, deficits are only present in scenarios 1, 4, and 7, while when accounting for these benefits deficits are only present in scenarios 1 and 4.

6.300 When compared to WRMP19, scenario 4 starts in a significantly improved supply-demand balance position, and this improved position is maintained until licence reductions under the High Environmental Destination scenario are made. This difference is mainly due to a difference in the demand forecast for the zone.

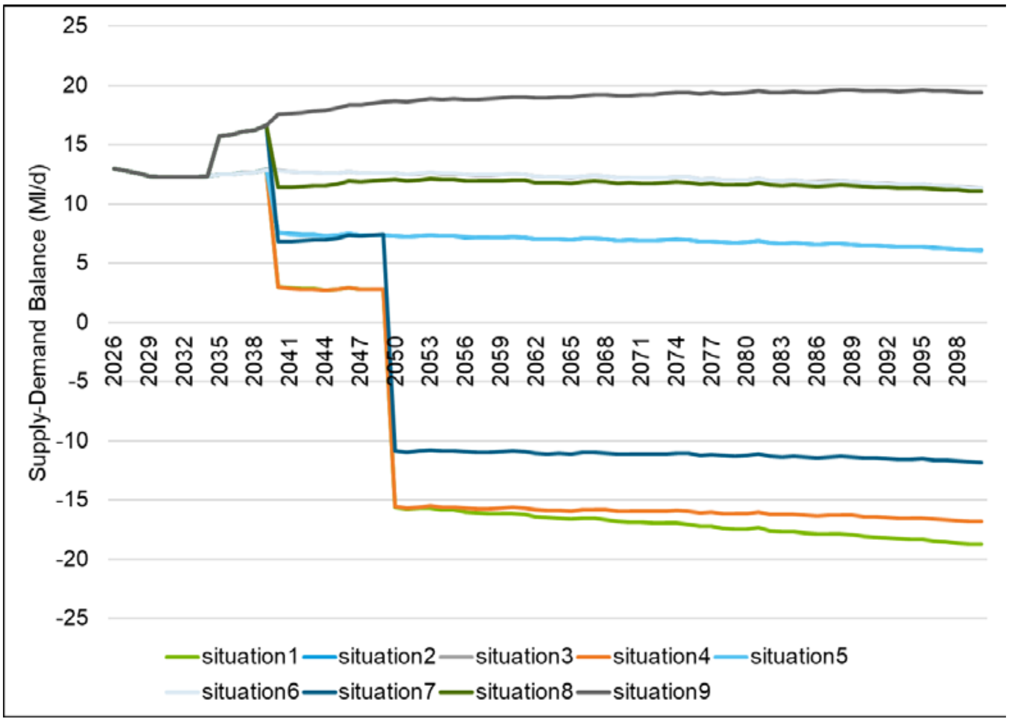


Figure 6 - 52: Supply-demand balances of 9 Branches for Guildford DYCP Scenario

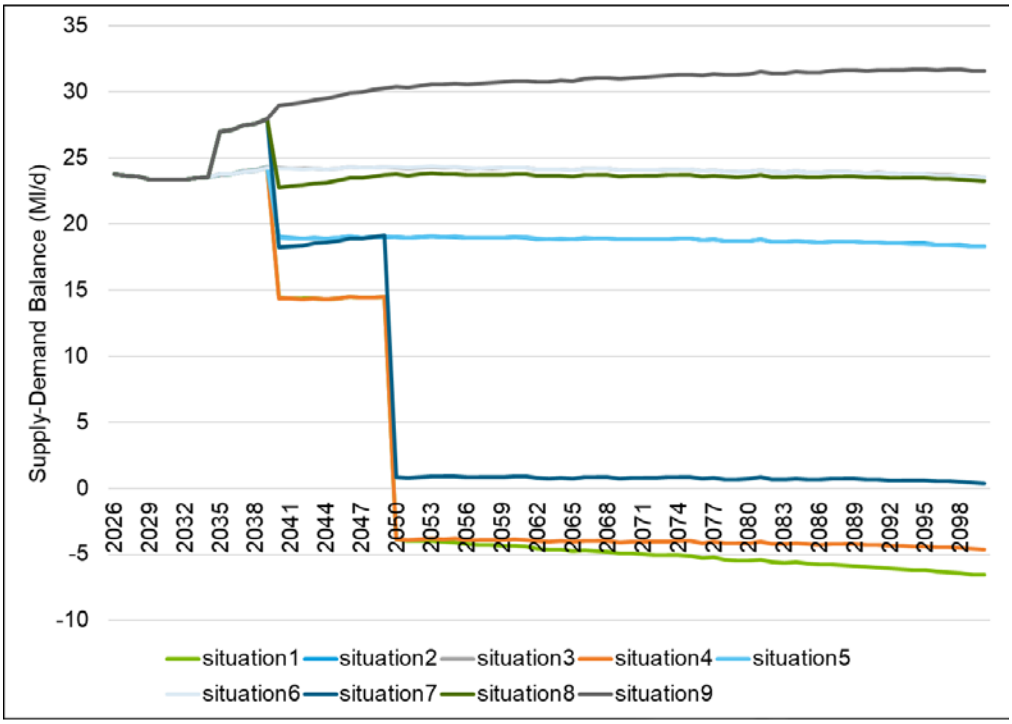


Figure 6 - 53: Supply-demand balances of 9 Branches for Guildford DYCP Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

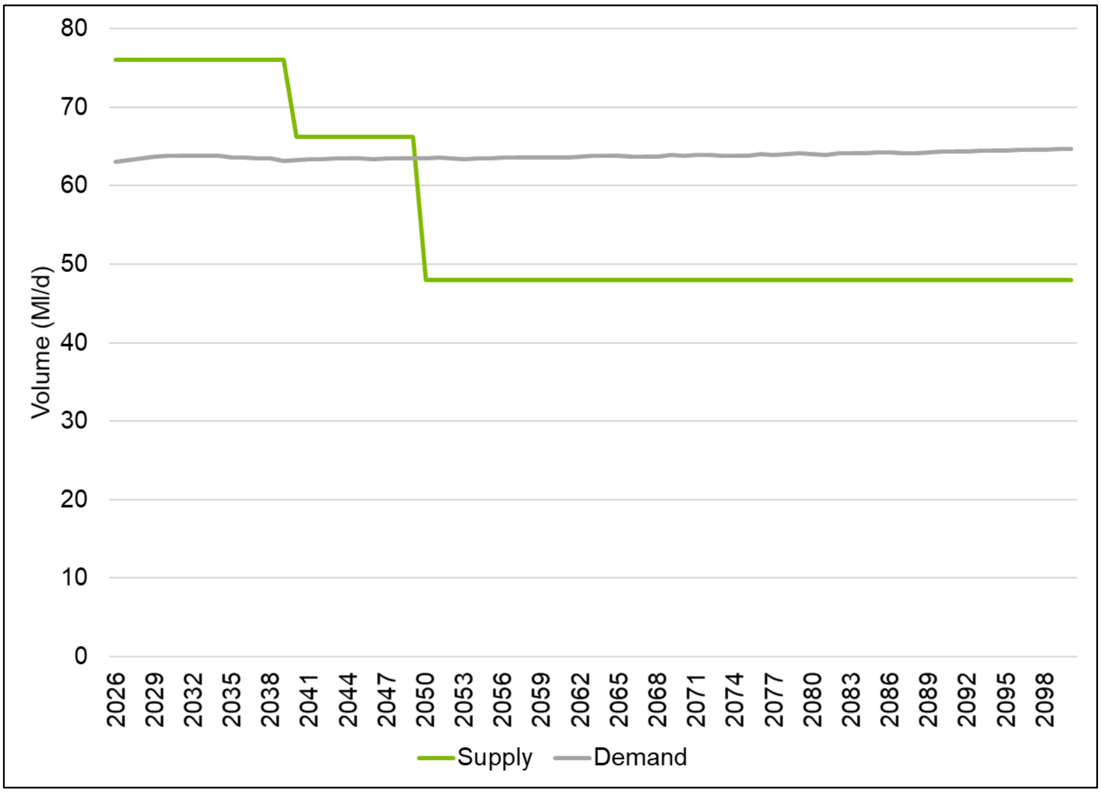


Figure 6 - 54: Baseline Supply-demand Balance for Situation 4, Guildford DYCP

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | -0.4 | -2 | -8 | -10 | -13 |
| WRMP24 | +13 | +12 | +3 | -16 | -17 |

Table 6 - 57: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for Guildford WRZ DYCP

## Henley DYAA

6.301 Uncertainties in the Henley WRZ are more modest than other zones. The High Environmental Destination scenario poses the most significant uncertainty for the zone.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 12.4 | 12.9 | 13.1 | 13.6 | 14.6 |

Table 6 - 58: Henley DYAA Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | 0 | 0 | 0 |

Table 6 - 59: Henley DYAA Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -6.2 | 0 | 0 |

Table 6 - 60: Henley DYAA Environmental Destination Impact Scenarios

6.302 The Henley DYAA scenario shows that almost all scenarios stay in surplus throughout almost all of the planning period. When demand management programmes are considered, it is very unlikely that any supply-side investment will be needed in the Henley WRZ.

6.303 There is a large gap between scenarios created at 2050 when the High Environmental Destination forecast diverges from other forecasts considered.

6.304 Compared to WRMP19, scenario 4 starts with a reduced surplus, due to a write-down in DO which was taken due to a long-term outage at Sheeplands WTW. This reduced surplus is maintained throughout the planning period and is increased when licence reductions are assumed to be implemented under the High Environmental Destination scenario.

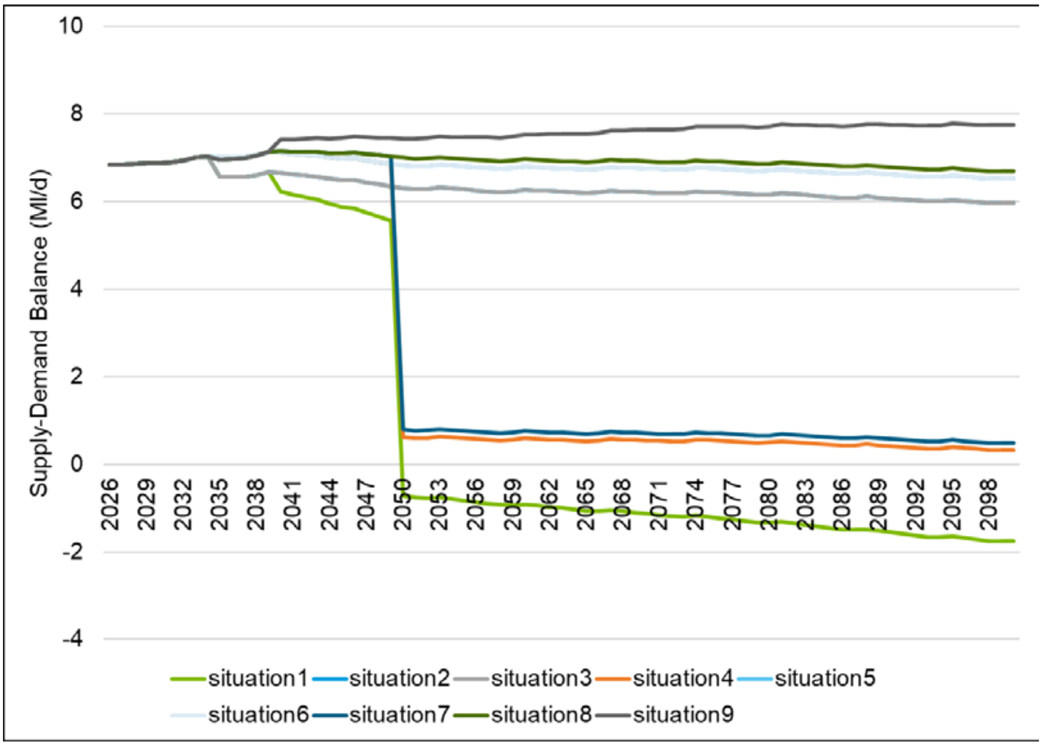


Figure 6 - 55: Supply-demand balances of 9 Branches for Henley DYAA Scenario

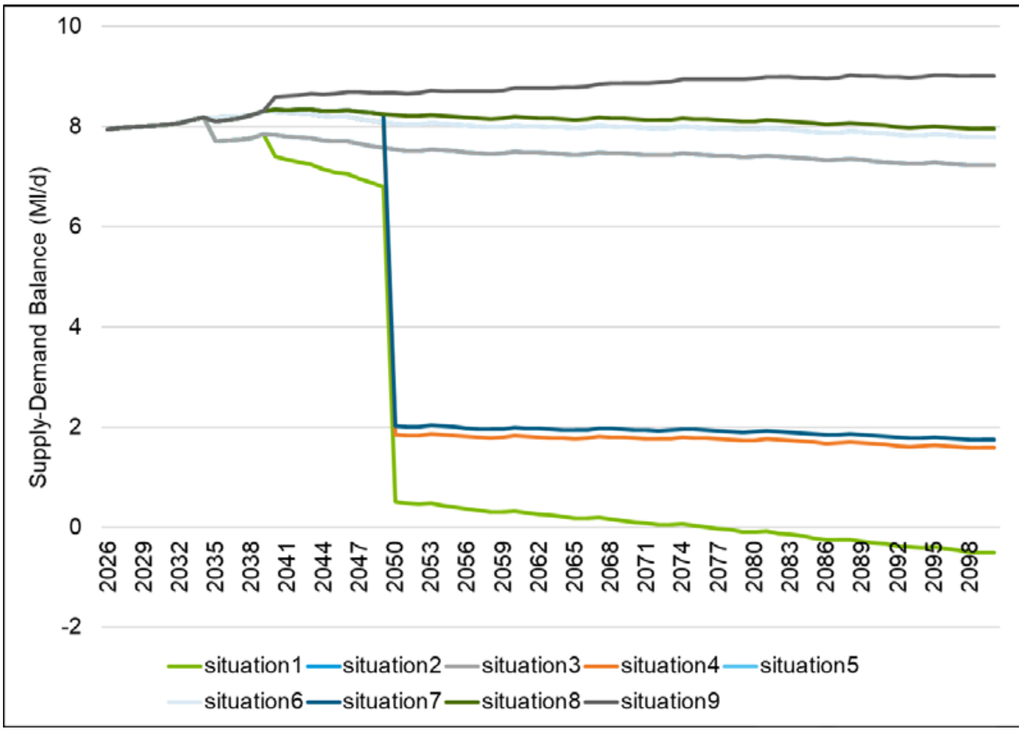


Figure 6 - 56: Supply-demand balances of 9 Branches for Henley DYAA Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

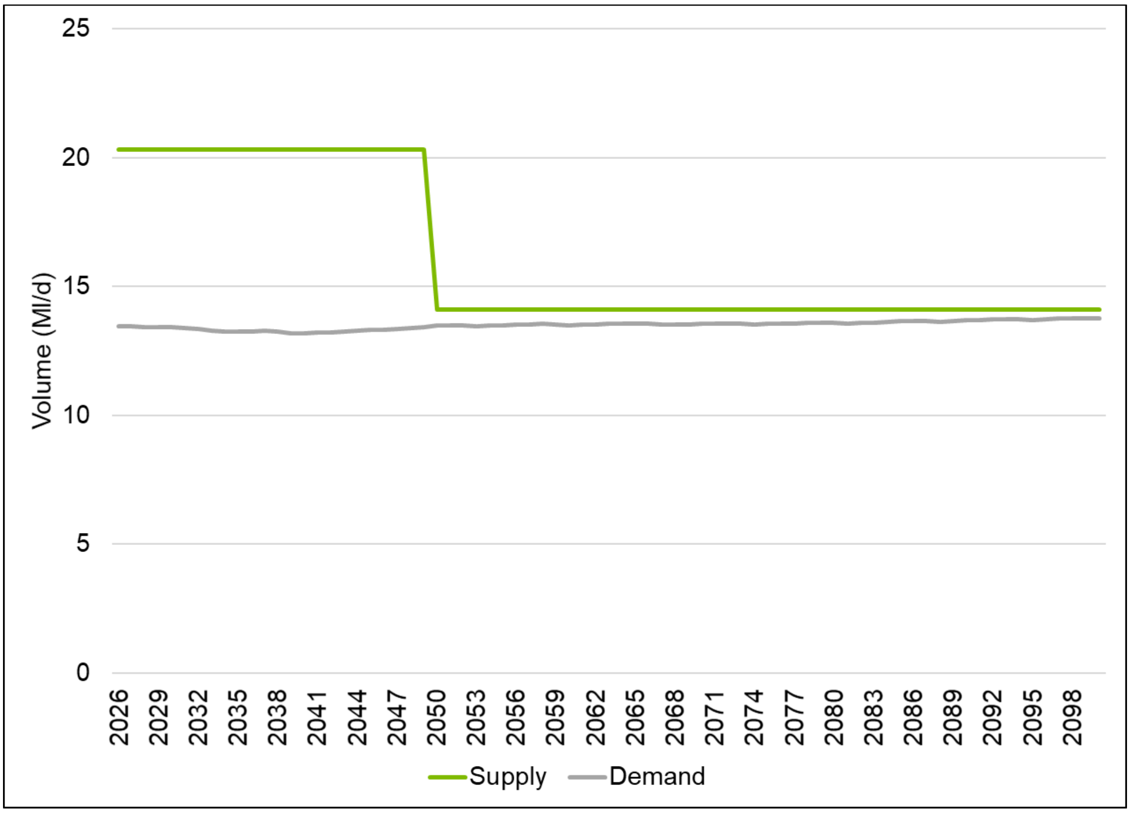


Figure 6 - 57: Baseline Supply-demand Balance for Situation 4, Henley DYAA

| | 2026 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +12 | +12 | +12 | +12 | +12 |
| WRMP24 | +7 | +7 | +7 | +0.6 | +0.3 |

Table 6 - 61: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for Henley WRZ DYAA

## Henley DYCP

6.305 Uncertainties in the Henley WRZ are more modest than other zones. The High Environmental Destination scenario poses the most significant uncertainty for the zone.

| Scenario | Minimum | ONS18 | Local Plan | Local Plan + OxCam | Maximum |
|---|---|---|---|---|---|
| 2060 Demand (Ml/d) | 17.4 | 18.0 | 18.2 | 18.7 | 19.7 |

Table 6 - 62: Henley DYCP Demand in Different Scenarios

| Scenario | High | Median | Low |
|---|---|---|---|
| 2060 Climate Change Impact | 0 | 0 | 0 |

Table 6 - 63: Henley DYCP Climate Change Impact Scenarios

| Scenario | High | Medium | Low |
|---|---|---|---|
| 2060 DO Reduction Due to Environmental Destination | -4.8 | 0 | 0 |

Table 6 - 64: Henley DYCP Environmental Destination Impact Scenarios

6.306 The Henley DYCP scenario shows that most scenarios stay in surplus throughout almost all of the planning period. When demand management programmes are considered, it is very unlikely that any supply-side investment will be needed in the Henley WRZ.

6.307 There is a large gap between scenarios created at 2050 when the High Environmental Destination forecast diverges from other forecasts considered.

6.308 Compared to WRMP19, scenario 4 starts with a slightly reduced surplus, due to a write-down in DO which was taken due to a long-term outage at Sheeplands WTW. This reduced surplus is maintained throughout the planning period until licence reductions through the High Environmental Destination scenario are assumed to be implemented.

6.309 The supply-demand balance position in Henley is more challenging in the DYCP scenario than DYAA, though supply-side investment is not likely to be required to meet any deficits.

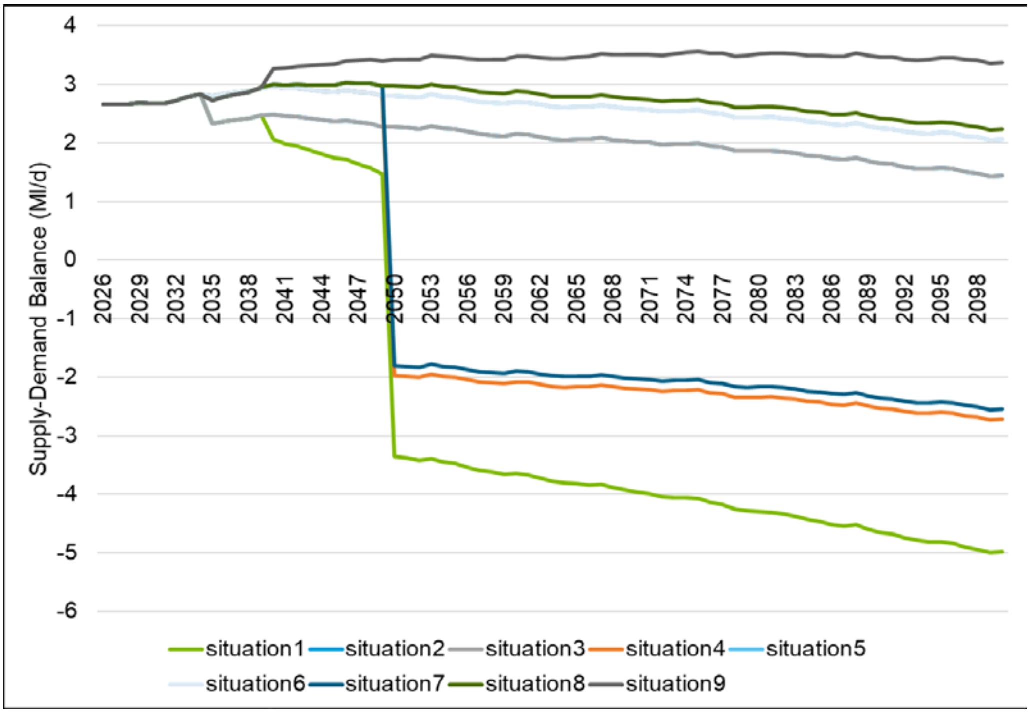


Figure 6 - 58: Supply-demand balances of 9 Branches for Henley DYCP Scenario

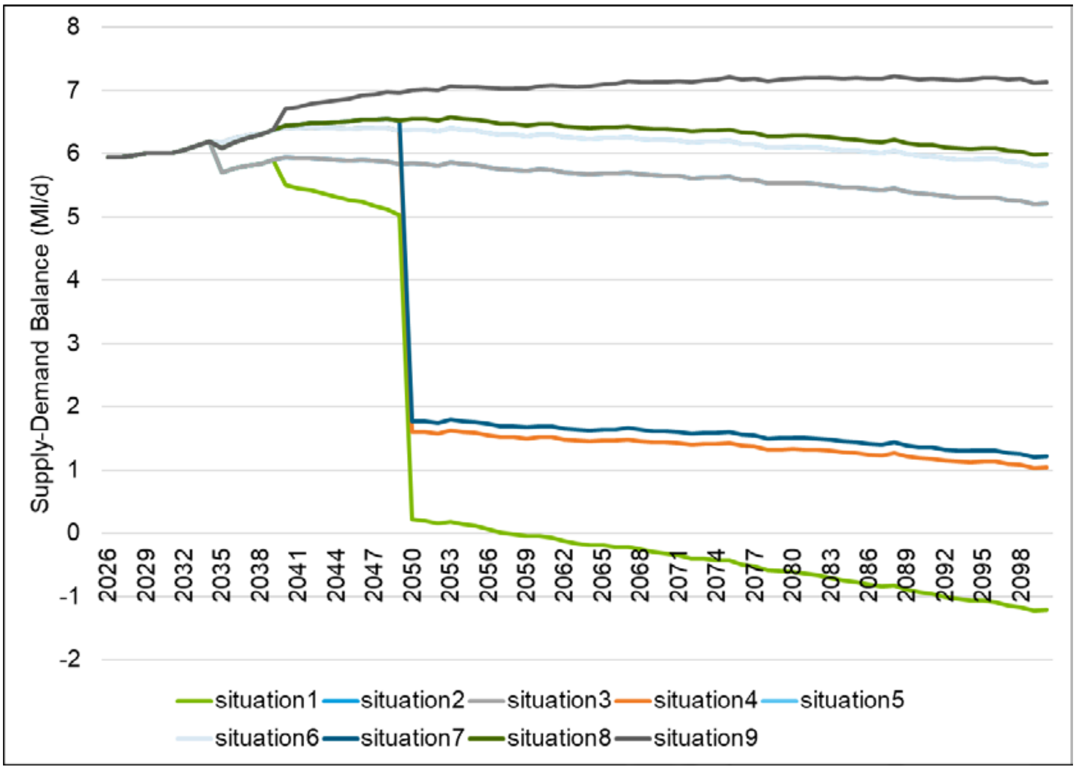


Figure 6 - 59: Supply-demand balances of 9 Branches for Henley DYCP Scenario, Incorporating Benefits Associated with Media Campaigns, TUBs, and NEUBs

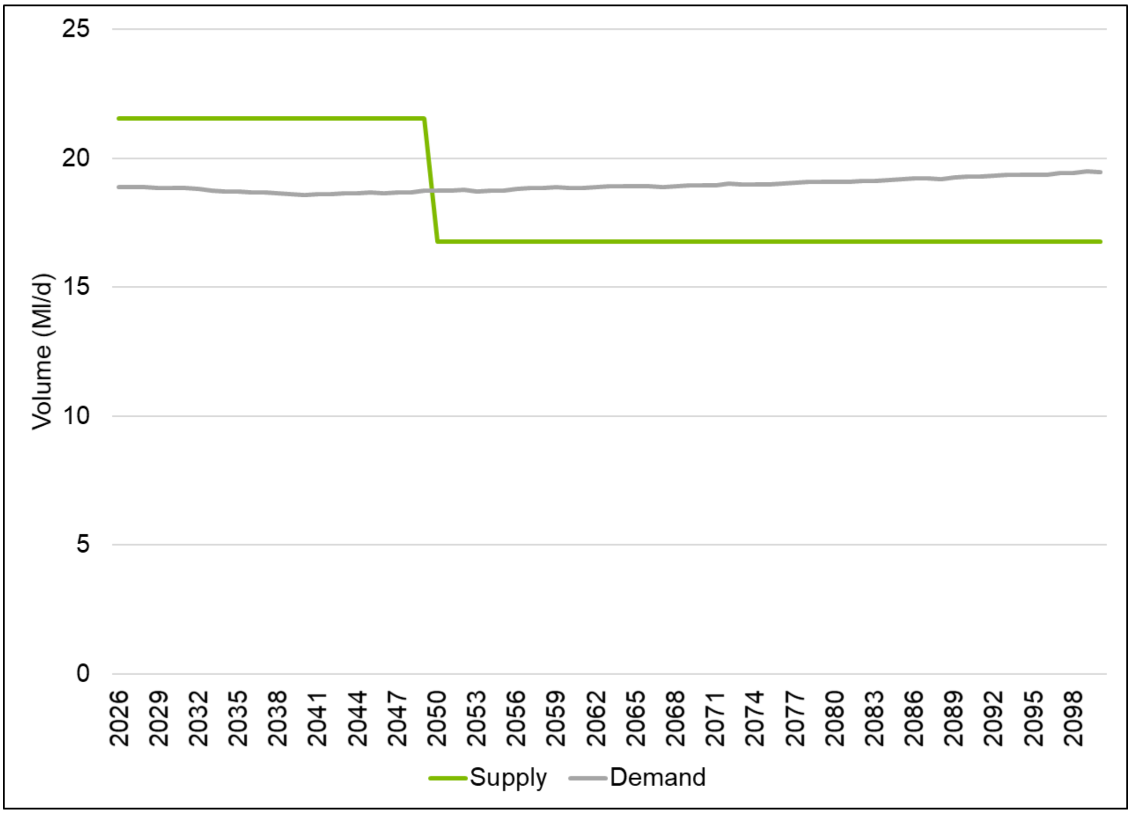


Figure 6 - 60: Baseline Supply-demand Balance for Situation 4, Henley DYCP

| | 2025 | 2030 | 2045 | 2075 | 2100 |
|---|---|---|---|---|---|
| WRMP19 | +5 | +5 | +5 | +5 | +5 |
| WRMP24 | +3 | +3 | +3 | -2 | -3 |

Table 6 - 65: Comparison Between WRMP19 and WRMP24 (Branch 4) Supply-Demand Balance for Henley WRZ DYCP

Thames Water