Drainage and Wastewater Management Plan

Technical Summary: Approaches to Uncertainty

Date: March 2023
Version: 2

Approaches to uncertainty

The Drainage and Wastewater Management Plan (DWMP) strengthens our planning for the longer-term. In our DWMP we look at the investment needs for the next 25 years to ensure our services are fit for the future and provide the level of resilience expected by our customers. It helps us understand the long-term risks to our business and move towards improved long term decision-making for our drainage and wastewater services.

We know the future is uncertain and likely to change. The purpose of this technical summary is to explain how we have approached managing the uncertainties and risks associated with the future performance of our assets and infrastructure and the external factors that affect this. It:

- Provides an overview of the areas of greatest uncertainty and our approach to understanding these uncertainties. We have done this by modelling a range of possible external factors, or scenarios, that may impact the future performance of our drainage and wastewater systems and associated infrastructure assets under different operating conditions.

- Explains how we are using adaptive planning to help manage these uncertainties.

- Sets out the underpinning factors we consider are the most uncertain and which could have the biggest influence on the future performance of our systems, and how changes in those factors may affect our operations in the future.

- Explains how uncertainty has been appropriately accounted for.

Managing Uncertainty in our DWMP

We established an end-to-end process in developing our DWMP that identifies the level of risk from each of our wastewater systems and the preferred options to manage that risk. This included a step-by-step Options Development and Appraisal (ODA) process to identify and assess the effectiveness of the options against the 14 Planning Objectives. We used a range of modelling scenarios within this process to help us identify how external factors are likely to further impact on these risks. Key areas of uncertainty identified within cycle 1 of the DWMP are summarised below.

- **ODA Option Costing**: A cost model was developed to estimate costs for all solutions derived in the ODA. The model was based on the historical costs of previously constructed schemes. The historical costs are based on a limited number of schemes. The models were further developed to estimate costs for sustainable solutions and nature-based solutions. Cost certainty attributed to sustainable solutions is expected to improve with future cycles of the DWMP.

- **ODA Option Efficacy**: The ODA methodology incorporates a detailed approach for assessing and quantifying an option's efficacy in meeting the needs set out in the Planning Objectives. The option of targeting operational activities has been identified as the preferred solution for addressing internal flooding for most wastewater networks. The efficacy of future operational interventions has been estimated and may change in future cycles.

- **Model Risk Profile**: Planning Objectives PO4 (1 in 50 Year flooding) and PO7 (Annualised Flood Risk) are based on outputs provided by hydraulic model simulations. The ability of the hydraulic model to replicate key hydraulic characteristics within a wastewater network has been assessed and used to determine the extent of work required to improve the hydraulic models. A modelling risk profile has been developed and assessed whenever model results have been utilised in decision making so the uncertainty is understood. The DWMP approach requires investment in hydraulic models and data to improve the accuracy. As models and data improve, the decisions and options in our DWMP may change for future iterations.

- **Surface Water Separation or Storage**: Solutions identified in our Drainage Area Plans (DAPs) have also been used when available. Optioneering undertaken for DAPs considered a variety of solutions such as conveyance, storage and separation schemes, and further scrutiny was undertaken with outputs being peer reviewed by operational staff. Preferred DAP solutions were often conveyance or storage schemes. Surface water separation schemes were identified in DAPs as being more expensive, although the wider multiple benefits that can be provided through separation schemes were evaluated in these plans. These wider natural and social benefits mean that surface water separation and attenuation schemes using sustainable drainage systems (SuDS) may provide the best value solution.

- **Annualised Flooding**: We incorporated DAP options within the ODA process. These options came from more detailed investigations and planning in AMP6, and these predominantly tackle high significance flooding validated against historical flood records. The DWMP evaluates flooding at a wastewater system level and considers the quantity of properties where flooding is predicted in both the annualised risk and during a 1 in 50 year return period storm. DAP options addressing flooding are localised at known flood locations and therefore have a reduced impact when assessed against catchment-wide BRAVA (Baseline Risk and Vulnerability Assessment) criteria.

- **Opportunities for Partnerships**: Catchment and nature-based solutions (C&NBS) have been identified as a more sustainable and long-term solution to the risks identified in the BRAVA, and these solutions are encouraged by several external partner organisations. These solutions can increase the risk to water companies of not achieving the permit conditions, as the ability to achieve the necessary permit conditions through catchment and nature-based solutions is less certain than traditional engineering solutions. We are keen to explore and develop our knowledge and understanding of the costs, benefits and the effectiveness of C&NBS in addressing our Planning Objectives. We have identified nature-based solutions opportunities in our DWMP, and we will continue to promote these types of solutions where technically possible.

- **Long Term Asset Health:** The types of options identified in the investment plan are based on addressing the root cause of the problem. Some of these are operational issues that can be addressed through enhanced, or changes to, maintenance activities. We are planning to include outputs from our asset deterioration modelling in future cycles of the DWMP.

Modelling our wastewater systems to reduce uncertainties

One of the foremost uncertainties that we needed to understand was the current causes of risks due to the performance of our wastewater systems and how external factors such as population growth and climate change might increase these risks.

Our mathematical hydraulic models enable us to replicate and analyse the performance of our wastewater networks. The models represent the flow in the sewer pipes and indicate where there is a current risk of discharges (from manholes or storm overflows) and flooding under different rainfall conditions. The models can also predict how and where these risks are likely to increase in the future when taking development, asset deterioration and climate change into account. The models help us make decisions on the type of operational response needed to address issues relating to the resilience of our assets and future demand.

We used wastewater modelling during the BRAVA (Baseline Risk and Vulnerability Assessment) to reduce uncertainties relating to the significance of the current and future risks. We also used our models to reduce the uncertainties regarding the causes of the risks during the PC (Problem Characterisation) stage of the DWMP.

Using modelling for the Baseline Risks and Vulnerability Assessment

The BRAVA stage of the DWMP assessed the current (2020) risks to customers and the environment from the performance of our drainage and wastewater systems, and the future risks (for 2050) for 6 of our POs where a future forecast was possible. These are:

- Risk of Sewer Flooding in a 1 in 50 year Storm
- Storm Overflow Performance
- Risk of WTWs Compliance Failure
- Risk of Flooding due to Hydraulic Overload
- Dry Weather Flow Compliance
- Nutrient Neutrality

We could not complete a 2050 assessment for the remaining 8 POs. Reasons for this include a lack of historic incident data, challenges in predicting climate impacts on future ground conditions and advances in available technologies. Our page on Planning Objectives explains this in more detail.

Our hydraulic models were used to predict the future risks to the performance of our wastewater systems taking urban creep, climate change, and the network's condition into account. We applied the forecast figures for development and urban creep to assess the future impact on domestic and trade flows. We also investigated the effects of increases in rainfall from climate change and from infiltration if groundwater levels were to rise in the future. This process is called design horizon modelling. The design horizon model results generated at the BRAVA stage were used to inform the risk bands (scores) for the six national planning objectives with 2050 assessments.

The hydraulic models were also used to understand the future risks from the wastewater network in the years 2020, 2025, 2030 and 2050 for the planning objective on the risk of flooding in storms of different intensities (annualised flood risk).

The models reduced the uncertainties regarding the risks to the baseline, 2020, BRAVA assessments, and also for the BRAVA assessment for the six 2050 POs.

Modelling for the Problem Characterisation

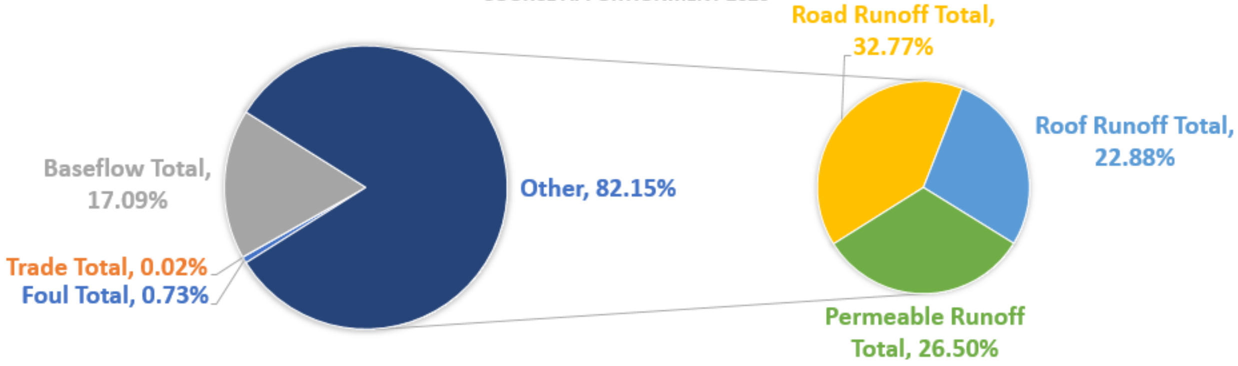
Our wastewater network models were also used during the Problem Characterisation stage of the DWMP to help us to identify what is causing the significant risks.

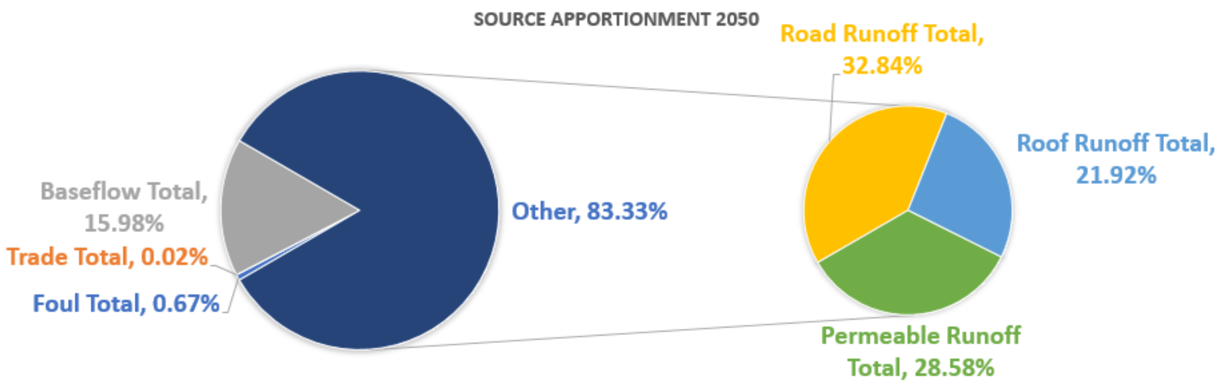
The models provided information on the origin and proportion of flow within the wastewater network, whether foul, trade, runoff or baseflow. This is called the source apportionment. Source apportionment helped us to identify which of the types of contributions are currently causing the greatest risks in each catchment and which are likely to be the greatest risk in the future. Source apportionment was undertaken on the 2020 and 2050 design horizon models and assessed the contributions from the following variables:

- Flow generated by the population served within the catchment, known as the foul total. These flows consist of water usage from properties based on the daily consumption rate per person.
- Flow generated by industries and commercial properties, known as trade total. These flows consist of water usage and wastewater generated from industrial or commercial practices.
- Flow generated by the direct runoff from paved and impermeable surfaces, known as "other sources". These include flows from roofs, roads, driveways and paths.
- Flow generated by the runoff from permeable (or pervious) surfaces. These flows include the direct runoff of rainwater as a result of ground saturation. These can include, but are not limited to, gardens and fields.
- Flow generated by infiltration, known as baseflow total. These flows are created when water in the soil surrounding the pipes infiltrate the wastewater network through the joints, cracks or deformations in the pipes where present. Infiltration has two components: baseflow infiltration from groundwater, also referred to as base infiltration, and rainfall-induced infiltration, termed groundwater infiltration.

For each wastewater system modelled, we represented source apportionment in a pie chart. These are available as part of the 'Causes of Risks' in the Problem Characterisation section of each River Basin Catchment on our website. An example of the pie chart showing a wastewater network modelling result for the baseline 2020 and future 2050 horizon is shown below in Figure 1.

Figure 1: An example of the Source Apportionment pie charts for 2020 and 2050





The source apportionment modelling helped us identify what is causing the most significant hydraulic risks in our wastewater systems. Results from the 2020 modelling provide baseline scenarios and reveal what is causing the most significant current risks. Results from the 2050 design horizon modelling enabled us to predict and consider what the future risks may look like and what is likely to cause them.

The source apportionment pie charts for all our modelled wastewater systems demonstrate that runoff from “other” sources (road, roof and permeable surfaces) constitute by far the greatest flow in our networks for the 2020 baseline. The charts also showed that the proportion of ‘other’ is likely to increase by 2050. The modelling indicates that the types of options that will be effective in reducing both the current and future risks are likely to be those that reduce the contribution of ‘other’ to the flow in our networks.

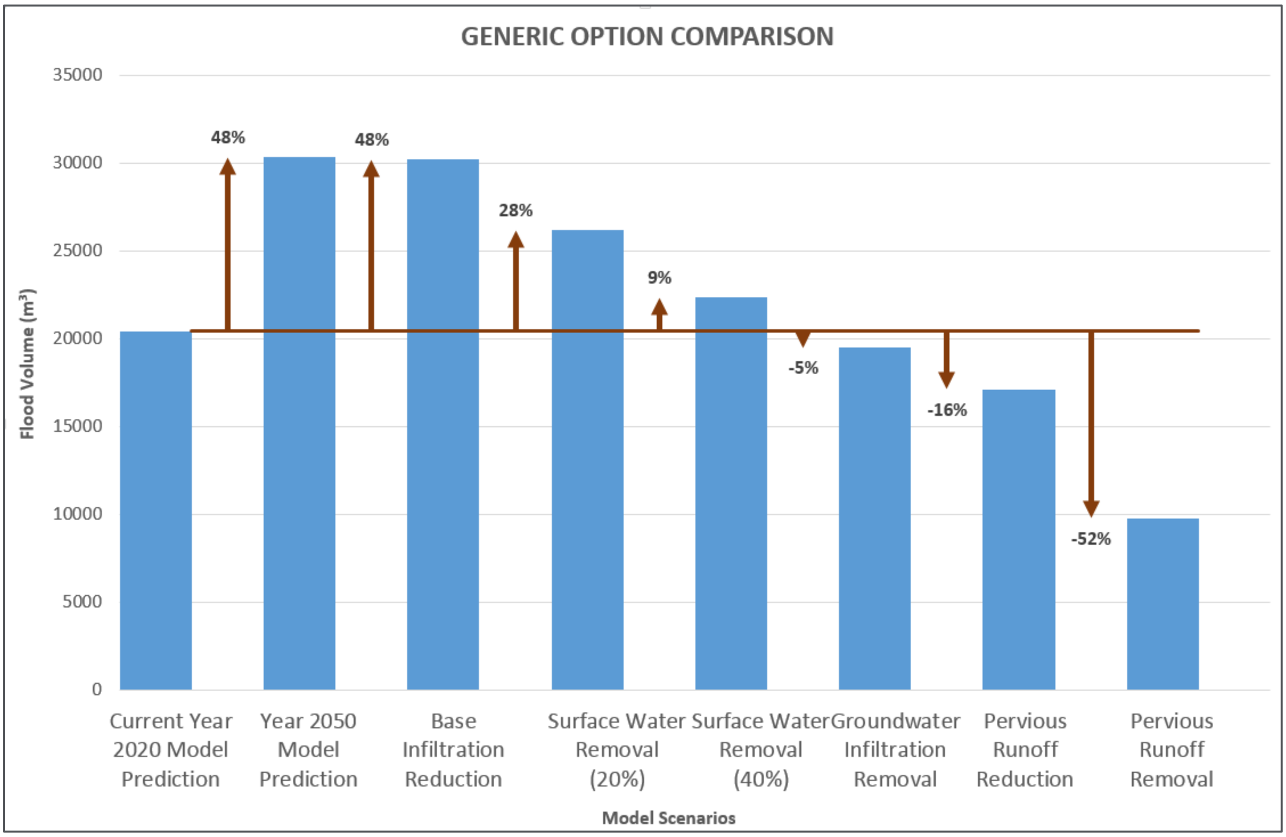
Using modelling to inform choices for the Options Development and Appraisal

The model results were presented in bar charts for each wastewater system, shown in figure 2. This allowed us to directly compare the 2020 model baseline results with the model results for the 2050 design horizon and understand which sources of flow present the greatest future risks. This information enabled us to identify which types of options would be the most effective in reducing the current and future risks during the Options Development and Appraisal (ODA) stage of the DWMP.

Figure 2 presents an example of how we used the modelling outputs to inform the selection of the options that will be the most effective investment choice to reduce the risks. The current model simulation results are shown in the first bar “Current year 2020 model prediction”. All following bars represent the theoretical reductions that could be achieved by each contributing flow for a 2050 design horizon. The red line indicates the increase or decrease in predicted flood volume when directly compared with the current model baseline.

Using this approach, we were able to assess how much an option could improve the future resilience of the wastewater network by reducing the contributing flows.

Figure 2: Using the hydraulic models to predict future flood volumes and potential options



Confidence in our model assessments through validation

We used our models to help reduce uncertainties regarding the significance of the risks to the hydraulic performance of our wastewater systems and the causes of the risks, so we needed confidence that our models are providing us with accurate information.

Our models are built using Infoworks ICM, an industry-leading modelling software. This software is the predominant tool used by water companies across the UK and is specifically designed to enable modelling of the interaction between the natural environment and constructed assets such as our wastewater networks. The models provide us with a scientific and repeatable assessment with which to compare the potential efficacy of potential options and support the quantification of the benefits that can be accrued by addressing specific hydraulic risks within our wastewater systems.

Our models undergo regular quality assurance to ensure the outputs reasonably represent our wastewater networks' current and future performance. This assurance process is called model verification. We conduct flow surveys to measure actual flow within a wastewater network at strategically chosen locations and then compare this data with that used in the model to ensure it reflects the reality of the flow in the wastewater network. The surveys typically take between 8 and 14 weeks to complete in order to collect sufficient information during rainfall events and storms. This validation technique also uses longer-term operational data collected at the pumping stations, storm overflows, and wastewater treatment works that make up our wastewater networks. A model confidence grade has been assigned to all hydraulic models. Where the model has a low confidence grade, we have identified that investment is required to upgrade the model to improve our confidence and further reduce uncertainties regarding the significance of the risks.

Future Modelling

All our hydraulic model simulations were undertaken using one-dimensional (1D) simulations. Simulations using two-dimensional (2D) models are planned for some wastewater systems in future DWMPs to improve the assessment of flood risk and determine the extent of flooding. Our Model Maintenance programme will prioritise model improvements for the wastewater catchments with Band 1 or 2 risks. We will continue to use the wastewater network models for further options development as the DWMP programme progresses. They help ensure that we can target and address the most significant risks in our systems.

Scenario Planning

Scenario planning helps us to address an uncertain future. We do this by using our hydraulic models to identify a range of potential impacts on our systems and infrastructure from external pressures and understand the most effective responses that will be needed to address these. We have used scenario planning to assess the future flow performance of our drainage and wastewater networks and associated infrastructure assets under different operating conditions.

The need for scenario planning is set out within Guiding principles for drainage and wastewater management plans[1]. The first of six guiding principles states that DWMPs are expected to:

> '*Be comprehensive, evidence based and transparent in assessing, as far as possible, current capacity and actions needed in 5, 10 and minimum 25-year periods considering risks and issues such as climate change. Plans should also align, as far as possible, with other strategic and policy planning tools*.'

Below, we set out how Scenario Planning was undertaken in our DWMP.

Method for Scenario Planning

Our Scenario Planning methodology was developed to meet the requirements set out in Water UK's DWMP guidance:

- Appendix C Baseline Risk and Vulnerability Assessment and Problem Characterisation[2] – This document provides an overview to the principals of how future scenarios should be considered within the BRAVA methodology.
- The Capacity Assessment Framework (CAF) Guidance Document[3] – This document provides details in relation to how Hydraulic Models should be used

[1] Guiding principles for drainage and wastewater management plans, DEFRA.
[2] Appendix C Baseline Risk and Vulnerability Assessment and Problem Characterisation, A framework for the production of Drainage and Wastewater Management Plans, September 2017
[3] Capacity Assessment Framework Guidance Document, 21st Century Drainage, Water UK, 2017

and set up in order to represent current and future scenarios of wastewater networks.

Using common scenarios for planning allows for an assessment and national comparison of the levels of resilience and the interventions necessary to achieve this resilience now and in the future.

Scenario Planning requirements as set out in the Water UK Capacity Assessment Framework

The Capacity Assessment Framework (CAF) was published by Water UK in 2017 as part of the 21st Century Drainage Programme[4] to enable the UK water industry, in partnership with the UK's government and regulators, to make plans to ensure drainage infrastructure is sustainable into the longer-term future. The 21st Century Drainage Programme recognised the need to move away from short term delivery of levels of service and promote the planning of long-term resilience.

The 21st Century Drainage Programme CAF sets out the approach UK sewerage undertakers should take to carry out a high-level assessment of the available capacity of their drainage systems for the purposes of long-term planning at the national and regional levels to accommodate the flows expected in the future.

The CAF included:

- A five-step framework which included guidance on:
  - data collection activities
  - asset performance assessment methods
  - performance assessment
  - an appraisal of interventions
  - planning for an investment strategy.

  These principals are aligned with the requirements of the Drainage Strategy Framework[5]

- Guidance in relation to representing the current and future scenarios within hydraulic models.

Adoption of Capacity Assessment Framework principals within DWMP Baseline Risk and Vulnerability Assessment

The performance of our networks and assets have been assessed against our 14 Planning Objectives, some of which require the assessment of the future capacity of the network to carry current and future flows. Hydraulic modelling, outlined above, has been an integral part of our

[4] 21st Century Drainage Programme, Water UK, https://www.water.org.uk/wp-content/uploads/2018/12/Assessing-the-Available-Capacity-in-UK-Sewerage-Systems.pdf

[5] Drainage Strategy Framework, Ofwat & Environment Agency, May 2013

scenario planning. It was used during the BRAVA process to assess the risks relating to the capacity of our wastewater systems, and also used during the ODA stage to test the effectiveness of potential solutions in addressing any shortfalls in capacity. Further information is available on our website pages on the Baseline Risk and Vulnerability Assessment and Planning Objectives used in our DWMP.

Our risk assessments were developed to be able to forecast the risks out to 2050, where it is possible to do so. This is essential to plan the investment need for the future risks.

Hydraulic model simulations were set up in order to replicate a range of future scenarios needed to complete the BRAVA assessments for the six future Planning Objectives. The Technical Summary on Population Growth and Urban Creep provides further details on the datasets used to replicate future scenarios within our hydraulic models.

The models were used to represent future scenarios based on the principals set out in the Capacity Assessment Framework (CAF):

- Urban Creep (CAF *Section 3.3.3 – Urban Creep)*
    - The likely extent of urban creep was estimated and represented within the hydraulic models. Details of these are provided in the BRAVA Methodologies for Planning Objective 4 and Planning Objective 5.
    - Urban Creep was applied to residential properties based on the property type. This meant the urban creep rate varied between 0.2 to 0.8 m3 per property per year.
    - Creep was applied to each model from the year the hydraulic model was verified to the design horizon year. For example, a model verified in 2015 would have had five years' worth of creep applied to the 2020 design horizon model and 10 years' worth of creep added to the 2025 design horizon model.
    - The amount of creep applied varied from catchment to catchment as the year the model was verified ranges from the 1990s through to more recent model updates in 2016.

- Infiltration (CAF *Section 3.2.1.3 – Infiltration*)
    - The infiltration rates applied within the verified models were maintained.
    - A further scenario was created for the 2050 model as part of the sensitivity analysis where all infiltration values were increased by 30% and groundwater infiltration profiles were updated to trigger immediately with the start of any rainfall.

- Population Growth and Planned Development (CAF *Section 3.2.1.1 – Population, Section 3.3 Future Pressures & Section 3.3.1 – Population change)*
    - The estimation of the 2050 population and details of how this is represented within hydraulic models are provided in the BRAVA Methodologies for Planning Objective 4 and Planning Objective 5.
    - Populations were initially updated by modelling the proposed developments for each design horizon. The developments were modelled as circular sub-catchments with the population and base infiltration rates applied. Experian 7.1, which provides current and projected (future) population levels across our operating region, was then applied to update the total catchment population to align with predicted future growth. These updates were applied to all the design horizon models.

- Per Capita Consumption (CAF *Section 3.2.1.2- Consumption Rate & Section 3.3.2- Change in Consumption Rate*)
    - Per Capita Consumption values were applied on a catchment basis for the 2050 design horizon. The values were taken from the Sage v16 database which provides an estimate of the population equivalent taking into account the following:
        - Resident and non-resident population reported in 2019
        - Trade effluent and cess reported
        - Projected population, based on Experian 7.1

- Climate Change (CAF *Section 3.3.4- Climate Change*)
    - Climate change predictions and the details of how it was represented within hydraulic models are provided in the BRAVA Methodology for Planning Objective 4 and Assessing the Impacts of Climate Change.
    - For sewer catchments where we have a hydraulic model of the system, we applied an uplift of 20% to design storms to account for the impact of climate change when assessing the long term (2050) planning horizon.

- Representation of the Tide when simulating Design Storms (CAF *Section 3.3.4.1- Design Storms*)
    - We created and represented three tide levels for 2020, 2030 and 2050 in our modelling for the wastewater systems where tidal influence is likely or is known to influence our networks. The 2020 tide level was applied as per the Spring Mean High Water. We applied a 60mm uplift for the 2030 tide level and the 2050 tide level had an uplift of 180mm applied.

- Time Series Rainfall (*Section 3.3.4.2- Time Series Rainfall*)
    - Analysis undertaken for PO5 Storm Overflow used a Time Series Regression (TSR) model simulation. The TSR is generated using the UKWIR (UK Water Industry Research) Rainfall Event Duration Uplift ('Redup') tool, which generates future time series rainfall from an existing TSR for a given location. The 2050 TSR incorporates the impact of climate change by reprofiling rainfall to account for changes in rainfall patterns and intensities. The results were analysed to produce an annualised average spill count using the '12/24' spill counting criteria.

Adaptive Planning

The future is uncertain and our DWMP is about planning for the future. This is a future where we do not yet know the full implications of climate change, what pressures there will be on the environment, whether new and effective technologies may be available or even how our future selves will be able to influence any developments. It is in this context of uncertainty that our DWMP attempts to understand the current and future risks to our drainage and wastewater systems.

Adaptive planning is the process of planning for this uncertainly. Although we cannot know what the future holds, we do know what will trigger a need for us to review our current investment strategy. For example, we can understand how resilient our current assets are to sea level changes or understand what future permit conditions our current assets and technologies are capable of complying with. This is outlined in our Problem Characterisation technical summary.

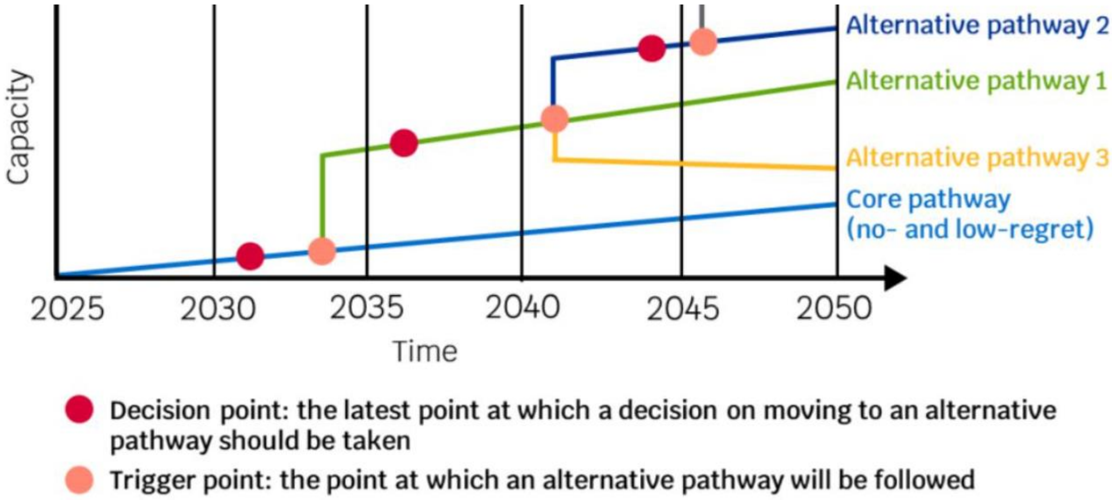
Adaptive planning sets out alternate pathways that are triggered when set criteria are exceeded.

How have we used Adaptive Planning to date

The DWMP BRAVA process provides us with a robust understanding of current risks affecting our wastewater business. We have been able to assess these risks up to the year 2050 for 6 of our Planning Objectives and our intention is to have a completed 2050 risk assessment for all 14 of the Planning Objectives by the end of Cycle 2.

Ofwat published the final PR24 guidance on long-term delivery strategies in April 2022[6], explaining how the DWMP will inform water companies Long Term Delivery Strategies (LTDS). Figure 3 illustrates the concept of core and alternative pathways (Ofwat, April 2022).

Figure 3 Example of Core and Alternative Pathways



[6] PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf (ofwat.gov.uk)

A core pathway represents costs to meet low risk, but likely, scenarios and low regret investment choices. “No and low regrets” investments are those that are cost effective and would apply to all current and future scenarios, or those which are essential to facilitate subsequent options.

Alternative pathways define the other plausible paths for investment needs depending upon the future uncertainties, such as growth and climate change, and the timing for when a change in risk is expected to occur. We have created the alternative pathways to enable us to change our investment needs as future uncertainties become more certain – such as the location for future development, the rate of climate change in the South-East, or the impact of government policies on surface water management and environmental standards.

Our core investment strategy is to ‘maintain’ the existing systems and assets to maximise, or ‘optimise’, their performance before investing in new assets (see the Problem Characterisation technical summary). This means we will invest, on a no regrets basis, in our 381 wastewater systems to ensure they work and perform as designed. Our core pathway also includes investment to keep pace with planned new development that has already been approved in Local Plans and the lower estimates of changes in climate.

Our preferred options for each wastewater system set out the investment needs in line with the identified investment strategy. These options will reduce the risks towards Band 0, and typically will be focused on tackling the issues at source, working with nature and delivering wider multiple benefits. Our preferred pathway is defined using the best value options identified in our DWMP.

Adaptive Planning Scenarios

The Ofwat guidance asks for four scenarios to be examined in water company long term plans, see Figure 4. The following paragraphs outline how these scenarios were tested and allowed for.

Figure 4 Ofwat Guidance on Scenario Testing for Long Term Delivery Strategies (April 2022)

	Climate change	Technology	Demand	Abstraction reductions	Wider scenarios
‘Adverse’ scenarios	**High:** RCP8.5	**Slower:** slower development than expected	**High:** higher growth forecasts	**High:** ‘Enhanced’ scenario (in England)	Material **local or company-specific factors**, as appropriate
‘Benign’ scenarios	**Low:** RCP2.6	**Faster:** faster development than expected	**Low:** lower growth forecasts and legislation on building regulations and product standards	**Low:** Current legal requirements (in England and Wales)	Parameters **between the reference scenarios**, e.g. a ‘medium’ scenario, as appropriate

Climate Change

A benign climate scenario for the DWMP is an increase of rainfall but at the lower end of the sensitivity testing specified in the DWMP Framework. This is a +20% with a -30% sensitivity which equals a 14% increase in rainfall intensity by 2050 above the 2020 levels. Ofwat defines the Adverse climate change scenario as the "Representative Concentration Pathways" (RCP) of 8.5. This is a high climate emissions scenario. The DWMP Framework also uses a high emissions scenario so the +20% increase used in the DWMP climate impact modelling can be considered an Adverse scenario.

Technology

The technology scenario is not in the national DWMP framework and was therefore not included during the modelling phases of the first cycle of the DWMP.

Demand

Demand (growth) projections (more simply referred to as "population") are identified using Experian population growth data, see the Factoring in Growth Technical Summary. This data has been used to provide the DWMP with future growth projections. This is the DWMPs "central" (2020 baseline) estimate of growth as defined in the national guidance.

Figure 4 identifies a requirement under "wider scenarios" for a "medium" scenario for sensitivity testing – the population growth data was selected as this "medium" scenario. From this, a "Benign" demand scenario for the DWMP was identified as an increase of growth but at the lower end of the sensitivity testing. This means a growth rate with a -30% sensitivity from our data for population growth. For an "Adverse" demand scenario the increase in growth rate is at the higher end of the sensitivity at a +30% sensitivity.

Abstraction Reductions

The abstraction scenario is not in the national DWMP framework and was therefore not included during the modelling phases of the first cycle of the DWMP.

Using combinations of the scenarios above, we identified the core, preferred and alternative pathways for the DWMP, see Figure 5. We aligned these to the required growth and climate change scenarios set out in the national DWMP Framework.

Figure 5 Defining Pathways using the Ofwat Scenarios

Pathway	Climate	Demand	Technology
Core	Benign	Benign	Benign
AP1 - Alternative 1	Benign	Medium	Benign
Preferred Plan	Adverse	Medium	Benign
AP2 - Alternative 2	Adverse	Adverse	Benign
AP3 - Alternative 3	Adverse	Medium	Adverse

Quantifying Alternate Pathways

Our overall investment needs for all 381 wastewater systems were developed by extrapolating the investment needs identified for the 61 wastewater systems that underwent Options Development (see Programme Appraisal Tech Summary).

The Programme Appraisal assessed the overall regional investment needs that are required to reduce the risks for each Planning Objective to Band 0. We developed alternative pathways for each Planning Objective's investment needs, using factors that were applied to the total cost for each planning objective (see Table 1 below, and note “100%” refers to values used in Programme Appraisal).

	Climate (Flooding)	Climate (Overflows)	Demand	Technology
Benign	90%	97%	93%	100%
Medium	100%	100%	100%	100%

	Climate (Flooding)	Climate (Overflows)	Demand	Technology
Benign	90%	97%	93%	100%
Medium	100%	100%	100%	100%
Adverse	100%	100%	104%	100%

Table 1 Applied Factors for Ofwat Scenarios

The factors were determined as described below, using data from the BRAVA assessments.

Climate (Flooding)

The Annualised Flood Risk planning objective (PO7) contains data on the number of properties at risk across future AMPs based on a 20% increase of rainfall intensity for 2050. By considering the impact of a 20% rainfall increase on the numbers of properties flooding compared to the 2020 baseline, we were able to determine an approximate increase in the number of properties at risk of flooding due to a benign scenario of a 14% rainfall uplift. This value equated to 90% of the Adverse scenario.

Climate (Overflows)

The aim for overflows is primarily to reduce the spill frequency per year, therefore an additional step was used that built on the methodology used for ‘Climate (Flooding)’. An average spill frequency per overflow was calculated for the Medium/Adverse scenario in 2050 based on the BRAVA PO5 assessment.

The change between 2020 and 2050 average spill frequency was then factored down based on the 90% value determined for a Benign Climate (Flooding) Scenario (see above). The factored down average spill frequency was then applied to the number of modelled overflows used in the BRAVA for PO5, giving a 97% reduction factor in the total number spills expected for a Benign Climate (Overflows) scenario.

Demand

Demand was calculated using the average consumption per person per day against the total population. This value was calculated every 5 years using data from Sage v16, from 2025 to 2050, based on the DWF Compliance planning objective (PO8). The DWMP model was based on a medium scenario. Therefore, we used a plus or minus 30% factor to the total population to account for population growth and create benign and adverse scenarios respectively. The current per capita consumption (average consumption per person per day) is 127l/s. Although we have set an ambitious target of working with our customers to reduce this to 100l/s as part of our Target 100 scheme, for strategic planning purposes we have used 118l/s in our benign scenario as detailed in 'Water UK Research on Reducing Water Use' for 2050. For our adverse scenario we have assumed the current per capita consumption remains the same as the current level between 2020 and 2050.

Technology

The DWMP Investment Needs only identifies and uses technologies that are in current use rather than those which require methods yet to be created, or those that cannot yet be implemented. The Benign and Adverse impact of technology scenario has therefore not been calculated in this cycle of the DWMP and the factors applied for the alternate pathways are 100%.

Preferred, Core and Alternate Pathway Totals

The preferred plan and alternative pathways for our DWMP are explained in Figure 6. Our preferred plan includes the investment needs for all planning objectives with the exception of some investment relating to sewer flooding. The uncertainties in modelling sewer flooding mean that we will focus investment on those areas where properties are known to have flooded previously. This means all investments under PO4 (1 in 50-year storm) have been excluded from the preferred plan. 22% of the investment needs under PO7 have been included. This is the percentage of the number of properties on our register of flooded properties compared to the number of properties identified by the modelling in areas at risk from sewer flooding. The investment needs under PO4

Pathways	Comments	Cost (£Bn)
Core pathway	**No/Low regrets** DWMP framework: Lower climate change sensitivity band and lower estimate of growth. Excludes 1 in 50 (PO4), Annualised Flood Risk (PO7), WTW Compliance (PO6) and Pollution Risk (PO2)	£5.5 Bn
AP1 - alternative pathway 1	**Low climate change** DWMP framework: Lower climate change sensitivity band and central estimate of growth. Excludes 1 in 50 (PO4) and pollution risk (PO2), includes 22%* of annualised flood risk (PO7), and includes WTW compliance (PO6)	£7.5 Bn
Preferred Plan	**Preferred plan: medium climate and growth** DWMP Framework: Medium climate change and central estimate of growth. Excludes 1 in 50 (PO4) and pollution risk (PO2), includes 22%* of annualised flood risk (PO7) and includes WTW compliance (PO6)	£7.7Bn
AP2 - alternative pathway 2	**High growth** DWMP framework: medium climate change and high estimate of growth. Excludes 1 in 50 (PO4) and pollution risk (PO2), includes 22%* of annualised flood risk (PO7) and includes WTW compliance (PO6)	£7.8 Bn
AP3 - alternative pathway 3	**Full DWMP: All planning objectives to band 0 by 2050** DWMP framework: Adverse climate change and central estimate of growth. Investment needed to get all planning objectives to band 0 by 2050.	£13.4 Bn

* 22% Ratio of DG5 at risk (555 internal and 8950 external) with total annualised properties at risk in 2050 (42361)

(the 1 in 50-year storm) is only included in full for alternative pathway 3, which is the total investment needs identified under all planning objectives to get to risk Band 0 by 2050.

Alternate Pathway "Trigger points"

The circumstances under which a change between alternative pathways is required is known as the "trigger" point.

A trigger point will not occur until after AMP8 as the business investment plan will not be able to be changed where current funding has been allocated. We have assumed the following trigger points from AMP9:

- Climate – a 5% change in the number of annualised properties at risk between a Benign / Medium Scenario to an Adverse Scenario. This percentage is based on engineering judgement following sensitivity analysis.

- Demand – a 5% change between the total Dry Weather Flow received to all our treatment works between a Benign to a Medium Scenario, and another 5% change between a Medium to an Adverse Scenario.

Note, there are only currently trigger points for Climate and Demand scenarios (see above for the impact of technology and abstraction scenarios on alternate pathways).

Future steps in managing uncertainty

We have developed an initial 25-year perspective of the investment needs for our drainage and wastewater systems during cycle 1 of the DWMP. This provides an estimated cost for the preferred investment options that are required to reach Band 0 status across our region. Future cycles of the DWMP will need to manage the following uncertainties:

- Options have only been developed for 61 of our wastewater systems. A total cost to achieve band 0 status for all 381 catchments has been extrapolated from these options (see our Programme Appraisal Technical Summary). Future cycles of the DWMP will need to determine more accurate costs and options of all 381 of our wastewater systems.

- The DWMP will need to become integral to our future business planning process and the development of the Water Industry National Environment Programme (WINEP). Future cycles of the DWMP are likely to be enhanced by using a spatially based options development process.

- In future cycles of the DWMP we will aim to develop alternative pathways for investment needs at specific wastewater system level (Level 3)**Error! Reference source not found.** for all our wastewater systems.