United Utilities Water

Drainage and Wastewater Management Plan 2023

Technical Appendix 3 – Demand Forecasting

Document Reference: TA3

May 2023

United Utilities

Water for the North West

Executive Summary

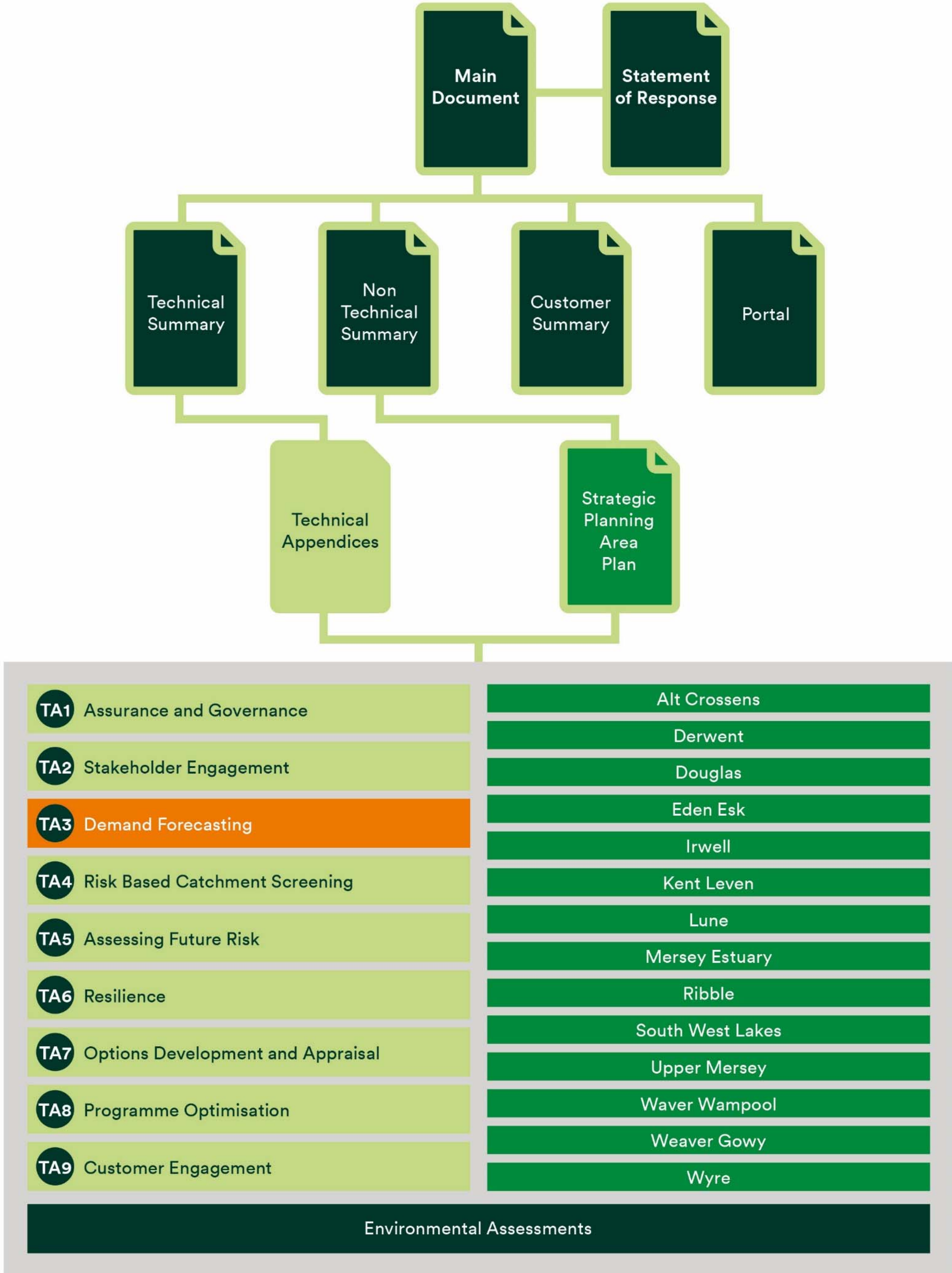
The Technical Appendix – Demand Forecasting, is one of a suite of documents that provides information used in the development of United Utilities Water (UUW) Drainage and Wastewater Management Plan (DWMP). Figure 1 DWMP document structure, pictorially represents this structure.

UUW have assessed the impact of current and future risks that arise from challenges such as population growth and climate change. This has enabled UUW to plan for, and develop an array of options to mitigate risk on a cost benefit basis before there is an impact on the wastewater service to the customers of the North West and the receiving environment. Some risks are within the control of UUW, but others require collaboration with regulators and partnership with external stakeholders, to enable UUW to adapt and mitigate.

This document provides information on historic and future demand for the wastewater system of UUW, including assumptions on population, consumption, infiltration and trade effluent, and the impact this has on continuous flow and load.

The document also describes how the demand forecast is calculated, the assumptions that are made and how this is used at a Tactical Planning Unit (TPU) to assess risk and develop solutions. It includes details of the sensitivity testing that is applied; an evaluation of uncertainty; and recommendations for how this is applied in future iterations of the DWMP.

Figure 1 DWMP document structure



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For the glossary, refer to document C003.

1. Introduction

1.1 Overview

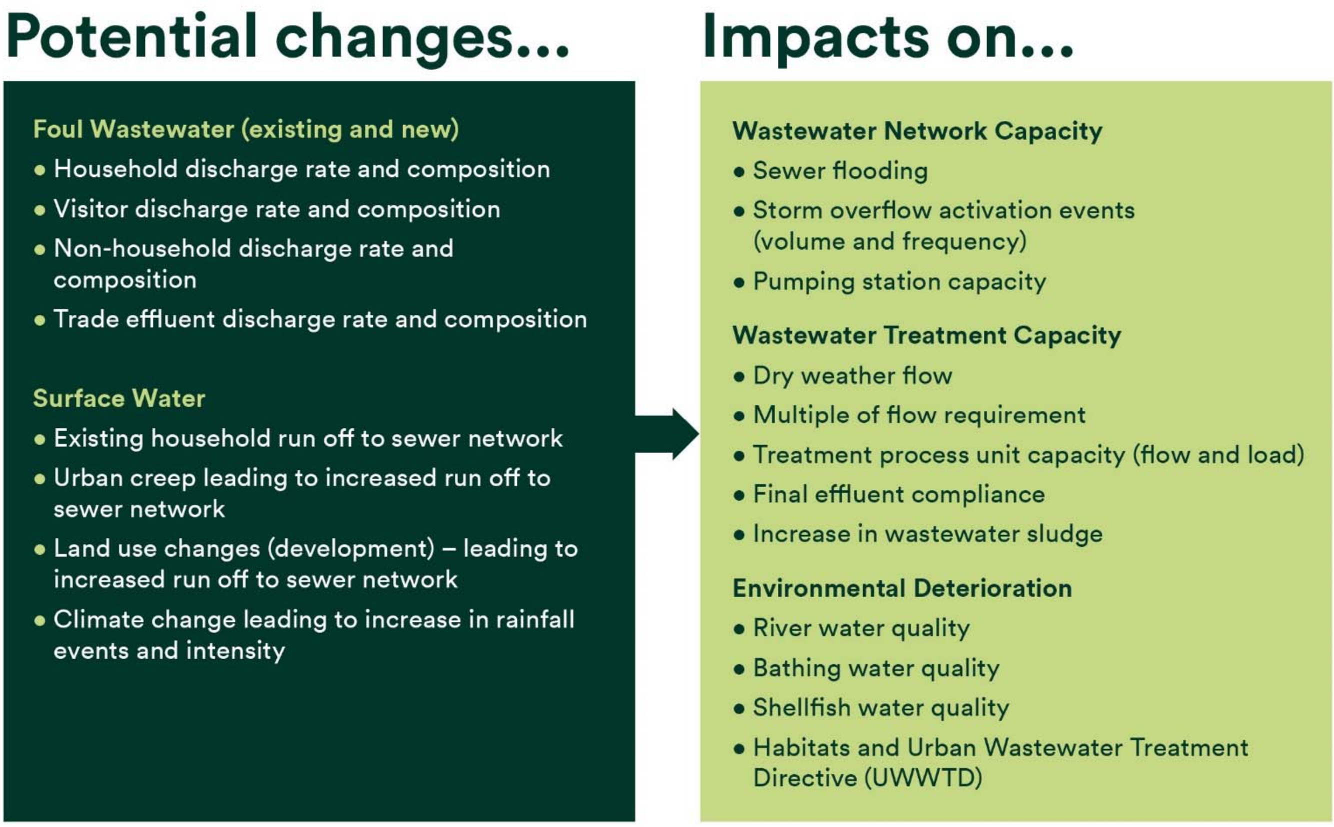
1.1.1 United Utilities Water (UUW) collects, transports and treats wastewater from over seven million people across an area of approximately 13,800km^2 in the North West of England.

1.1.2 The demand forecast has been prepared in line with guidance, using the latest available methods, and is in line with flow assumptions and models used for the Water Resources Management Planning (WRMP). It covers the planning period for 2020 to 2050.

1.1.3 The demand forecast is used at multiple stages during the development of the DWMP. It provides inputs to Risk Based Catchment Screening and Baseline Risk and Vulnerability Assessments (BRAVA), and the outputs are also used for option development.

1.1.4 Wastewater demand is defined as the discharge volume and composition for which capacity is required to transport and treat. It includes all elements of discharge to sewer networks listed below and has an impact on receiving wastewater network, treatment and sludge assets, as shown below in Figure 2 Elements of wastewater demand

Figure 2 Elements of wastewater demand



1.1.5 This technical report outlines the key components of wastewater demand, how it is forecast and assessed to understand the existing and future risk of meeting customer and environmental expectations as well as legislative requirements.

1.2 Geographical zones of assessment

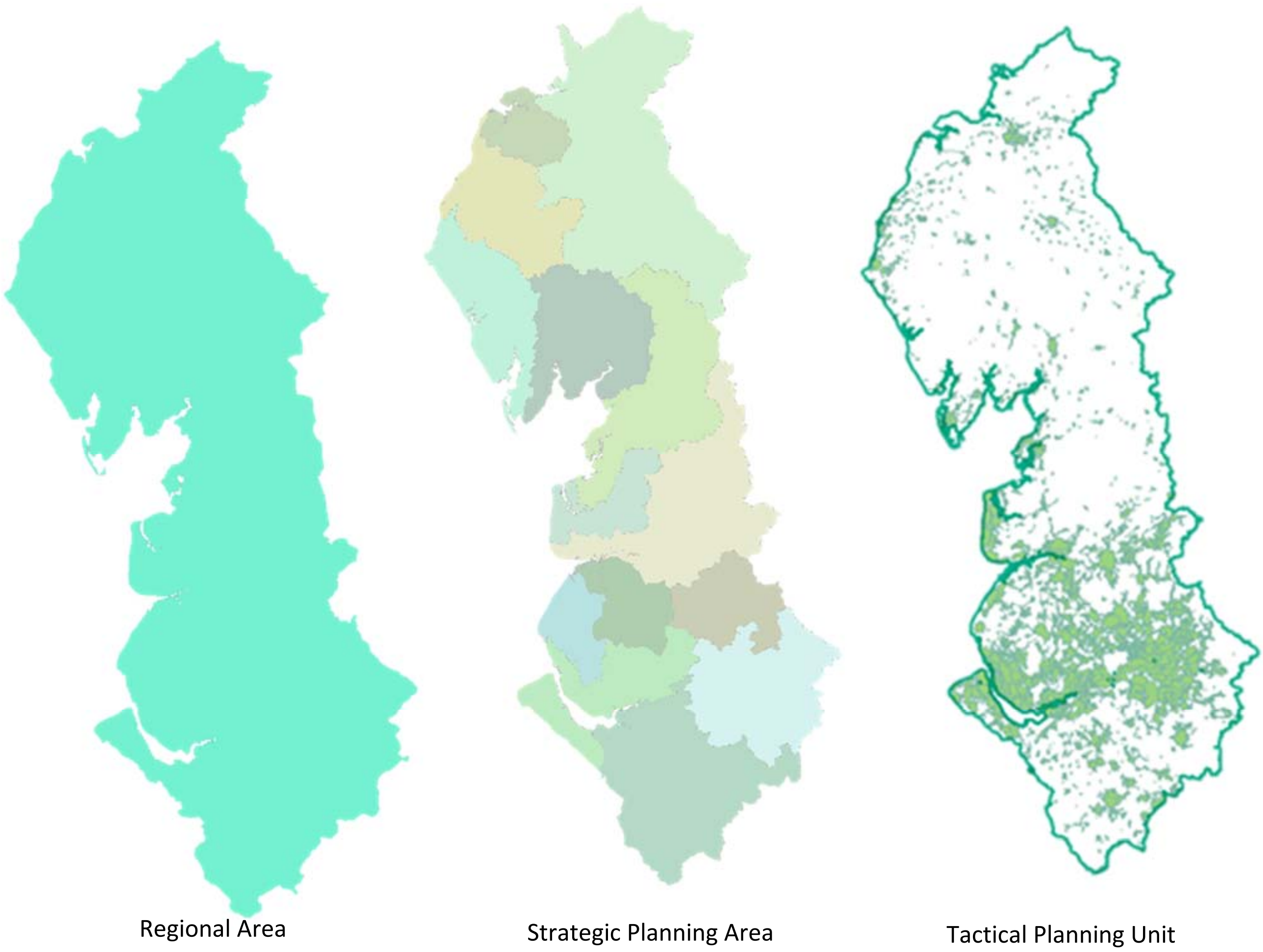
1.2.1 The region is divided into geographical zones for assessment as defined in Table 1 Definition of tactical planning units.

Table 1 Definition of tactical planning units

Tactical Planning Area Name	Definition	UUW Defined
Regional Area	Overarching company level	Regional area
Strategic Planning Area (SPA)	Aggregation of TPU Units	River catchment area
Tactical Planning Unit (TPU)	The basic TPU is wastewater treatment works drainage area and its catchments (or aggregations of small catchments, or discrete sub catchments for larger drainage areas)	Wastewater treatment drainage area
Sub-drainage area (SDA)	Sub-catchments of wastewater treatment drainage areas	Wastewater treatment sub-drainage areas

1.2.2 TPUs are the usual operating areas for the distribution of wastewater, there are 567 TPUs in the regional area and the geographical distribution of drainage and catchment areas as defined in

Figure 3 Geographical drainage and catchment boundaries of the UUW area



1.2.3 Demand is usually measured at a wastewater treatment works level, due to existing monitoring facilities such as flow measurement and crude sample analysis of wastewater received for treatment being located here. Flow variation is also reviewed at a greater granularity at a sub-drainage area if monitoring is available, but this is not consistently available across the region. A dynamic network monitoring programme is in place to increase the locations where network flow is recorded, this will provide better understanding of demand volumes and variations.

1.2.4 Dry weather, (defined in section 2.2.2) or average flow can be aggregated to a volume at strategic planning unit level so that multiple demands can be assessed together. It can also be collated regionally, but the nature of the wastewater network with discrete, unconnected drainage areas means that it is better assessed within the area it is transported and treated, as it represents the community served in this area.

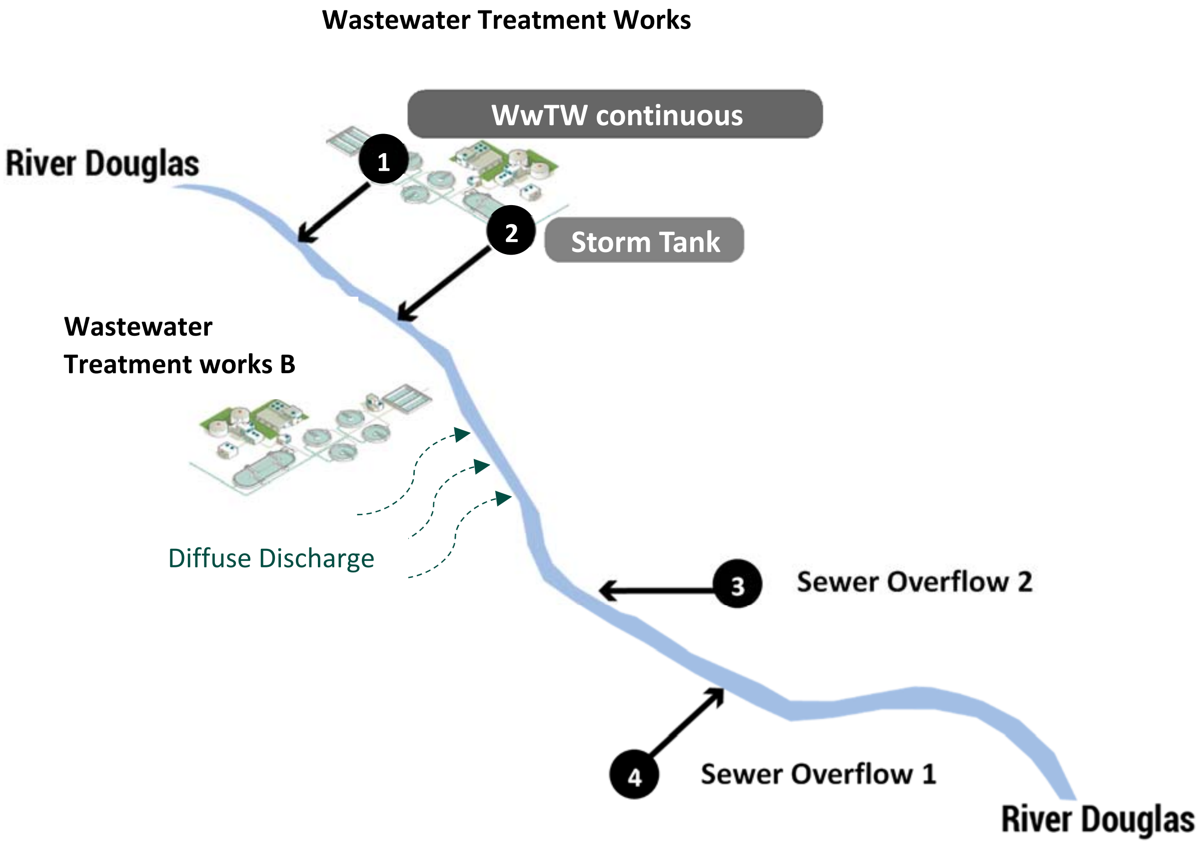
1.2.5 Demand on a specific river stretch (from multiple TPUs) is also used to monitor the full impact on environmental quality. Assumptions can be made on the overall demand (flow and load) against the capacity of the receiving watercourse (dilution of flow, biological and chemical quality deterioration).

1.2.6 There are areas of North West England that are not included in these tactical planning units, where a sewer network is not available and individual properties (or groups of properties) have private treatment. These areas are identified through horizon scanning as part of assessing future risk and are included in future plans if appropriate.

1.2.7 In some locations, previous National Environment Programme (NEP) water quality improvements have led to improved levels of service over areas with multiple TPU (or SPA) drainage areas, leading to requirements to operate groups of treatment works or network assets at this level. Where a river stretch has multiple wastewater assets impacting the water quality, there may be a combination of improvements at different locations to achieve the environmental goal and, therefore, the demand has to be assessed at this level.

1.2.8 Figure 4 illustrates the potential for multiple discharges to a section of watercourse. More information on this specific TPU is available within the SPA_03 Douglas document.

Figure 4 The interaction between tactical planning units, upstream discharges and the receiving environment



2. Historic wastewater demand

2.1 Overview

2.1.1 The flow and composition of sewage effluent is monitored at wastewater treatment works (within TPUs) to different levels of granularity depending on the discharge permit requirements.

2.1.2 Locations with low environmental risk are likely to have less stringent monitoring requirements, so less historic information is available. As more efficient monitoring equipment is developed, a better understanding of demand can be achieved at all wastewater treatment works.

2.2 Continuous flow

2.2.1 Overview

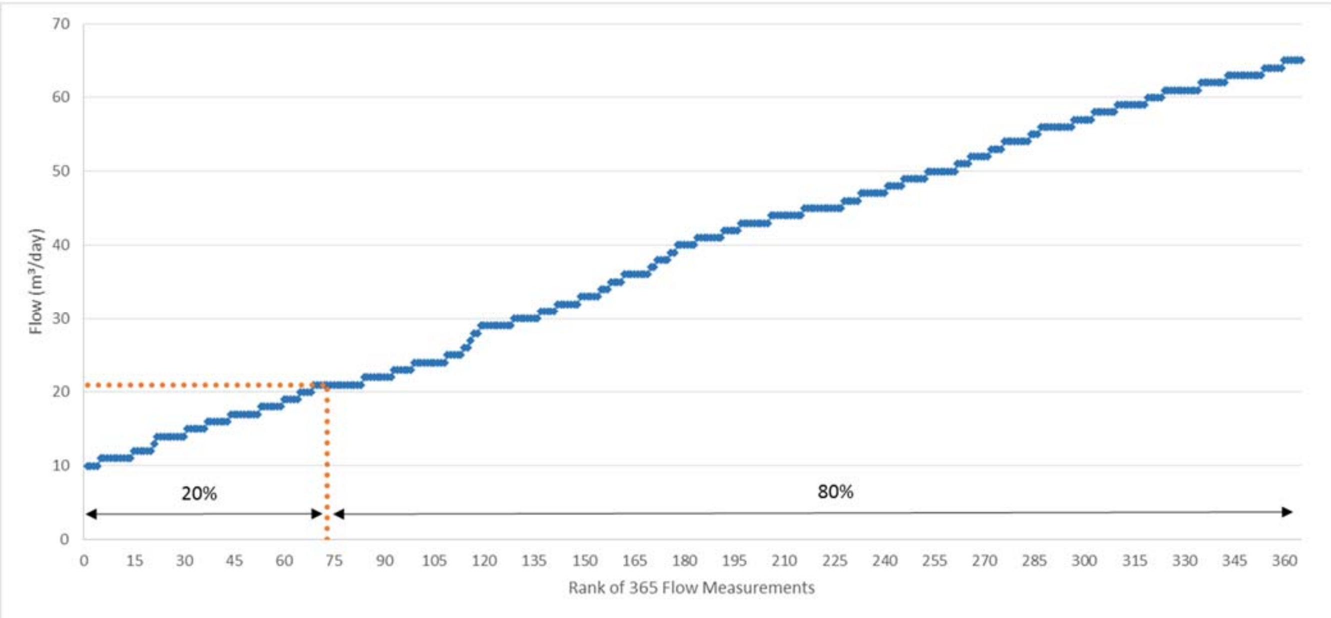
2.2.1.1 Continuous flow is measured at >52% of our wastewater treatment works (covering >99% of the population), usually those with a population greater than 250. Historic data provides an indication of Dry Weather Flow (DWF), multiples of flow treated and permit limits are usually applied to both, or one of these, with values of m^3/day and/or l/s.

2.2.1.2 Some permits may not have either of these values, and there are a number with a requirement to “treat all flows’ received at the works”.

2.2.2 Dry Weather Flow (DWF)

2.2.2.1 Dry weather flow is measured using MCert flow meters, which record the total daily volume. It is well-represented by the non-parametric 80% exceeded daily flow of the discharge (known as the Q80, the Q80 percentile or 80%ile) and accepted by the Environment Agency as an appropriate measurement of DWF. Out of 365 measured values of the total daily volume in a year, the DWF will be the value that is exceeded by 80% of the values (73rd Value) as below:

Figure 5 Q80 Calculation for wastewater treatment works using total daily volumes. (Q80 is the 73rd total daily volume when ranked)



2.2.2.2 DWF is calculated using historic five-year Q80 values from years with reliable data. In turn, reliable data is defined by the number of days in a year that a total daily volume is available. More than 329 days (90%) is considered reliable to calculate an annual Q80/Q90.

2.2.2.3 Where there is no measured flow data (or the data is unreliable) a theoretical DWF is calculated as below:

$$\textbf{DWF (m}^3\textbf{/day) = PG+I+E}$$

Where **P** = population; **G** = consumption; **I** = infiltration and; **E** = trade effluent volume.

2.2.2.4 Assumptions associated with each of these elements are included in section 3 of this report, along with how the baseline year was defined (2020) for DWF to account for a non-typical year.

2.2.3 Total household consumption

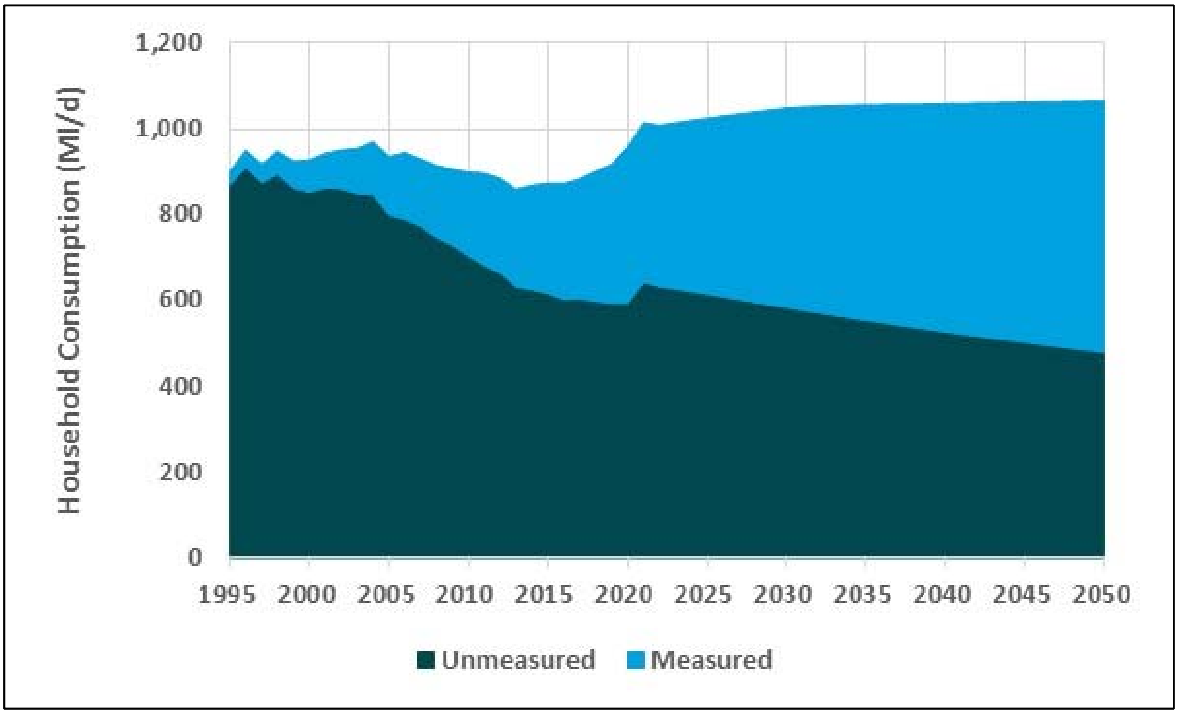
2.2.3.1 Household consumption is the volume of water supplied to all domestic customers in the region. It includes both measured (metered) and unmeasured water consumption in household properties. Projections of likely future household consumption form a key part of UUW's demand forecasts and are analysed at a TPU level.

2.2.3.2 Total household consumption is calculated as part of the WRMP, and is based on measured consumption (where available) and a micro component modelling approach and is allocated as a value of l/hd/day. This is then applied to total household population for the region.

2.2.3.3 It is assumed that 95% of water consumption is discharged to the sewer network.

2.2.3.4 Increase in total household consumption is mainly due to additional new population. Individual consumption rates are more variable and discussed in section 2.2.4.

Figure 6 Historic and forecast total household consumption United Utilities regions (from Draft Water Resources Management Plan 24)



2.2.4 Per Capita Consumption (PCC)

2.2.4.1 Per capita consumption is the volume allocated per person per day, following the household consumption analysis detailed above and applied to resident population numbers. PCC varies depending on household and customer type, and with changes over time with behaviour, appliance use and other influences such as:

- Increased metering of household properties;
- Development of more efficient appliances (e.g. dishwashers and washing machines);
- Building regulations driving more efficient use of water in new properties (e.g. smaller toilet cisterns);
- Water efficiency promotion; and
- Increased customer awareness to use water more efficiently.

2.2.4.2 There are a range of factors affecting future demand for water and the changing patterns of demand following the COVID-19 pandemic, economic and migration factors and climate change impacts, meaning it is challenging to forecast future demand. Whilst UUW aims to employ the best available data and methodologies to forecast demand, there is inevitably uncertainty inherent within our forecasts. Consumption is only one element of the discharge to sewer, and whilst it is important to accurately reflect the rate within the forecast, uncertainties can be mitigated by refreshing baseline measured data and monitoring the forecast against updated values.

2.2.5 Visitor consumption

2.2.5.1 Visitors are defined as temporary non-household population with a domestic discharge. They can be day visitors or overnight visitors, such as holiday population or commuters. Visitor numbers are allocated to TPU drainage areas annually, based on assumptions from Global Tourism Solutions STEAM model. STEAM is a tourism econometric impact modelling process, which measures tourism from the bottom up, using a wide range of tourism impact data. It generates data from four main visitor types: staying in serviced accommodation; staying in non-serviced accommodation; staying with friends/relatives and; tourist day visitors.

2.2.5.2 For this iteration of the DWMP, visitor numbers have not been used in continuous flow assumptions due to the reliability of the information available. Where there is good evidence on number of visitors (usually at a defined local drainage area), this can be applied for additional scenarios at TPUs. Visitor numbers are also included for more detailed option development at locations where there is significant impact at peak times. Peak times could be working days for commuters or summer months and bank holidays in areas with significant tourism.

2.2.5.3 It is assumed that overnight visitors consume 80% (l/hd/day) and day visitors consume only 20% (l/hd/day) of domestic consumption rate.

2.2.6 Non-household consumption

2.2.6.1 Non-household consumption is the volume of water UUW supplies to all commercial customers in the region (e.g. universities, hospitals, cafes, offices and other premises) that are not considered to be trade effluent and, therefore, not monitored and regulated as such. The volume of non-household consumption is calculated regionally for the Water Resources Management Plan (WRMP) and allocated to Water Resource Zones. There is not enough reliable data to allocate this to TPU drainage areas, and water used for industrial purposes (which is included in the water consumption volumes) does not necessarily discharge to sewers in the same levels as it does for domestic or non-household customers, so it is difficult to make assumptions based on these volumes. As more reliable data is collated over time on domestic discharge volumes from commercial properties, this can be assessed better. The benefit of using measured flow as a baseline means that individual elements have been accounted for.

2.2.7 Trade Effluent discharge

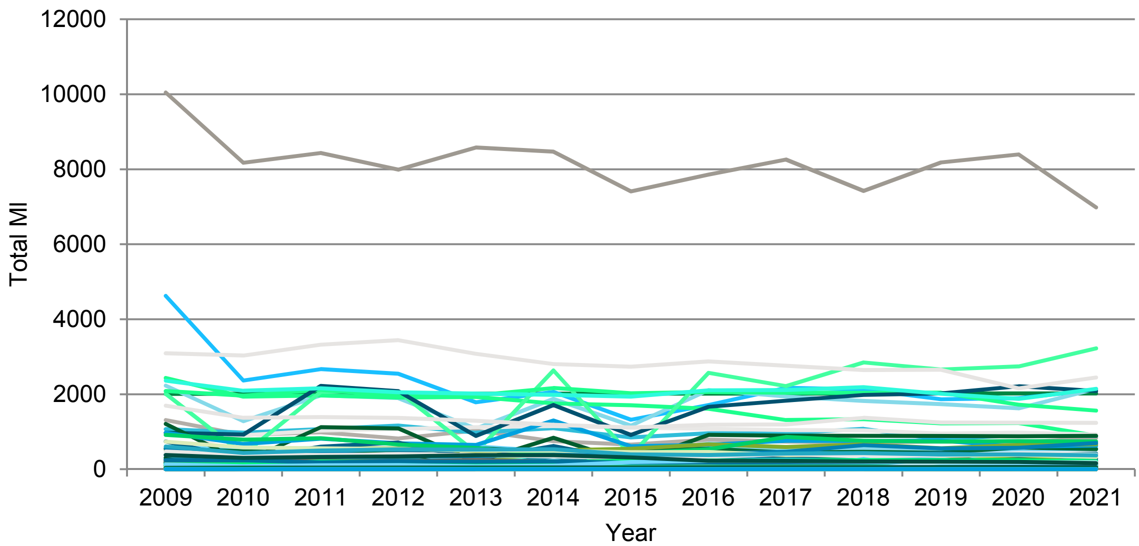
2.2.7.1 Trade effluent volumes are discharges from commercial traders that are measured and reported annually for each wastewater treatment works. Daily volumes are recorded for different traders and can be analysed independently at specific locations if required. Assumptions are applied to annual values to calculate daily volumes as below.

- Standard Assumption: Total (annual) Volume ÷ 365 (days per annum) = average m^3/day; and
- Alternative assumption: 5 (working days per week) ÷ 7 (days per week) × Total (annual) Volume÷ 365) = average m^3/weekdays.

2.2.7.2 Historic trade effluent discharge is reviewed as part of the forecasting with analysis of trends of different trader type. It is difficult to interpret trends from trader types at TPU (Figure 7), as historic variations may be due to drivers specifically associated with individual traders. For example, the performance of a large trader could disproportionately affect the trend of trade flow into a wastewater treatment works. Evaluation of the flow by trader type shows variation year-on-year (could be due to different economic factors associated with individual traders, so assumptions are based on historic values in the majority of locations).

2.2.7.3 Overall, the historic trade effluent volumes in the region have reduced over time.

Figure 7 Historic trade effluent volumes (Ml/year) by wastewater treatment works



2.2.7.4 A standard assumption for the baseline (2020) trade effluent is used. For future baseline assumptions, the impact of COVID-19 will be accounted for as the months where traders shut down will influence the annual flow volumes.

2.2.8 Infiltration (continuous surface water discharge)

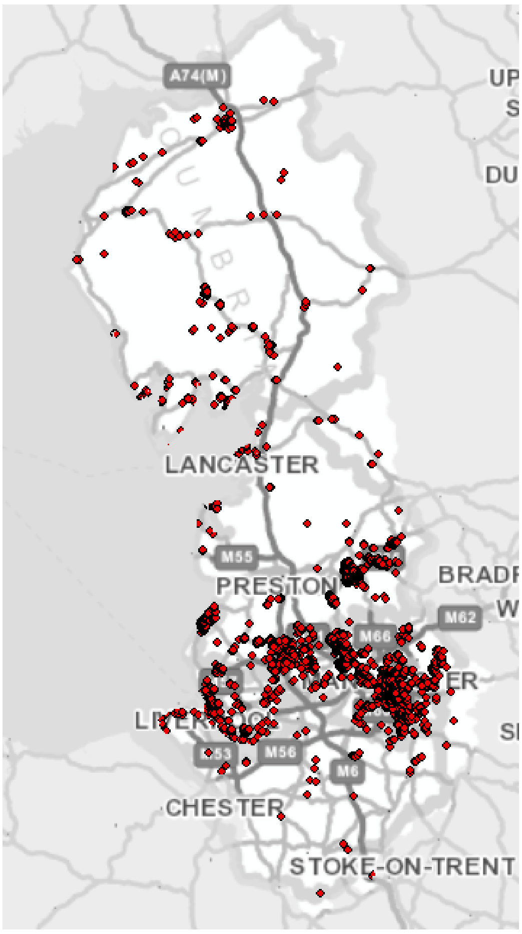
2.2.8.1 Infiltration for continuous flow is defined as the element of flow that is not foul discharge. It is surface water that enters sewers from property or land. For the calculation of continuous flow, it is assumed that once domestic foul discharge and trade effluent has been accounted for, the remaining flow is infiltration. The calculation Infiltration (I) = DWF-PG-E is applied to measured flows, where P = population; G = consumption; and E = trade effluent volume (assumptions associated with each of these elements are included in section 4 of this report).

2.2.8.2 Infiltration values within continuous (measured) flows are variable for each TPU and are also seasonal due to rainfall.

2.2.8.3 Where there is no measured flow data, a standard assumption of infiltration can be applied to the existing population. This is usually between 100 and 200 l/hd/day, depending on the drainage environment. Some areas in the region have significantly higher levels of infiltration due to sewer length, ground conditions and rainfall run-off rates, amongst other things. Locations with higher infiltration levels are usually where there are long sewer lengths in rural areas with high rainfall (Figure 8).

2.2.8.4 Newly built properties have low levels of infiltration as the majority of the surface water should discharge to a waterbody or sustainable drainage system (SuDS), but an assumption is applied when forecasting to account for some additional surface water associated with new development. More information on this can be found in section 4.4

Figure 8 Regional map of historic continuous infiltration in the region using assumptions applied to measured flow data where available



2.2.8.5 In some areas with high numbers of visitors in comparison to the household population, the infiltration value for existing population may include the domestic discharge by default in the assumption as it is not possible to isolate the visitor discharges within the measured baseline flow. Better analysis of historic visitor data will enable us to allocate elements of continuous flow more accurately, and lead to a better understanding of actual infiltration in each TPU. This will help develop more accurate forecast flow and loads.

2.2.9 Non-Household Infiltration (continuous surface water flow)

2.2.9.1 An assumption on surface water run-off from non-household properties is not currently available. Better information on infiltration associated with commercial properties is needed to fully identify the element of total surface water flow allocated to non-households, but has not been included in this iteration of the demand forecast. The benefit of using measured flow as a baseline means that individual elements have been accounted for.

2.3 Influent composition

2.3.1 Composition of influent at wastewater treatment works is measured through spot or composite sampling. Typical determinands that are sampled are shown in Table 2. Sixty one percent of permits have numeric limits, and this covers more than 99 percent of the population.

Table 2 Determinands sampled at wastewater treatment works influent (crude). (Note: crude sample data is not available at every treatment works)

Determinand	Units
Commonly Measured	
Biological Oxygen Demand (BOD)	mg/l
Chemical Oxygen Demand (COD)	mg/l
Suspended Solids	mg/l
Ammonia	mg/l
Less commonly measured	
Alkalinity	mg/l
Phosphorous	mg/l
Iron	mg/l

2.3.2 The information is used to understand the risk of incoming load composition at wastewater treatment works, and the treatment process type and size required to reduce volumes for discharge to the environment. It can also be used where percentage removal across the process is used for compliance assessment.

2.3.3 The total incoming load is calculated as a daily and/or annual volume where flow measurement is also available. This is not completed as part of the demand forecast, but has been completed for individual capacity models developed for the wastewater treatment compliance BRAVA. A ratio of load to flow is applied as a baseline assumption. More information on how this has been applied is available in Technical Appendix 5 – Assessing Future Risk.

2.3.4 Understanding of trade effluent crude composition is measured independently and the values can be extracted for analysis (section 2.3.8).

2.3.5 Where there is no crude data available, an assumption for some of these determinands based on domestic population is applied (section 2.3.7).

2.3.6 Evaluation

2.3.6.1 Measured crude data is collected at many of our wastewater treatment works and there may be limited sample results making regional analysis inappropriate. Changes and trends are hard to verify unless there are enough sample results to make the review statistically significant.

2.3.6.2 Additional elements that impact on treatment, and increase with changes in upstream discharge quality such as rags and grit, have not been included in the demand forecast, but could potentially be reviewed in future iterations of DWMP if more analysis on the cause and impact provides better understanding.

2.3.7 Domestic influent composition

2.3.7.1 An estimate of household discharge composition can be applied to establish a population equivalent (PE) from measured crude data. The table below indicates which elements are used to verify baseline data and for forecasting purposes.

2.3.7.2 Different wastewater sources, such as trade effluent and holiday populations, result in a variation in the loads observed in the influent. Table 3 defines standard theoretical per capita loads for a range of domestic sources.

Table 3 Assumptions of criteria per capita load for resident population

	Residential Domestic	
BOD g/hd/day	**60**	Based[1] on the PE definition of 1PE = 60g BOD/d
Chemical Oxygen Demand (COD) (unsettled) g/hd/day	**120**	Align with typical wastewater constituent data recorded in Metcalf & Eddy[2], (2013)
Suspended Solids (SS) g/hd/day	**70**	Align with typical wastewater constituent data recorded in Metcalf & Eddy[3], (2013)
Ammonia g/hd/day	**7.7**	Align with typical wastewater constituent data recorded in Metcalf & Eddy[4], (2013)
Total phosphorous g/hd/day	**2.2**	Based on crude sewage sampling data for 16 AMP5 phosphorous removal projects
Total nitrogen g/hd/day	**12**	Based on proportion of ammonia comprising 60–70% of total Kjeldahl nitrogen (TKN) (Metcalf and Eddy, 2013). This value is subject to confirmation as more information becomes available

2.3.7.3 Alkalinity in sewage is dependent on a wide range of factors and, for this reason, consideration of alkalinity should be based on measured data.

2.3.8 Trade effluent composition

2.3.8.1 Trade effluent (defined in section 2.2.7) is an element of influent composition that can be reviewed separately to the overall composition of the influent and analysed independently. The volumes and some compositional elements are recorded annually as kg of BOD and associated PE. Additionally, specific determinands from trade are measured depending on the trade permit requirements. These are reviewed at a TPU and in more detail than is included in the regional demand forecast. Information on

[1] IWA Biological Wastewater Treatment Principles, Modelling and Design 2008; pg.32 Section 3.4

[2] Metcalf & Eddy, Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, 2013

[3] Metcalf & Eddy, Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, 2013

[4] Metcalf & Eddy, Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, 2013

composition by trader type is collated to inform the trade effluent forecast (more detail on how this is applied is available in section 4.10.2).

2.3.8.2 The usual relationship between an unsettled COD crude sample measurement and a settled crude sample measurement is given below. This assumes 25% removal of COD in Primary Settlement.

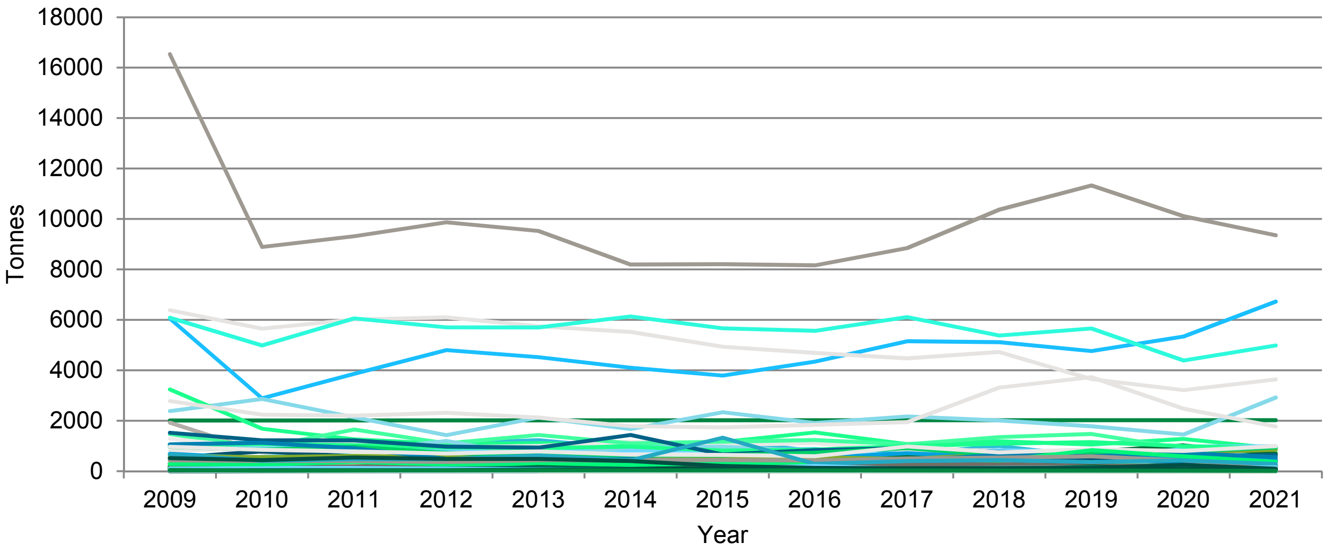
2.3.8.3 Settled COD = 0.75 x Crude unsettled COD

2.3.8.4 Estimation of BOD is made by applying the calculation to the settled COD and then modifying using the BOD/COD ratio. The default ratio is 1:3. However, this is subject to alteration on the basis of site specific information, particularly if there is a large load contribution from one or more trader(s). The COD/BOD ratio is liable to alter dependant on the type of trade effluent being discharged. For example, if there is a high proportion of food waste then the proportion of BOD is likely to be higher.

2.3.8.5 Suspended solids is also measured and reported for traders discharging to a wastewater treatment works, so can be analysed independently to establish a baseline value to build forecasts on.

2.3.8.6 Historically, there is variation in these elements year-on-year, but the long-term trend is a reduction in both flow and load (since 2010), due to more traders pre-treating discharges, and an overall decline in trade effluent. There are variations locally where new traders are established, existing traders change trade type or cease to trade, the impact of this is monitored and used to inform trade effluent forecast assumptions. The variation in historic total COD is shown in Figure 9.

Figure 9 Historic trade effluent total COD (Tonnes) by wastewater treatment works



2.3.9 Other elements of influent composition

2.3.9.1 Composition of visitor discharge, infiltration and non-households is difficult to define as they are not monitored independently.

2.3.9.2 Assumptions are made for visitors (day and overnight) if a more detailed understanding of theoretical baseline or forecast is required. Assumptions identified below.

Table 4 Assumptions criteria per capita load for visitor population

	Overnight visitors	Day visitors	Caravans
BOD g/hd/day	40	20	40
COD (unsettled) g/hd/day	80	40	80
SS g/hd/day	40	20	40
Ammonia g/hd/day	5	3.5	7.7

2.3.9.3 Overnight visitors assumption is two-thirds residential per capita load for BOD and COD and day visitors assumption is one-third residential per capita load for BOD, COD and suspended solids, and half the ammonia load based on the activities of this group.

2.3.10 Using measured influent load to calculate PE

2.3.10.1 The assumptions in different wastewater sources, such as trade effluent and holiday populations, result in a variation in the loads observed in the influent. Table 3 and Table 4 define standard theoretical per capita loads for a range of domestic sources and can be applied to calculate a PE, this includes all incoming loads (including trade) and converts it to a common unit for comparison between TPUs. This is usually completed using measured BOD mg/l per population. The values are used to verify population assumptions for solution design.

2.4 Sludge volume and composition

2.4.1 Sludge volumes are measured at wastewater treatment works with sludge treatment facilities and indigenous sludge figures in dry tonnes per annum, with the corresponding % dry solids reported annually as part of the Regulatory Return for each applicable site.

2.4.2 A regional sludge forecast is produced by applying assumptions on sludge volumes to population growth and trade effluent forecast. Assumptions are also applied based on the treatment type and phosphorous removal requirements (current and future). The detail of these assumptions is included in Appendix A.

2.4.3 In addition to this, a three-year average of the tanker movement data is used to get an indication of where sludge is typically transported between smaller works to thickening/digestion sites and adjusted to reflect future operational requirements.

2.4.4 Additional sludge volumes are also generated as an output of the wastewater treatment options so different scenarios can be analysed and reflected in the regional sludge strategy.

3. Regulatory guidance on forecasting demand

3.1 Overview

3.1.1 UUW agreed demand forecasting methodology follows the guidance set out by the Environment Agency in their Water Resources Planning Guideline[5] (2020) and referred to in DWMP Framework Report[6]. The guidance has been developed through a range of UK Water Industry Research projects and other relevant studies.

3.1.2 In addition to this, assumption on flows and loads from internal technical standards have been applied, based on previous recorded data, research and agreed values with the Environment Agency.

3.2 Planning Scenarios

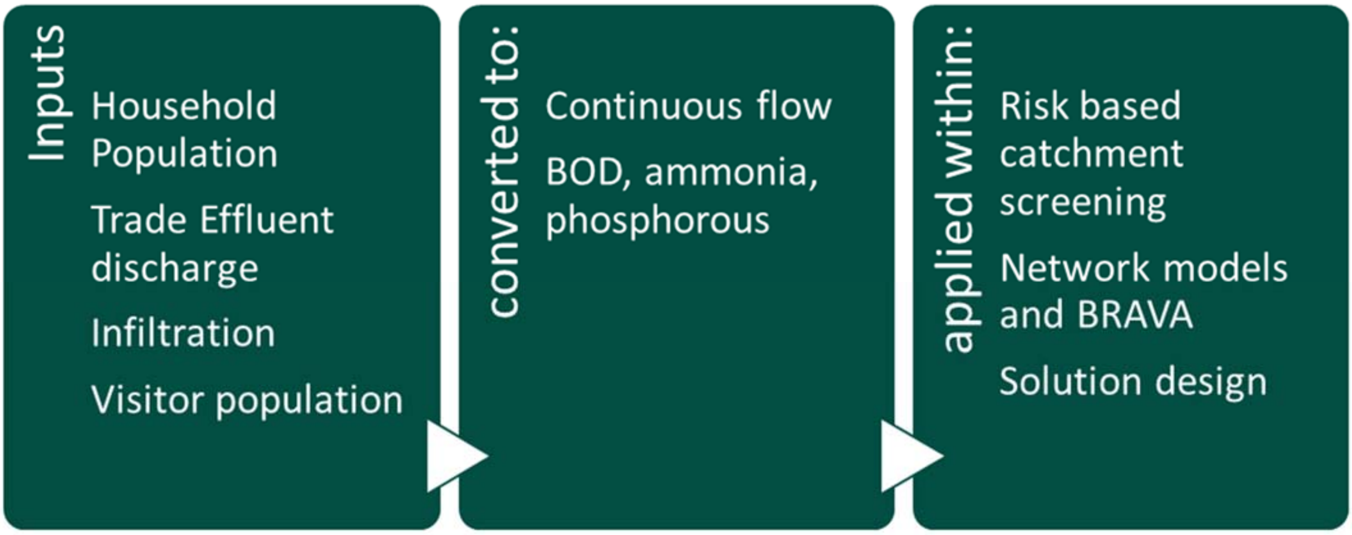
3.2.1 The planning period, for which demands will be forecast for UUW's DWMP, is 2020 through to 2050, with a scenario identified at 2030.

3.2.2 A central forecast of demand is applied to all drainage areas, with alternative forecasts at those identified as requiring extended or complex risks assessments (Section 5: Alternative scenarios).

3.2.3 Application of the Central Forecast:

- The central forecast is used throughout the DWMP process as indicated in Figure 10:

Figure 10 Central Forecast



[5] https://www.gov.uk/government/publications/water-resources-planning-guideline/water-resources-planning-guideline [accessed: 28/12/2022]

[6]DWMP Framework Report *Appendix C Baseline risk and vulnerability assessment; and problem characterisation, Section C.2.4. Inputs to the assessments*

4. Demand forecast inputs and processes

4.1 Overview

4.1.1 This section provides information on how the baseline was calculated for each element of demand and the assumptions applied to provide a forecast. It also gives a view of certainty in the forecast and how variations in this can be mitigated.

4.1.2 The demand forecast is used for different stages of DWMP, initially as part of Risk Based Catchment Screening (RBCS), then as inputs to multiple Baseline Risk and Vulnerability Assessments (BRAVA) and it is also refreshed for option development.

4.1.3 Continuous flow is calculated using forecast household consumption, infiltration and trade effluent discharge. Methodologies and assumptions for these elements are detailed below.

4.2 Population, properties and occupancy

4.2.1 Overview

4.2.1.1 The baseline year is set at 2020, and the reported household population or this year is used. There are population variations in preceding years at some TPUs, but most increase consistently over time in line with local development and, therefore, the 2020 baseline is considered representative of the existing population.

4.2.2 Population and properties forecast

4.2.2.1 In line with the DWMP framework, UUW has used a local plan housing plan 'trajectory' forecast for much of UUW's population forecast. Along with UUW's property forecast, this feeds into the household demand forecast. The forecast approach is in line with that used for WRMP.

4.2.2.2 The methodology for deriving housing plan population forecast starts from using the trend-based Office of National Statistics (ONS) projection. In order to link population growth to UUW's housing plan forecast, the ONS forecast is uplifted to ensure the reconciliation between population change and the capacity of the housing stock. The forecast has been derived from local authority data at sub drainage level. This is built up to tactical planning units for DWMP.

4.2.2.3 In addition to this, a review of current planning applications and local authority plans and information to ensure any recent changes are incorporated in the risk assessments and solution development.

4.2.3 Demolitions

4.2.3.1 The forecast does not account for demolitions but overall population is reconciled to the regional forecast. Numbers become superseded in the long-term forecast as the population data is re-baselined every year.

4.2.4 Void properties

4.2.4.1 Assumptions on void properties have not been included as part of the demand forecast. It is assumed that using baseline measured flow for the majority of TPUs mitigates the risk of discounting the flows and loads associated with these, as the numbers are included in baseline assumptions.

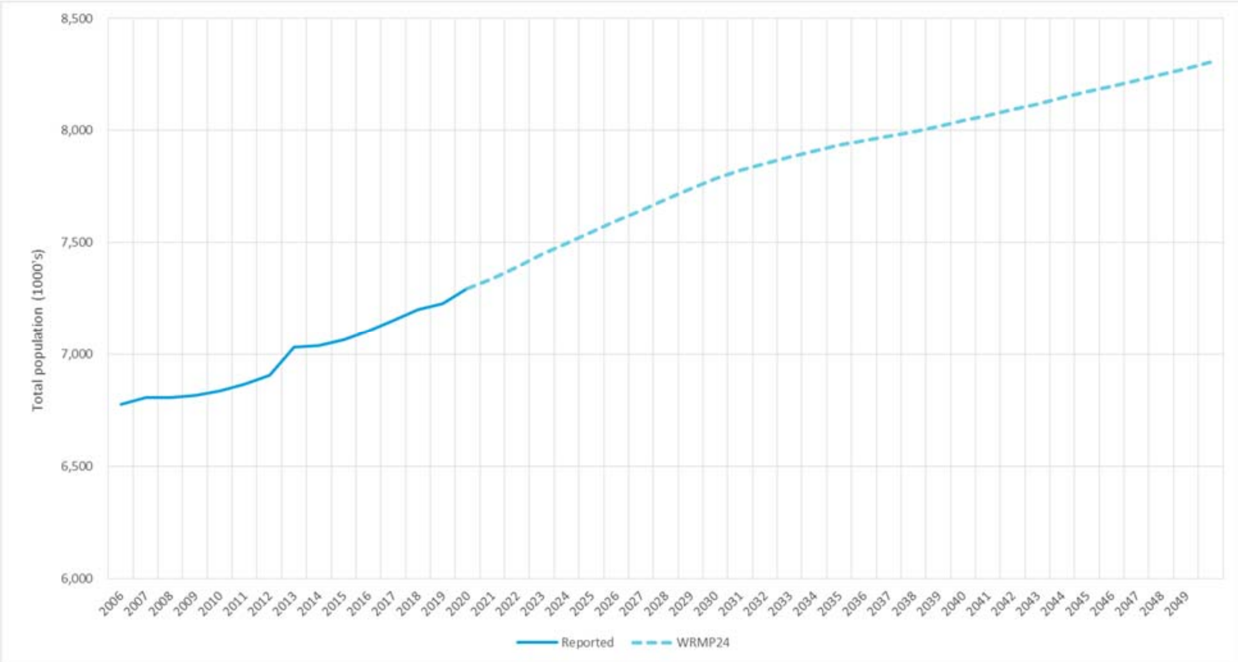
4.2.5 Occupancy forecast

4.2.5.1 A key component of any housing-led population and property forecast is the average 'occupancy' associated with the changing housing stock. The general 'aging' of the UK population results in a reduction in average occupancy, with the older population typically having smaller occupancy levels compared to the younger population. Since the financial crash of 2007/08, a counter-trend brought about by both financial constraints and a mismatch between demand and supply of new homes, has seen a reduction in the speed at which young adults are able to form new households, resulting in a dampening of the rate of occupancy reduction. These factors are considered in the housing-led analysis.

4.2.5.2 In WRMP19, assumptions of household occupancy rates are based on surveys of household size undertaken in 2003, 2007, 2011 and 2016. For the WRMP24, the updated occupancy rates as forecast by Edge Analytics are used. This is in line with UUW's most recent occupancy rate survey.

4.2.5.3 Due to the timescale for DWMP risk assessments, WRMP19 occupancy rates were applied for risk assessments (RBCS and BRAVA), with changes over time as occupancy reduces. Solutions were developed with updated occupancy rates and these will also be included in PR24. The regional total population values from the WRMP24 are shown in Figure 11.

Figure 11 Long-term trend in UUW's total population, with housing-plan led forecast from 2020. Draft WRMP Technical Report – Demand for Water



4.2.5.4 Using the housing plan as an assumption instead of ONS trend-based population leads to a higher overall discharge volume, but is viewed to be more representative of future growth.

4.2.6 Bespoke household population forecast

4.2.6.1 In addition to the population forecast produced for the WRMP, a more detailed assessment of local planning data and planning applications has also been undertaken to make sure the development locations are allocated to the most likely drainage area with assumptions on occupancy rates from the WRMP applied to property forecasts. This analysis is to understand specific impact on drainage areas and the approach has been shared with all local planning authorities.

4.2.6.2 Wastewater treatment assessments have also used local detailed assessment results, where available, and local plan-based housing trajectory where not. Network models use the local plan housing trajectory, with the exception of locations where it was identified that a significant development would cause a capacity risk to the local sewer network. The details from these new development sites were included in the network model for these locations. More detail on assumptions used for network modelling is available in Technical Appendix 5 – Assessing future risk.

4.2.6.3 Significant updates (such as major changes in planning information) have been applied through the screening, risk assessment and option identifications process to capture changes in assumptions of extent or locations of new developments.

4.2.6.4 Limitations of this methodology is that the assumptions made on location, timing and extent of new properties can change over time. Planning targets are reviewed, local plans may be developed, and planning applications can be refused. This risk is mitigated by reviewing population forecasts when there is a substantial change in the Local Development Plan, when forecasts are updated as part of other business processes such as the WRMP or the Price Review and by tracking connection data. Population risk-based screening is also reviewed every year so that changes to the baseline versus the forecast can be monitored.

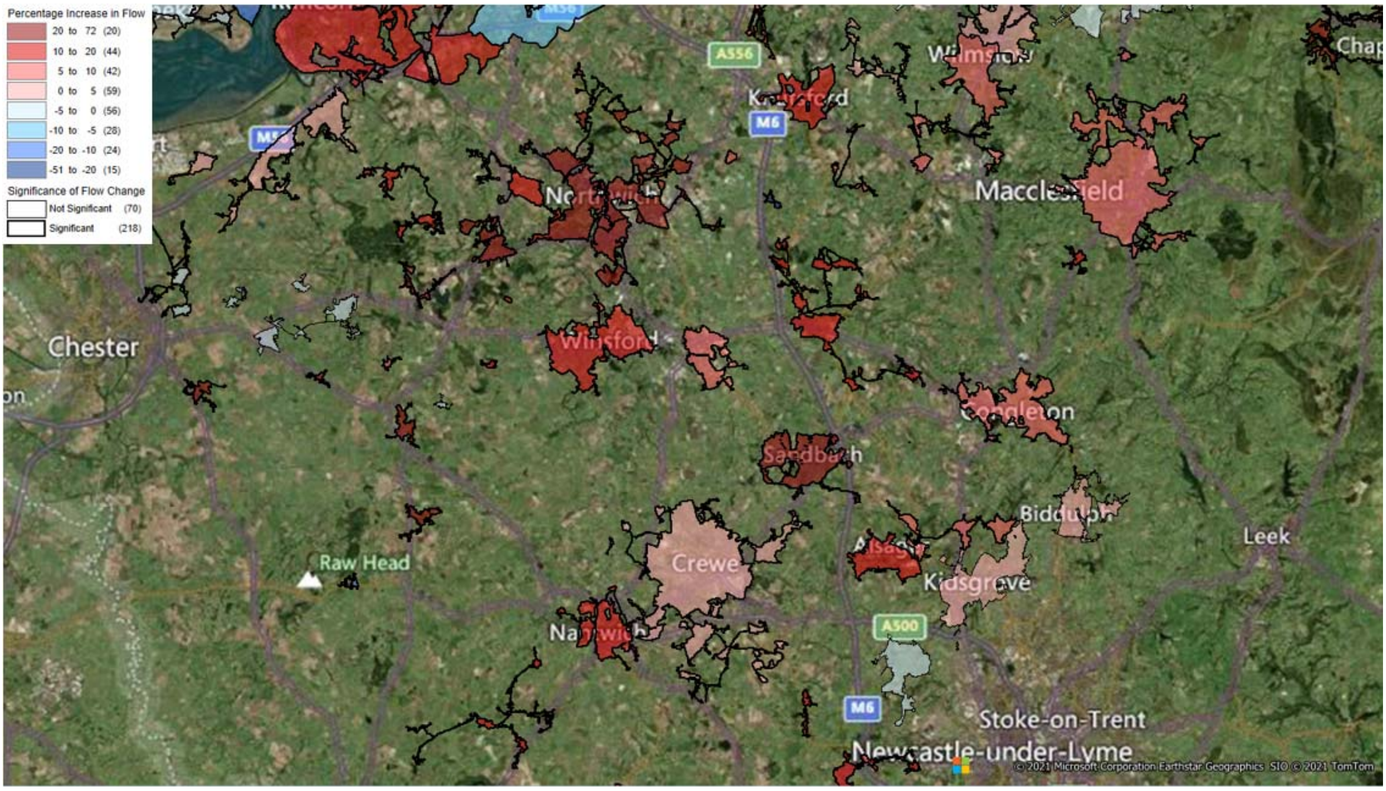
4.2.7 Visitor population forecast

4.2.7.1 Visitor populations are defined as a non-household customer that has a domestic discharge volume. They can be overnight visitors or day visitors and both can have an impact on domestic demand.

4.2.7.2 A forecast of visitor population is not completed regionally, but historic numbers are allocated to TPUs and reported annually. For the demand forecast, the baseline visitor numbers are set at 2020, this was allocated before the COVID-19 impact on movement. The impact of COVID-19 led to an initial reduction of holiday population, as local restrictions were in place, and a subsequent increase due to restrictions on travel abroad and an increase on UK holidays. It also led to a large number of household customers working from home, so commuter locations saw reductions in daytime numbers, and commuter towns outside of business intense towns and cities showed an increase.

4.2.7.3 Visitor numbers have been included as static (baseline 2020) for this iteration of the demand forecast. A review of the impact of COVID-19 on visitor numbers has been completed and the information from this impact on flow volumes, along with ongoing monitoring of visitor numbers, will be used to understand potential changes and the likely impact of this for the next output of the DWMP. There is currently uncertainty associated with the permanence of any significant change. The example below shows locations in the South of the region where an impact on dry weather flow to wastewater treatment works has been observed during the COVID-19 pandemic period; likely due to people working from home and reduced numbers of visitors.

Figure 12 Flow changes to wastewater treatment works during the COVID-19 Pandemic



4.2.8 Population forecast methodology evaluation

4.2.8.1 The key assumption in using housing plan forecast for population is that there is a relationship between the homes that are built and population increase in UUW's operating area. This can be explained where people enter the North West region over and above natural population changes and international migration. For example, in Carlisle, UUW are anticipating the new garden village development; considering the size of the development, it is likely additional people will move from outside the drainage area in order to fill the new properties. For consistency, UUW have applied the same assumption to all drainage areas.

4.2.9 Application of population forecasts

4.2.9.1 Population forecasts are included within the demand forecast as an assumption for future flow and load, and applied to the baseline risks and vulnerability assessment (assessment of future need).

4.2.9.2 Population forecast is also a specific risk-based catchment screening assessment, to identify which locations are likely to see significant growth and, therefore, need a more detailed review of risk.

4.2.9.3 Population forecasts are also used in assumptions for option development. Regional options (customer side management) benefits can be allocated to numbers of future population, and drainage area or problem specific options are designed for the future flow and load associated with the increased population (along with additional identified risks).

4.2.9.4 Where there is uncertainty on which TPU new development(s) will discharge to, the risk can be addressed strategically. Different scenarios are identified and the risk assessed for all. More information on this is given in TA5 – Assessing future risk.

4.3 Consumption rate

4.3.1 Household consumption rate

4.3.1.1 Baseline household consumption rate (regional average) from WRMP19 is included in baseline flow calculations and included as a l/hd/day value for all future populations in line with changes in the WRMP. These assumptions were used for RBCS and BRAVA that had continuous flow as an input.

4.3.1.2 Updated WRMP24 forecast consumption rates are used for option development to ensure that the change is accounted for in solutions.

4.3.1.3 Further changes in consumption rate are incorporated into the demand forecast and used to assess the increase in future continuous flows. This can also be used in environmental models to understand if there is an impact on environmental deterioration, and as part of the Price Review to ensure the most up-to-date assumptions are included in solutions. The data is refreshed fully for the next iteration of DWMP.

4.3.2 Evaluation of household consumption rate methodology

4.3.2.1 There are limitations using a standard consumption rate per person, as discharge can vary between house types (single occupancy households use more water per person than multiple occupancy). These differences are not included on the standard forecast scenario, but can be developed for TPU locations if required to better design solutions. If more information becomes available on demographics and housing types (existing and future) more detailed assumptions can be applied.

4.3.2.2 The risk of over or underestimating consumption rates within certain demographics is mitigated by using a measured baseline flow wherever possible. Standard assumptions are applied to current and future consumption, but this is built on a measured starting point.

4.4 Infiltration (continuous surface water discharge) forecast

4.4.1 Measured household surface water is included in the baseline flow where available and a theoretical assumption applied where not, as a value per person (section 2.2.8).

4.4.2 An assumption of 55 l/hd/day is applied to new property population and added to the baseline flow. There is no change to the infiltration rate per person (existing or new properties over time) as there is insufficient evidence to verify that values increase or decrease over time. Some alternative rates are applied as part of complex BRAVA to provide some sensitivity analysis to different future situations. The details of these differences are included in section 5 Alternative scenarios.

4.4.3 No assumptions of forecast infiltration are applied to non-household or trade properties, but the volumes are included in the baseline flows.

4.4.4 Infiltration is, therefore, allocated by a common variable (household population) for continuous (dry weather) flow.

4.5 Trade Effluent flow forecast

4.5.1 Baseline and central assumptions

4.5.1.1 Baseline trade effluent flow is usually applied as an average of five recent years and forecast at this level unless there is reliable information on a change. Alternatively, a maximum historic value can be applied or a total permitted value to ensure that a sufficient level of risk has been accounted for.

4.5.1.2 Using permitted flows can lead to overestimation of the extent of the risk as many traders have permit headroom but don't use it, and don't have plans to increase the current operational discharge. This assumption is acceptable for small trade effluent discharges below minimum billing.

4.5.1.3 Alternative (site specific) analysis can be applied for solution design that includes the permit limits of the highest trader and the historic average of all others. The decision on trade effluent design allowance is made on a site by site basis, depending on the latest and best information available at the time.

4.5.1.4 For calculation of the trade contribution to theoretical DWF as part of the demand forecast, the average flow and loads of the last five years is used as a baseline value and an assumption that the flow and load will continue at this rate with the exception of locally identified trade effluent increases, with high certainty that there is an increase or decrease.

4.5.2 Regional trade effluent forecast

4.5.2.1 A trade effluent forecast is produced regionally using economic scenarios applied to different trader types. The assumptions on increase (as a factor by trader type) is applied to all trader discharging to a wastewater treatment works and consolidated at TPU, but this is not a reliable assumption to apply to small geographical boundaries where there may only be one or two trader discharges.

4.5.2.2 Changes in trader volume and composition at a local level, are more likely to be due to individual trader changes (either increase/decrease or change in trade type). Therefore, trade effluent forecast values are only used as an input to the sludge forecast (at a regional level) or reviewed as an alternative for UUW's larger wastewater treatment works.

4.6 Non-household discharge forecast

4.6.1 Non-household discharge is included in the baseline flow for 2020, with the assumption that it remains at that volume. If the baseline flow is theoretical, it is generally small, domestic catchments with low numbers of non-households so the flow and load from these properties are within the assumptions of consumption for resident population.

4.7 Total DWF discharge volume forecast

4.7.1 Baseline DWF (2020) has been calculated using up to five years of measured Q80 (2015–2019) where available. Where there are <90% of total daily volumes recorded, the data is considered unreliable and not included and where <90% of days do not have reliable data (over a year), the measured flow is not included in the baseline. The years of reliable data used is indicated for all wastewater treatment works in the Demand Forecast so a level of confidence can be assigned. A consolidated baseline flow is required to account for inconsistences over previous years associated with external factors such as rainfall, dry weather and more recently, the impact of COVID-19 on population movements and trade.

4.7.2 Where measured flow data is not available or unreliable, a theoretical DWF calculation is made:

$$\textbf{DWF (m}^3\textbf{/day) = PG+I+E}$$

Where **P** = population; **G** = consumption; **I** = infiltration and; **E** = trade effluent volume.

4.7.3 This calculation is also applied to future population, consumption and trade forecasts and added to the baseline to produce the future dry weather flow.

4.8 Average discharge volume forecast

4.8.1 The baseline average flow is applied in the same way as DWF using average measured total daily volumes up to five years (if reliable). The ratio of DWF to Average flow can be different, but once the measured baseline has been set, a percentage increase (from DWF forecast) is applied to the baseline to calculate future average flow. Where measured data is not available a 1.3 × DWF is considered representative of average flow.

4.8.2 Average flow is used within environmental river models to assess deterioration, more detail on how this is applied is available in technical appendix 5 – Assessing future risk (TA5).

4.8.3 Average flow is also used for wastewater treatment solution design calculations.

4.9 Hydraulic network models

4.9.1 Individual TPU hydraulic network models are utilised to assess hydraulic flood performance and storm overflow activation performance across the region. The baseline models (2020 planning horizon) are historically verified against short-term flow surveys and long-term measured flow data where available.

4.9.2 Assumptions taken in model inputs are aligned with those included in the continuous flow demand forecast where appropriate, and were uplifted to account for future growth, development and urban creep.

4.9.3 Hydraulic model detail is included in Technical Appendix 5 – Assessing future risk (TA5).

4.10 Influent composition

4.10.1 Household composition

4.10.1.1 Baseline values of BOD, suspended solids, ammonia and phosphorous are set using measured crude data over five years (mg/l) where available, applied to measured flow to give a total daily volume. Additional assumptions are applied per person for future population to give forecast values.

4.10.1.2 This forecast is not calculated for all TPUs, but has been completed as an input to the wastewater treatment compliance BRAVA models, more detail is given in Technical appendix 5 – Assessing future risk (TA5). Two hundred and eighty wastewater treatment models were produced, covering more than 98% of PE for the region.

4.10.2 Trade Effluent composition

4.10.2.1 The same baseline assumptions from measured trade effluent flow data is applied to measured load, (an average of five recent year's data).

4.10.2.2 Using permitted loads can lead to overestimation of the extent of the risk as many traders have headroom within their permit but don't use it, and don't have plans to increase the current operational discharge, or pre-treat the discharge to a higher quality. The assumption to use permitted values is acceptable for small trade effluent discharges below minimum billing.

4.10.2.3 Alternative (site specific) analysis can be applied for solution design that includes the permit limits of the highest trader and the historic average of all others. The decision on trade effluent design allowance is made on a site by site basis, depending on the information available at the time.

4.10.2.4 For calculation of the trade contribution to load, the average loads of the last five years are used as a baseline value and an assumption that the flow and load will continue at this rate with the exception of locally identified trade effluent increases, with high certainty that there is an increase or decrease or a confirmed change in pre-treatment process.

5. Alternative scenarios

5.1 Overview

5.1.1 For locations that require an extended or more complex risk assessment (following criteria given in Technical Appendix 5 – assessing future risk (TA5), alternative demand assumptions are applied to understand the range of potential future risk.

5.1.2 Variations are applied to population, consumption rate, trade effluent flow and infiltration to recalculate continuous flow as below. No alternative assumptions on composition are applied for risk assessment purposes, but can be applied at a bespoke level for wastewater treatment works to develop alternative option scenarios e.g. maximum historic trade effluent load assumption instead of average.

5.2 Extended continuous flow forecast(s)

5.2.1 Extended continuous flow forecast (DWF)

5.2.1.1 Dry weather flow (and theoretical pass forward flow) is calculated with +/- 30% population increase.

5.2.1.2 These alternative demand forecasts are used to assess risk of future DWF compliance and potential multiples of flow requirements and applied to environmental (deterioration) models to understand the impact on final effluent permit limits.

5.2.1.3 The percentage increase in DWF at each wastewater treatment works is also applied as a risk factor to individual capacity model results to assess the risk of final effluent compliance with these alternative future flows (and loads associated with the additional population).

5.2.2 Extended flooding, pollution and cso activation forecast

5.2.2.1 Variations in assumptions (including rainfall) used for network and PIONEER models to assess flooding, pollution and cso activations are included in Technical Appendix 5 – Assessing Future Risk (TA5).

5.2.3 Extended sludge forecast

5.2.3.1 The impact of extended demand was not applied to sludge models as the regional risk is assessed. The detail within the standard model was sufficient to understand the level of risk.

5.3 Complex continuous flow forecast(s)

5.3.1 Complex continuous flow forecast (DWF)

5.3.1.1 Alternative scenarios were developed through visionary work in collaboration with Arup, more detail of this is included in the DP1 Main Document Planning tools and modelling methodologies.

5.3.1.2 The scenarios identified are 'Climate Chaos'; 'Green Guardianship'; and 'Centralised Control' with a 2050 design horizon and assumptions on population growth, consumption rates, infiltration and trade effluent applied to DWF, multiples of flow, no deterioration models. More information on this is available in TA5 Assessing Future Risk.

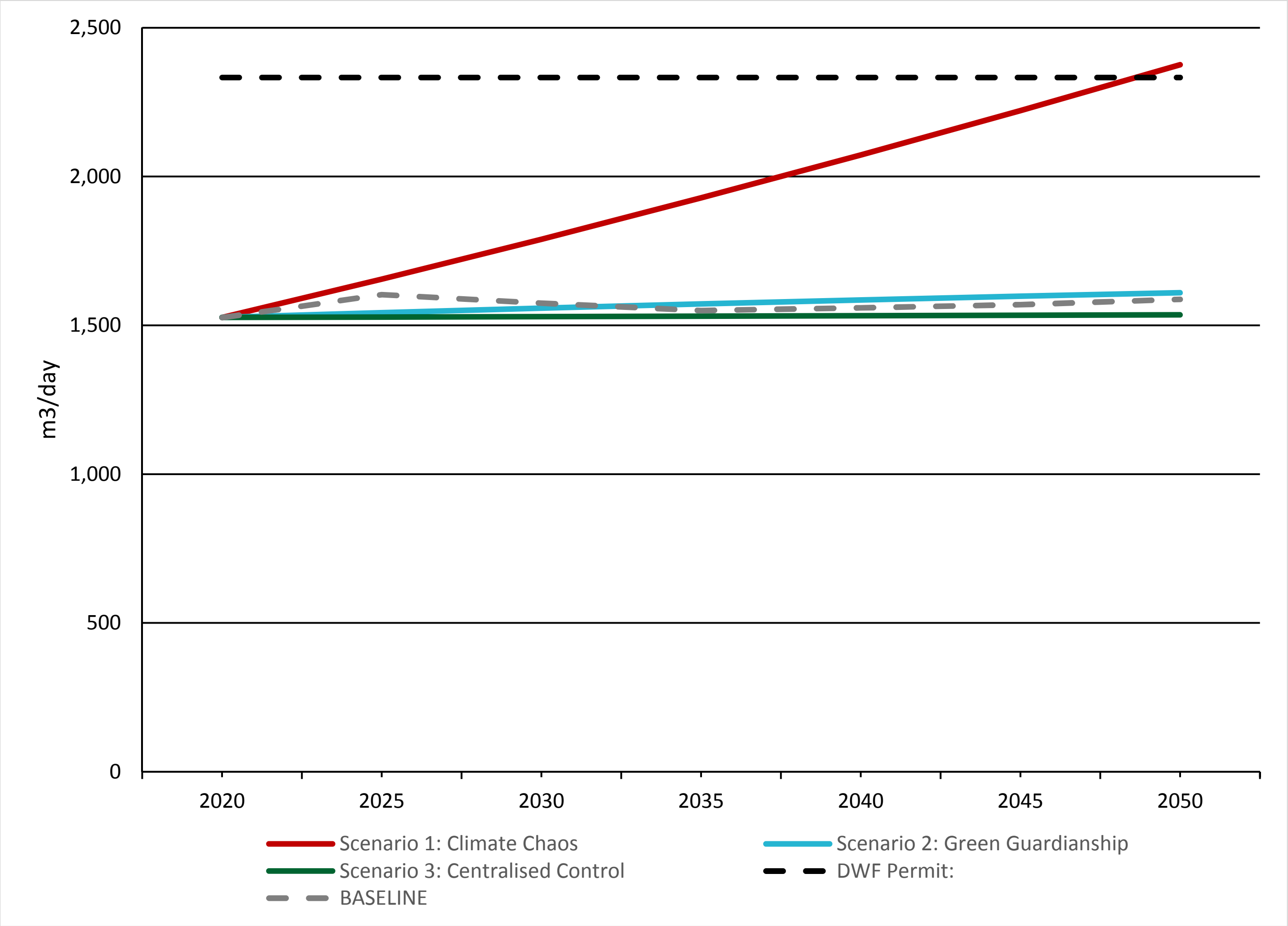
Table 5 Alternative assumptions used to forecast continuous flow in more complex drainage areas

Element of demand	Climate Chaos	Green Guardianship	Centralised Control
Per Capita Consumption	2020 rate + 35%	2020 rate -15%	2020 rate -4%
Population	Urban -3% Rural +7%	Urban +8% Rural +3%	Urban +10% Rural -1%
Trade Effluent	Average of 5 years	Maximum of 5 years	Minimum of 5 years

Element of demand	Climate Chaos	Green Guardianship	Centralised Control
Surface water (current properties)	Baseline assumption +5%	Baseline assumption	Baseline assumption +5%
Surface water (new properties)	Central assumption +5%	Central assumption	Central assumption +5%

5.3.1.3 An example of the variation of different flows as a result of the varying scenarios is shown below in Figure 13 (in a rural drainage area).

Figure 13 Applying different assumptions to elements of demand to forecast future dry weather flow



5.3.1.4 The 'Climate Chaos' scenario represents a situation where global effort to mitigate against climate change has been minimal over several decades. Green recovery intentions and the carbon ambitions have not been met and assets are being managed day to day, rather than with planned investment.

5.3.1.5 This example above is a rural location, where population has accelerated at a higher rate than in urban environments leading to increased infiltration from rainfall run-off. Household consumption has also increased as the target consumption rates have not been delivered, so the overall continuous flow has accelerated beyond the existing design capacity.

6. Evaluation and allowing for uncertainty

6.1 Overview

6.1.1 The central demand (most likely) forecast has assumptions associated with every element. Forecasts based on a measured baseline are more reliable in the short term, but uncertainty increases over longer time periods. The biggest regional risk for certainty is population forecast as both consumption and infiltration rates are applied to these numbers to understand the future flow, and future load is calculated as an assumption per person. For wastewater treatment works with high volumes of trade effluent, the impact of changes can be greater, and those with a large single trader, the impact of changes for that trader can be greater still, but data from numerous years removes some of this uncertainty and overall the forecast includes for these uncertainties.

6.1.2 Risks are mitigated by reviewing the baseline DWF assumptions annually and tracking against this. It is also important to review build out rate of new developments in different locations and understand changes in local planning information. Uncertainty is also managed through refreshing risk-based catchment screening annually and comparing the previous results to identify additional risks.

6.1.3 Multiple scenarios are applied to test risk in locations with greater uncertainty and catchments identified as requiring more analysis will have bespoke scenarios developed as part of options.

6.1.4 As more information becomes available on visitor population, household discharge rate and composition and surface water run-off through better monitoring, the demand forecast can be adapted to include this data so that future iterations have greater certainty.

7. Conclusions

7.1 Overview

7.1.1.1 For the majority of the TPUs, the central estimate is appropriate for risk-based catchment screening and for the baseline risks and vulnerability assessments. Although there are a high number of assumptions included in the forecasts, these are baselined to measured data for most of the TPUs and verified annually.

7.1.1.2 Where significant changes are made to any elements of the forecast for specific locations, such as population or trade effluent, an additional risk assessment may be required for that TPU and when a fundamental change in an assumption, such as consumption rate is made, baseline risk assessments (where continuous flow has a big impact) may need to be refreshed.

7.1.1.3 As options are developed, changes are included in the design to accommodate the additional risk, this is processed through a change control process and is part of adaptive planning over the longer term.

Appendix A

Table A1 Assumptions for sludge forecast based on treatment type

Treatment Category	g/hd/day
Conventional filter works sludge make	62
Filter works for chemical Phosphorus removal up to 1 mg/l	71.5
Filter works for chemical Phosphorus removal <1mg/l	77.5
Conventional Activated Sludge Phosphorus	71
Filter works for chemical Phosphorus removal to 1mg/l and <1 mg/l	81.9 and 88.8
Biological P removal to 1 mg/l	71
Biological P removal to <1 mg/l	82.2

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United Utilities

Water for the North West