Draft

Final Drought Plan

2022

Appendix A: How we have developed this plan

United Utilities

Water for the North West

1 Introduction

We supply water to some 6.9 million people and 200,000 business customers in Cumbria, Lancashire, Greater Manchester, most of Cheshire and a small portion of Derbyshire. We own and operate over 100 water supply reservoirs, various river and stream intakes, as well as lake abstractions and numerous groundwater sources. More than 90% of the water we supply on average each year comes from rivers and reservoirs, with the remainder from groundwater. This contrasts with the rest of England, where an average of only 60% is supplied from rivers and reservoirs. This means the way that we experience droughts can be different to other companies, particularly in terms of how quickly a drought can develop and also how quickly the system can recover. Abstracted water is treated at water treatment works before being supplied to our customers through an extensive network of aqueducts and water mains.

Our Drought Plan helps to ensure that we can maintain a resilient supply to customers during droughts. This plan represents a major update from the previous one published in 2018. This appendix highlights some of the key changes:

- New Environment Agency (EA) guidelines
- New hydrological data
- New drought levels
- Lessons learned from 2018 dry weather event
- Formation of the Strategic Resource Zone (RZ)
- Operational focus, including enhanced leakage and pressure reduction activities
- Agile communications

1.1 Updated Environment Agency Guideline

A new Drought Plan guideline was published in April 2020 and has led to several improvements over our 2018 plan. First and foremost the EA emphasises the need for the plan to be clear and easy to follow, and to take the form of an operational tactical manual. We have therefore shortened and re-formatted the main body of our plan. The document structure closely resembles the example provided in the guideline. Table 1 outlines the main changes in the guideline and how we have addressed them.

Table 1 – Summary of how we have responded to the new Environment Agency Guideline

Environment Agency Requirement	Our Approach
The technical methods and scenario testing to assess the vulnerability of your water resources to dry weather and droughts should now be in your WRMP [Water Resources Management Plan].	Our new Drought Plan links very closely with our 2019 Water Resources Management Plan (WRMP19) and will link closely with the upcoming Water Resources West Regional Plan and our 2024 plan (WRMP24). For example, we are currently building up a detailed understanding of the droughts in our

Environment Agency Requirement	Our Approach
	stochastic dataset (Section 1.2) so that common scenarios can be used across the Drought Plan and future WRMPs. This said, we feel there is still a need to undertake some new analysis for the Drought Plan due to the 2-3 year gap between drought plans and WRMPs. This is a long time in terms of tool development and data collation. Since we completed the technical work for WRMP19 we have had dry events in 2018 (Section 1.4) and 2020 which have contributed significantly to our understanding and drought management procedures. We believe that it would impair our planning if we did not update our analysis with new information. However, we have undertaken and reported new analysis in a way that does not take away from the Drought Plan as an operational tactical manual, for example by using technical appendices.
You should implement your demand saving actions first and prioritise the use of your least environmentally damaging supply actions. This means you should take actions to reduce leakage, outage and customer demand before taking more water from the environment.	We have reordered our drought actions relative to the 2018 Drought Plan. This has, for example, involved delaying drought permits until temporary use bans (TUBs) have been implemented and demonstrated to be working. We have separated drought permits into high and low environmental impact and introduced two separate implementation points (Section 2.4.5). Enhanced leakage and pressure reduction are amongst the first actions to be implemented; for more details see Appendix C. We have also outlined the actions we will take to reduce outage prior to taking more water from the environment in Section 2.4.4.1.
Your plan should categorise your drought plan actions using the level 1 to 4 definitions. This will help improve customers' and regulators' understanding of drought actions and move towards the use of consistent language.	We have replaced our previous drought triggers with the new drought levels, as shown in Section 2.3 and outlined below.
Your plan should include extreme drought management options that you could implement to delay or remove the need for level 4 severe restrictions (such as emergency drought orders that authorise stand pipes or water tanks).	We have carefully reviewed our "more before 4" actions and also enhanced our planning for the implementation of emergency drought orders (Section 2.4.6).
Your plan should show how you will work with neighbouring companies looking at region-wide responses and other stakeholders across the water sector to mitigate the impacts of droughts. This includes the benefits of joint regional water resources group communication campaigns and aligned customer restrictions as well as regional supply actions.	At the time of producing this Drought Plan we are also formulating the inaugural Water Resources West Regional Plan. We are working through each of these considerations with our neighbouring water companies and stakeholders to ensure that they can be fed into the Drought Plan at the earliest possible opportunity. An example of this is the mutual aid (tankering support) agreement.
Your plan should show that you are application-ready for your more frequent drought permit and order sites. Taking these proactive steps will help you and the regulators understand what evidence will be expected when making an application and what environmental mitigation measures should be implemented.	As outlined in Section 2.4.5, we are now "application-ready" for our more frequently applied for drought permit and order sites.

Environment Agency Requirement	Our Approach
Your plan should show how you have thought ahead to help minimise the possible environmental effects of droughts. This means you need to be proactive in implementing drought actions and consider the use of environmental triggers and actions.	We have carefully reviewed all drought actions from an environmental impact perspective. We have also sequenced actions to provide the best possible protection for the environment, balancing this with the need to maintain resilient supplies. Where we have retained drought permits scenarios with a higher potential environmental impact we have delayed their implementation until Level 3.

1.2 New hydrological data

We use measured, modelled and forecasted hydrological data such as meteorological, river flow and reservoir storage to help effectively manage droughts. Hydrological data are also central to our water resources and drought planning. In particular, river flows and reservoir inflows are key inputs to our water resources models.

Water resources models are now central to water resources planning and used for a range of drought planning purposes, for example testing the availability of supplies during droughts and designing drought levels (Section 2.3 in the main document). Droughts by definition occur very infrequently, limiting the amount of useful observable data to feed into our models. Traditionally we used long historic inflow records to capture as many droughts as possible, often using tools such as rainfall-runoff models to extend flow records backwards by using earlier rainfall records. Even then, with almost 100 years of historic data, we only had a handful of droughts on which to base planning. In addition, government focus on drought resilience has shifted towards events which are more severe than we have experienced in our recorded past, specifically targeting events with a return period of 1 in 500 years (0.2% annual risk).

In the 2018 Drought Plan we focused on assessing historic droughts but also created some more severe synthetic events by joining together different droughts, for example the poor reservoir winter refill of 1995-1996 with the severe spring-summer conditions of 1984. Whilst this provided an effective means to test the Drought Plan to more severe droughts, it was difficult to ascertain the plausibility of these events or the risk of occurrence. For the 2019 Water Resources Management Plan (WRMP19) we therefore developed a new “stochastic” hydrological dataset. We used a “weather generator” which combined historical rainfall and climatic drivers such as sea surface temperature (SST) and North Atlantic oscillation (NAO) to generate new synthetic rainfall. Evapotranspiration (PET) data were then matched to the stochastic rainfall data and a “rainfall run-off model” used to simulate flow.

The weather generator was run 400 times which resulted in a new daily hydrological dataset of 19,200 years (i.e. 400 realisations of the 48 year historic rainfall record). This dataset provides a vast range of plausible drought events against which to test our supply system. It also allows us to estimate the frequency of customer restrictions, for example temporary use bans (TUBS) or emergency drought orders, with much greater confidence.

We have, for the first time, incorporated climate change into the modelling assessments for this Drought Plan. Whilst the plan is relatively short term the hydrological data we are using are either historic or derived from historic. We therefore incorporate the estimated current impacts of climate change. We include the 50th percentile impact from the WRMP19 assessment in all modelling, including the creation of new drought levels (Section 1.3). We have also tested some more severe climate change projections as scenarios (Appendix E).

1.3 New drought levels

As noted above we have switched from using drought triggers to drought levels, as stipulated by the new Environment Agency guideline. The main objectives of drought levels are to:

- Indicate the overall drought status of a resource zone (RZ)
- Guide the implementation of pre-planned drought actions

We have reviewed the geographical location of the drought levels. We do this for each Drought Plan but it was particularly important this time due to the creation of the Strategic RZ, and additional knowledge and experience gained from managing recent dry weather events. After a comprehensive review we concluded that retaining the current drought level locations at Haweswater reservoir and Dee combined (Celyn and Brenig) was the best option. We looked carefully at introducing new levels at Thirlmere reservoir (where the new West Cumbria transfer will soon be commissioned) but analysis indicated that they would be unnecessary due to the high level of simulated and actual synchronisation with the operation of Haweswater. Combined Pennines drought levels were also considered but rejected as the specific mode of operation of these sources cannot be practically or effectively combined with drought levels. In dry weather abstraction is progressively transferred to regional sources such as Haweswater, therefore the Haweswater drought levels remain a strong proxy for the overall situation in the Pennines sources. Transferring dependence based on the local conditions and control rules at each source ensures that the risk is balanced across the resource zone as much as possible, accepting that it is impossible to draw all sources down perfectly evenly due to spatial differences in the weather and constraints in the supply system.

We also reviewed the drought level locations in the other RZs and opted to retain the current configuration for the Carlisle and North Eden RZs (Castle Carrock storage and North Eden annual licence usage respectively), and design new levels for the Barepot RZ (Section 2.3 in the main document).

The next step was creating the new drought levels which is a complex activity and must account for a number of factors:

- Correct sequencing of a wide range of drought actions
- Timing required for and between certain actions, for example the notification period for customer restrictions or the expected duration of the drought permit application process
- Meeting the company's agreed levels of service, for example to implement temporary use bans (TUBs) no more than 1 in 20 years on average
- Providing resilience across a wide range of drought patterns that could occur in the future (Appendices E and J)

This means that as per previous drought plans the analysis was heavily dependent on water resources modelling. For this drought plan, however, we incorporated an additional step for the Strategic RZ to optimise the positions of the drought levels using a multi-objective evolutionary algorithm. We believe this is the first time the approach has been used for drought levels/triggers in the UK and builds on our successful optimisation of reservoir control curves over the past few years. Optimal placement of the drought level boundaries taking into account the above complex factors is very difficult to achieve manually, so our new approach uses high specification computers and the latest optimisation techniques to help us find the best positions for the level boundaries.

1.4 Lessons learned from 2018

Since publishing our last Drought Plan we have experienced several dry weather events, most notably in 2018. Fortunately, none of these events progressed into a severe drought (in 2018 we got to the point of issuing notification of a temporary use ban but did not implement it due to significant rainfall). Nevertheless, they could have become serious if the dry weather had persisted, and as such their occurrence provided a wealth of new information that we have been able to use to enhance this plan, for example:

- New weather and hydrological data for events with very low rainfall over the period of a few months.
- New information on customers' response to dry weather, in particular the levels of elevated demand for water (which we have used as the basis for our modelling, as outlined in Appendix E). Also, outputs from the Artesia 2018 peak demand project, into which we fed our demand data.
- Further understanding of the performance of our assets during dry weather.
- Live opportunities to refine our drought management procedures and operational practices.

Following the 2018 event in particular, we spent a considerable amount of effort reviewing our performance and have since implemented a wide range of improvements. Some of the actions that have directly influenced the Drought Plan are listed below (the list is non-exhaustive):

- Significant investment to convert standby drought sources, for example Widnes boreholes, into "business as usual" supplies.
- Revised TUBs notification period.
- Comprehensive review of water treatment works minimum and maximum flow capacities.
- Smarter use of water resources modelling and hydrological datasets for dry weather operational planning.
- Critical review of drought permit sites focusing on priorities, risks and benefits.
- Review of task team structure.
- Research on and piloting of enhanced customer communication approaches.
- Improved communication of the Drought Plan within the business and planned Drought Plan exercises to test the drought plan and drought readiness (as held previously).
- Preparedness for management of compensation only reservoirs (Appendix G).

1.5 Strategic RZ

As outlined in our 2019 Water Resources Management Plan (WRMP19), on completion of the Thirlmere transfer scheme (sometimes referred to as the West Cumbria Water Supplies Project), the Integrated and West Cumbria RZs will combine to form the Strategic RZ, therefore this Drought Plan is based on the Strategic RZ.

The scheme will place additional demand on Thirlmere Reservoir. However, through a reduction in abstraction to other parts of the RZ via the Thirlmere Aqueduct, this additional demand will be effectively shared across many sources. Nevertheless, the scheme constitutes a significant update to the supply system and it was imperative for us to build up a comprehensive understanding of the planned changes and their effects to ensure that our plan is robust.

In particular, the water resources models that we used extensively in the production of the Drought Plan were set up to simulate the Thirlmere transfer and West Cumbria demand. In reality we have been simulating this scenario since 2012 as the Thirlmere transfer scheme was appraised and selected in the 2015 WRMP. Like this Drought Plan, WRMP19 was also based on the Strategic RZ. Over the years, as more detailed information has become available, the model has been refined. The operational rules applied in the model, for example our Pennine reservoir control curves, have all now been defined with the Thirlmere transfer scheme in place. As noted in Section 1.3, we carefully considered introducing new drought levels at Thirlmere Reservoir but ultimately found them to be unnecessary. The new Haweswater and Dee drought levels however were generated taking into account the Thirlmere transfer scheme.

So, in summary, from a planning perspective we have been working with the Thirlmere transfer scheme and the Strategic Resource Zone for a very long time and we are confident that our plans are robust in this respect. It goes without saying that Thirlmere Reservoir will be operated taking into account the knowledge we have built up, and we will of course monitor the situation going forward to identify any further opportunities to improve the resilience of the Strategic RZ and the accuracy of our models. We always aim to operate of all our sources in a way that ensures risk is balanced across our RZs as far as possible.

1.6 Operational focus

As outlined in the latest Environment Agency guidance, the Drought Plan should be operationally focused. We need to ensure that we have effective plans in place for the operation of our supply system during dry weather. Since our last Drought Plan was published in 2018, and since the 2018 dry weather event, we have put considerable effort into improving our supply system and the way in which it is operated. For this Drought Plan we have also undertaken the most extensive update ever of the water resources models that underpin our plan, particularly with regard to their operational realism. The result of this is that our planning outputs and real-life operations will be much closer than was the case for the previous Drought Plan.

This all being said, we need to retain an element of flexibility both in the real world and in our models to deal with drought patterns that we haven't encountered before and everyday operational issues faced, such as outage of sources. This means, particularly for the Strategic RZ, that we can't simply produce a prescriptive list or even a flow diagram of operational actions to follow during dry weather. Part of ensuring that we have a resilient supply system and effective drought plan is designing in the flexibility to cope with changing conditions. Our models also need a certain level of operational flexibility, so that we can stress-test the supply system to different demands, drought patterns and climate change effects, as well as conduct crucial 'what if?' trials. The decisions that operational staff take in the real world are represented in the models by sophisticated daily allocation optimisers (for example, Aquasolver2 in Hydro-Logic® Aquator) but most of the operational 'rules' they follow are the same. It is inevitable that there will be some differences between model outputs and actual operations but over time, as the modelling hardware and software continue to be developed, the gap will narrow further.

As shown in Section 2.3 in the drought plan, our new drought levels now include an enhanced monitoring and operational line, at which point there is a step change in our operational focus. In our Drought Plan scenarios (Appendix E) we have described and labelled some of the specific operational changes that occur during the model runs and would be likely, depending on actual conditions on the ground (including, importantly, the levels and patterns of customer demand for water), to be replicated if we were to encounter the same event in the future. We have also updated our water resources models to take account of the estimated savings from planned dry weather leakage and pressure reduction activities (Appendix C).

To strengthen our response to the 2018 dry weather event we used our hydrological datasets and water resources models to forecast the water resources situation over the next 12 months from the current conditions. Using all of these data and tools enabled us to produce risk-based forecasts of water availability (e.g. estimated reservoir storage for a repeat of worst historic drought conditions, or 80% of long term average rainfall). We then used this information to inform operational water production planning modelling to optimise the use of sources whilst ensuring we supplied enough water to customers. Utilising our water resources planning tools in combination with operational water production planning in this way significantly enhanced our dry weather operational planning and management.

1.7 Agile communications

As summarised in the drought plan and detailed in Appendix B, we have developed an agile communications approach that aims to provide comparable demand savings through customer-led behaviour, understanding the right incentives to encourage and sustain this, as well as how and when best to encourage voluntary restraint, when compared to enforcement through TUBs. We will use agile communications to delay the introduction of TUBs where equivalent benefits can be demonstrated.

