Drought Plan 2027

Drought triggers and worked examples of drought scenarios

Yorkshire Water

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YorkshireWater

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In accordance with Drought Plan guidance, this statement certifies that Yorkshire Water's Drought Plan has been reviewed by our security team. Some information has been redacted or edited in this published version for reasons of national security.

1 Introduction

The scenarios below describe droughts of different severities and the actions we would take in these examples. It should be remembered that these are examples, and the actions described are indicative of how we would respond to these particular examples. The figures here and in annexes 1.1-1.5 show graphs of our five drought management reservoir groups and the Yorkshire regional reservoir group (Section 2.2 in the main DP27 report). The graphs are generated as part of our weekly Water Situation Reports and are used for operational planning. A temporary use ban (level 2 restriction) or drought permit / order (level 3a restriction) triggered in one area does not mean that such restrictions will be implemented. If temporary use bans or drought permits are forecast in only one or two areas, we will manage resources to try to balance stocks across the region, and only implement restrictions in the Yorkshire region once this had been done. We will generally only implement a temporary use ban or drought permits / order if they are triggered in a number of areas, or in the Yorkshire regional reservoir group.

The worked examples in this document have been used to test our drought plan, and shows that our triggers work well for these scenarios. We will continue to update scenarios in response to events, and use this process to identify any required updates to triggers if shortcomings are identified in the future. The worked examples are based on either historic inflows, or on inflows from the stochastic time series used for the WRMP modelling of our levels of service (Section 1.4.2 in the main DP27 report).

2 Drought triggers - control line calculations

To calculate our control lines (CLs), net inflows assume that once we have calculated the normal control line (NCL) and drought control line (DCL), we linearly interpolate between the 100% full level and the NCL, the NCL and DCL, and the DCL and emergency storage level, to obtain the ten control lines (CLs) used in our modelling and reservoir stocks monitoring. The NCL is CL3, the DCL is CL7, and we use CL4 as the Environment Agency control line (EACL). Control lines are calculated for individual reservoirs, and amalgamated to represent our reservoir groups. For the revised draft drought plan we have introduced the use of bands to represent our drought triggers, and these are shown in Figure 2-1, along with some of the control lines they are based on.

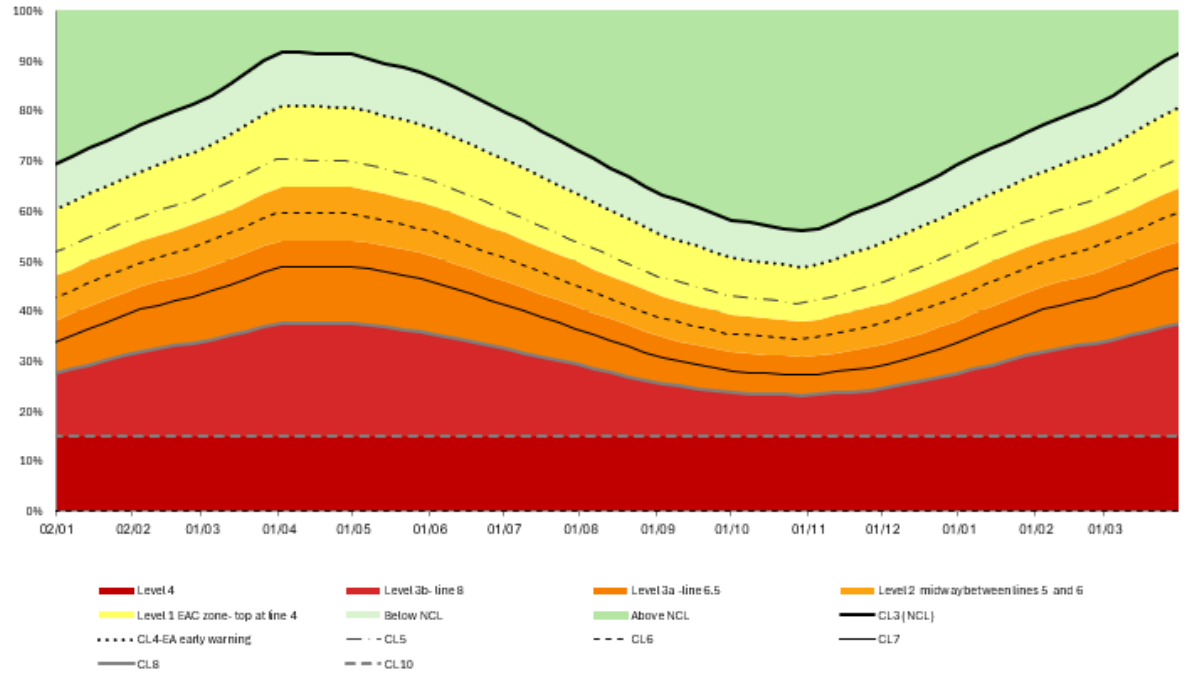

Figure 2-1 Example of Control lines and Drought bands

For WRMP24 we developed new inflows using GR6J rainfall runoff models, which could be used for the stochastic data series required for the estimation of the 1 in 500-year return period system response now required for the WRMP.

The drought bands are defined in terms of the level of restrictions.

Table 2-1: Drought Bands

Drought level	Band and Control line
Normal	Above normal control line
Normal	Below normal control line
Level 1	Top of band is at the EA Early Warning Trigger line
Level 2	Top of band is midway between control lines 5 and 6
Level 3a	Top of band is midway between control lines 6 and 7
Level 3b	Top of band is at control line 8
Level 4	Top of band is at control line 10- marginal storage

We have updated our control lines on a regular basis following learning from dry weather events and guidance updates and they were updated in:

2021 – Control lines updated following the 2018 dry weather using the GR6J rainfall runoff models with inflows from 1900-2020. This represented a considerable change in control lines, because as well as incorporating any dry periods from 2018, it also included the change of inflows from water balance (and Hysim modelled data for historic inflows) to the new GR6J modelled inflows. These control lines were used during the 2022 drought. In 2022 we experienced low rainfall and inflows resulting in very low reservoir levels in some areas and we imposed a TUB and drought permits for the first time since 1996. A considerable amount of support was provided to compensation reservoirs by supply reservoirs. We used this experience to reconsider our drought actions and triggers and inform this drought plan.

2023 - We updated our control lines again based on minimum inflows from 1900 - 2022 using historic datasets. We review our control lines using inflows calculated using the latest data when available and provide any updates in

annual reviews of our drought plan. The 2023 control lines were similar to the 2021 versions.

For our WRMP24 modelling we used the control lines updated during 2021, but these lines are compared to those updated in 2023 following the 2022 drought.

2026 - Inflows have been updated until the end of 2025, and control lines have been calculated using these updated inflows, including the 2025 drought, for the revised draft Drought Plan 2027 and for WRMP29. For this revised drought plan we are also moving from the use of a TUB trigger based on forecast rates of fall, to the use of bands (as mentioned in our draft drought plan 2026) and shown in Figure 2-2, which also shows the modelled reservoir stocks for the same simulation models using the different control lines. It can be seen that the modelled regional reservoir stocks are similar for the two simulations using the different control lines.

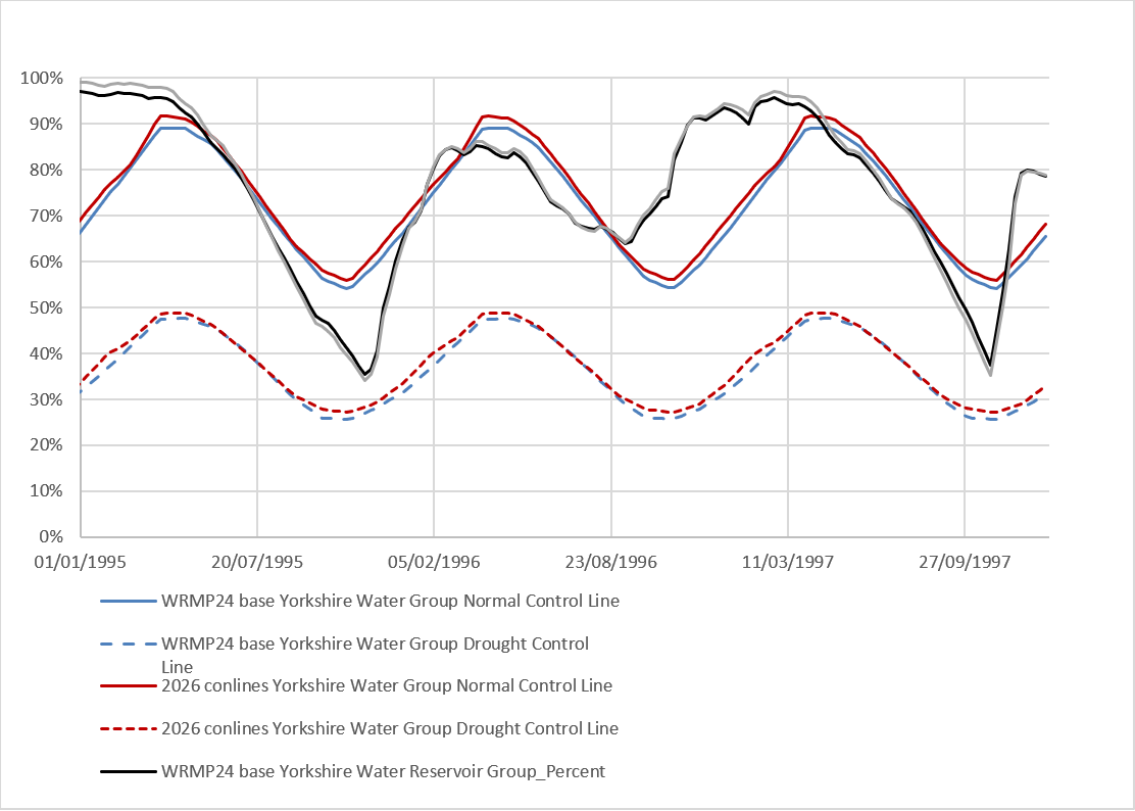

Figure 2-2: Comparison of 2021 (WRMP24) and 2026 (Revised) control lines and modelled reservoir stocks for the Yorkshire Regional Group

3 Historical Droughts

The historical inflows series show droughts occurring at various points in the period of record, with notable dry periods in 1929, 1933-34, 1959, 1995-96, 2003, 2018, 2022 and 2025. These droughts are listed below, along with other less severe dry periods.

1929 - A single season drought that saw reservoir storage recover by the end of December 1929.

1933-34 – This drought had a much more pronounced impact on surface water than groundwater in Yorkshire[1].

1959 - The months of February, May, August and September were particularly dry, and the summer and autumn were broadly warmer and sunnier than average; only from November onwards did rainfall amounts recover.[2]

1975-76 – The concept of 'grid management' was developed following lessons learnt from this drought.

1995-1996 – This was the most extreme two-year drought experienced in our supply area. The summer of 1995 was hot and dry and was followed by a dry winter. This 2 year drought event was unprecedented; the usual winter refill of reservoirs failed to occur to any significant degree, meaning that at the start of the drawdown season in the spring of 1996 reservoir stocks were significantly below normal levels for the time of year. Customer demand was restricted and drought permits / orders were in place through the region. This instigated considerable investment in new pipelines and pumping stations. We laid major raw and treated water transmission pipelines and by the end of 1996 around 95 % of customers were linked to a robust integrated grid water supply network (See Figure 1-3 in the main DP27 document). Developments in computer modelling enabled the optimisation of water supplies together with centralised production planning, management and control. Since 1996 we have further extended our grid network, and 99% of customers are now connected. The drought of 1995-1996 highlighted our reliability on the surface water reservoirs in the

[1] The Locked Pump Drought - 1933 to 1935 | UK Centre for Ecology & Hydrology

[2] Testing the Water Act - 1959 | UK Centre for Ecology & Hydrology

Pennines and led to investment to increase the resilience of our system by laying a major raw water transmission pipeline.

2003 - Drought conditions became established over most of the UK during the late winter and early spring of 2002 / 2003. The spring period saw a lack of rainfall and gave way to a long, hot summer.[3] The summer of 2003 was hot and dry late into the autumn, with no significant reservoir refill until November.

2006 - In the summer of 2006, some very high temperatures led to extremely high peak demands. We used this to reappraise our peak demand profile to reflect a worst-case scenario of high summer demands.

2010-2011 - In 2010 and 2011 we experienced uncharacteristically dry springs, which led to earlier than usual reservoir drawdowns. In both years, the spring was preceded by an unusually cold winter. At the end of 2011 we recalculated our control lines using the latest data and changing the way we dealt with the issue of supporting compensation reservoirs from supply reservoirs when deriving control lines, making them more conservative.

2018 - During the drought in 2018, a period of exceptionally dry weather led to an unprecedented and prolonged period of high demand across our region. In reaction to falling reservoir stocks, we implemented parts of our Drought Plan, and the Environment Agency classified the region as "in drought" from November 2018 to February 2019. To ensure we were resilient to the dry weather continuing into 2019, we started the process of applying to the Environment Agency for drought permits for the first time since 1996.

Significant rainfall in late 2018 meant our reservoirs recovered sufficiently enough for us to only progress with two drought permit applications. These permits were to temporarily modify licence agreements we hold with the Environment Agency for abstracting water from the River Wharfe and River Derwent. The applications were to increase the total volume we could abstract over the year from 1 April 2018 to 31 March 2019. The instantaneous and daily maximum abstractions were not changed, and neither were the rules that govern how much we abstract at different river flow rates. Both permits were granted by the Environment Agency.

[3] The Hot Summer - 2003 | UK Centre for Ecology & Hydrology

We applied for and obtained these permits as a precautionary measure as we had used a larger than usual proportion of the licensed volumes in 2018 and there was a risk we could reach the annual limits if we experienced high demand through winter 2018 / 2019. As the winter demand was not exceptional, we did not implement the permits.

2020 - In 2020 we experienced high demands in spring and early summer, partly due to the hot dry weather, but also influenced by the Covid-19 lockdown. There was unprecedented volatility in demand due to more people being at home during the week and responding to the hot weather with increased water use for activities such as garden watering and paddling pool use. Reservoir stocks fell rapidly, and forecasts showed level 2 triggers to be expected in August. We started to prepare drought permit applications required for level 3a actions, but rainfall in June and July increased reservoir stocks, and we stopped the drought permit application process. During 2020 we carried out our usual Water Resources Planning Report (WRPR) modelling but developed a new demand profile to better reflect the spatial and temporal patterns of demands we were seeing during lockdown, so that our forecasts were based on the latest information.

2022 - Rainfall was significantly below long-term average in March and April. The dry weather continued into June as temperatures increased to unprecedented levels, leading to high customer demand and rapid depletion of reservoir stocks. A temporary use ban (TUB) was in place from 26 August to 6 December and 21 drought order / permits were granted with three implemented. The worked example shown for 2022 shows some of these high demands and rapidly falling reservoir stocks and are taken from the permit applications made in that period.

2025 – The driest February to August for 137 years resulted in an unprecedent early onset of severe drought that continued to the end of the year. A TUB restricted household water use from 11 July to 10 December 2025. We applied for 44 drought permits, and one order, and implemented 24 permits and one order.

The events in 2018, 2022 and 2025 include some very hot periods with extremely high demands, and show a worsening trend, with drought restrictions applied for in 3 out of 8 years, after a period of over 20 years without any restrictions or applications for drought permits or orders. This could be indicative of a changing climate, with greater extremes of weather,

corresponding to the warmer wetter winters and hotter drier summers expected due to climate change. Figure 3-1 shows a clear picture of increasing temperatures in Yorkshire over the last century. Figure 3-2 showing seasonal rainfall gives a more varied picture, with low rainfall in winter, spring and summer. There are more frequent low spring rainfall totals in recent years than there have been since the 1950s with low rainfall amounts in the springs of 2022 and 2018. Analysis of the trends indicates a significant increase in temperature, and a significant increase in winter rainfall, but no significant changes in spring, summer or autumn rainfall, although there is high variability of seasonal rainfall.

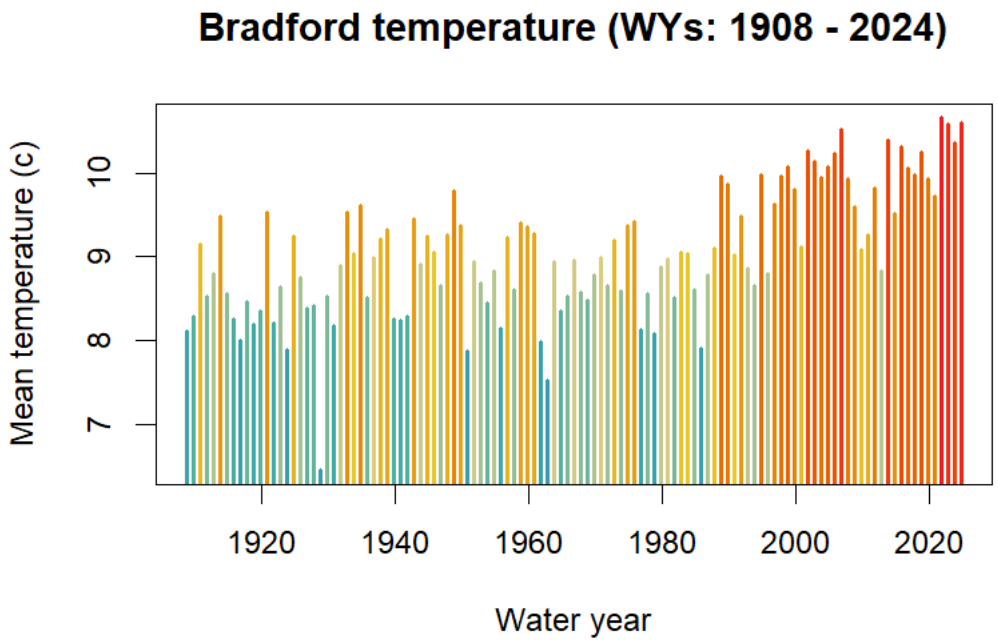

Figure 3-1: Temperature in Bradford

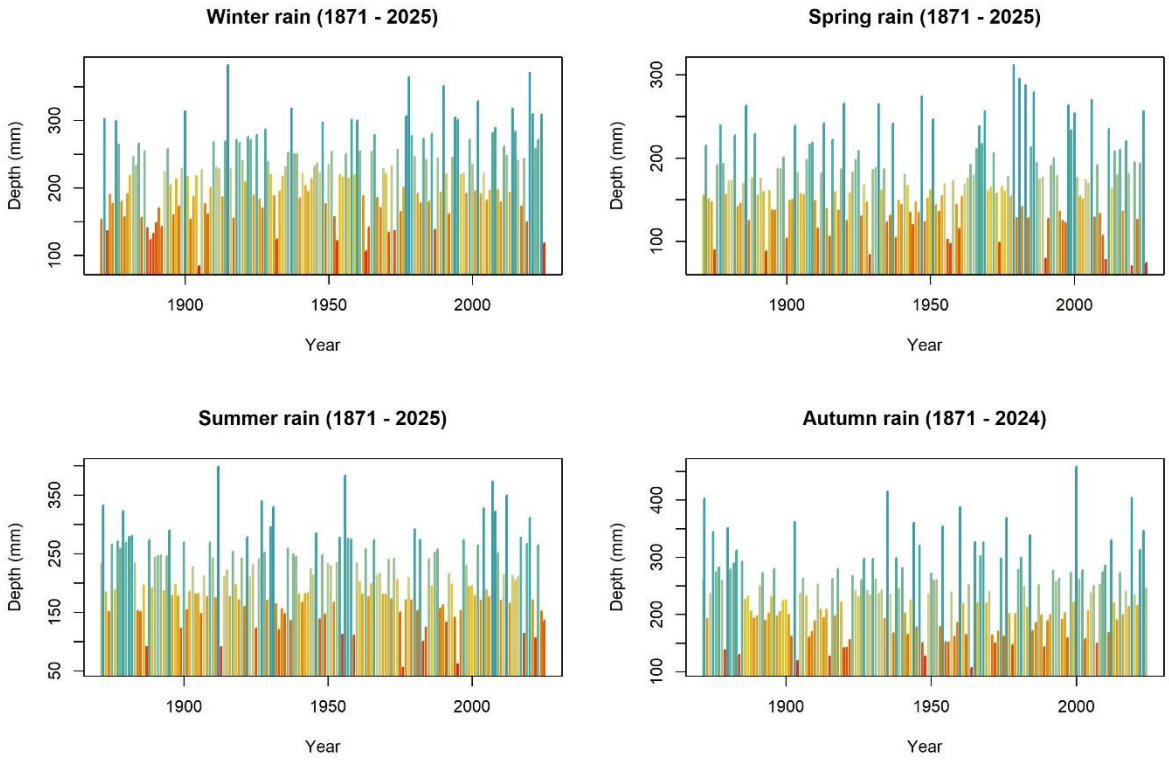

Figure 3-2: Rainfall in Yorkshire

We have periodically generated demand profiles for use in our water resources simulation modelling and use these to test our triggers against a range of demand profiles. The 2006 demand profile is still one with the highest monthly peak, the 2018 profile has a long period of high demand, so the scaled peak is lower compared to the annual average, and the 2020 profile has a different spatial distribution due to the effects of the Covid-19 lockdown. In 2022 unprecedented high temperatures for long periods led to prolonged high demands which led to WTWs having to run at high levels for far longer than previously and showed where areas of the distribution network were vulnerable. The Water Resources team work with our colleagues in Water Production Planning to agree the most appropriate demand profile to use for our WRPR planning report (see section 2.5 of the main DP27 report), and in recent dry years we have used demand profiles adjusted to better reflect the demand patterns we were seeing and expected to see based on weather forecasts.

It should be noted that the demand profiles reflect the temporal and spatial shape of demands, and in our modelling and in the worked examples, we use these profiles scaled to annual average demands of different magnitudes.

The water situation report is produced weekly, along with a spreadsheet that shows historic stocks for reservoirs and reservoir groups. The area and regional reservoir stocks are shown in Figure 3.3 for the years from 2014-March 2026. The background colour indicates the current reservoir stocks (March 2026) in relation to the control lines: green is above NCL, amber between NCL and DCL, and red below DCL. In the plots below, all except for the east group are above the NCL. This section of the water situation report will be updated to include the reservoir bands before the final drought plan is published in spring next year.

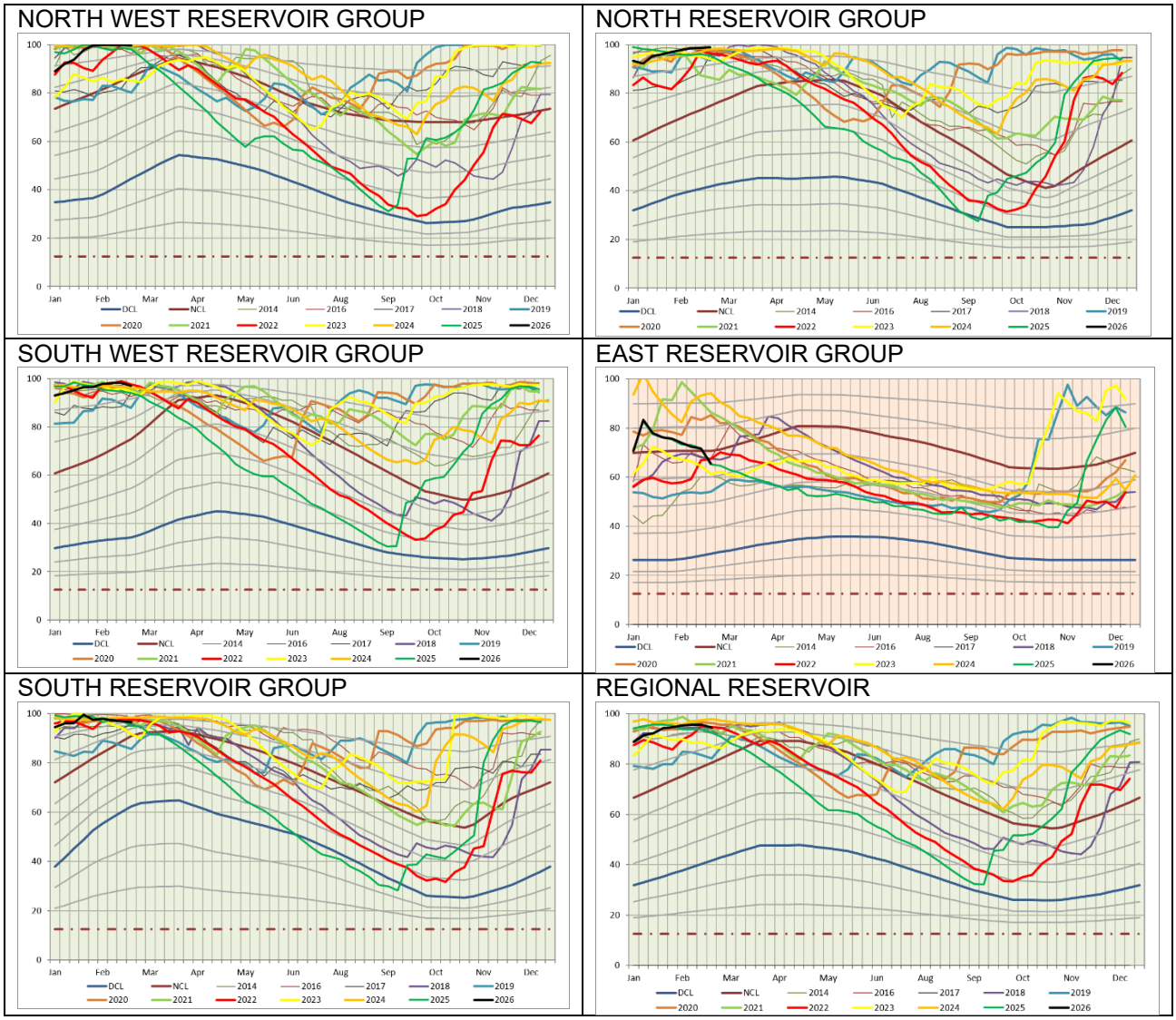

Figure 3-3 Area and Regional reservoir stocks- Drought monitoring in the weekly Water Situation Report

3.1 Scenarios, triggers and actions

Examples of likely sequences of drought measures are shown in section 2.4 of our main DP27 report– linking triggers to actions. We use our PyWR Water Resources Simulation model to simulate our water supply system. It is a behavioural model which incorporates system constraints and our reservoir operating rules. Our model assumes that when reservoir stocks fall into Band 3a for a given reservoir group, drought orders or permits will be implemented, affecting demand zones, abstraction licences and compensation releases in the relevant area. However, in reality if we had low stocks in only one area, we would be unlikely to apply for such measures as we would use our grid system to manage resources across the region.

We would apply for a TUB and drought permits or orders on a regional basis if triggers in the regional group were crossed.

The exact timing of consultation and implementation of drought measures will be subject to the particular circumstances prevailing at the time but generally will be in line with the timing determined by the drought level bands. In a drought we will be monitoring all our reservoir levels, and we will identify within each reservoir group which supply side actions are necessary. Although we operate to balance reservoir stocks as much as possible, localised rainfall and interconnectivity of reservoirs will mean some reservoirs stocks are lower than others and we will only apply for orders or permits that reduce reservoir compensation flows where a deficiency of supply exists or is threatened. Our preference would be to maintain the regulatory compensation flow if it does not pose a risk to supply.

In this report we show a number of worked examples of potential droughts, which illustrate the timing and extent of drought measures under different storage conditions. We have used known low inflow years (for example, 1929, 1995-1996) in order to trigger more extensive drought actions including the implementation of extreme drought options. The simulations have been at various levels of demand and for some of our worked examples we have selected droughts from the stochastic inflow series used in our WRMP24 to produce longer and more extreme droughts than those contained in our historic record.

Some have been run using the drought bands in use now, which were developed using inflows from 1900-2025 for this revised draft drought plan 2027, and with varying levels of demand. The demand quoted is the annual average demand, with regional and seasonal profiles from recent years, so summer demands are typically higher than the average annual demand quoted. The examples for the 2018, 2022 and 2025 dry weather and drought events use the control lines in use at the time of those events.

Following the prolonged dry weather in 2018 we applied for winter drought permits to aid reservoir recovery into 2019. Depending on prevailing conditions at the time, we may apply for winter drought permits if we believe they will promote reservoir recovery and have less impact on the environment than waiting until the spring or summer months. The triggers we use are the same as for summer drought permits /orders.

During the drought conditions of 2022, we implemented a TUB for the first time since 1996 and applied for drought permits to reduce compensation flows for reservoirs in the north west area reservoir group, and prepared drought permit applications for other areas, that were not required as rainfall allowed stocks to recover in the autumn and winter.

The two annual licence increase drought options, (which we received drought permits for in 2018-2019) would only be implemented in winter as we would not reach the existing licence limit until later in the year. One of these is no longer an option in our drought plan as we have increased the annual licenced quantity to the previous drought permit value.

Examples of various drought scenarios with high level Yorkshire Water responses or actions are presented in Table 3.1 below. These examples are based on experience of one and two-year droughts in the Yorkshire region. In all these examples we only required level 1 to 3a drought interventions. An unprecedented third year of drought has been included to demonstrate additional action we could take if a three-year drought did occur. In this example we do not trigger level 4 actions but do show the impact of implementing extreme drought actions (level 3b).

Section 4 of the main DP27 document discusses extreme drought options (level 3b) that we would consider if level 1 to 3a actions were implemented and our existing resources were not recovering sufficiently. Our extreme drought actions include actions to further reduce water use. They also include additional actions to increase supply such as new supplies and interconnecting infrastructure. These actions would require greater permissions than level 3a supply-side actions (for example, planning permission) or are actions (for example, tankering) that only become necessary once available supplies in some areas of the region have become severely depleted. Some of the Level 3b actions with long lead times, such as new sources or transfers, are designed to provide additional supplies to aid recovery and resilience during a long drought, providing additional resources and allowing for repairs and outage.

Grid Zone Drought Scenarios with potential high level decisions and actions (not based on any specific historical drought)				
Scenario	**Trigger**	**Action 1**	**Action 2**	**Action 3**
Serious drought in autumn of year 1	Prolonged dry summer with total reservoir stocks falling (typically in level 1 band)	Re-zone supplies to maximise grid and prepare drought pumping stations (level 1)	Enhance conservation campaign and appeal for voluntary reductions in use, enhance leakage control in reaction to breakouts (level 1)	Consider, in consultation with the Environment Agency, winter drought permits to aid reservoir winter refill
Serious drought in spring of year 2	Dry winter following dry year, with total reservoir stocks decreasing (typically low in level 1 band or approaching level 2 band)	Enhance conservation campaign with further calls for water usage restraint, continue increased leakage control (level 1)	Prepare for temporary use ban. Prepare drought permit / order applications for both increasing supply and restricting non-essential use.	Consult the Environment Agency on potential monitoring requirements for extreme drought options
Severe drought in summer of year 1	Dry spring and summer, with reservoir stocks decreasing, and Reservoir storage falling or forecast fall into level 2 band by late summer	Re-zone supplies to maximise grid and prepare drought pumping stations (level 1), Enhance conservation campaign with further calls for water usage restraint, continue increased leakage control (level 1)	Prepare for temporary use ban. Prepare drought permit / order applications for both increasing supply and restricting non-essential use.	Impose Temporary Use Ban (level 2) Apply for drought permit / orders for increasing supply and drought orders to impose a non-essential use ban (level 3a) Consider extreme drought options

Grid Zone Drought Scenarios with potential high level decisions and actions (not based on any specific historical drought)				
Scenario	**Trigger**	**Action 1**	**Action 2**	**Action 3**
Severe drought in summer of year 2	Reservoir storage within level 2 band and falling	Impose temporary use ban (level 2)	Enhance conservation campaign and calls for water usage restraint, continue increased leakage control	Apply for drought permit / orders for increasing supply and drought orders to impose a non-essential use ban (level 3a) Consider extreme drought options
Severe drought in autumn of year 2	Reservoir storage in level 3a band	Level 1 to 3a actions in place	Continue enhanced conservation campaign and increased leakage control and consider extreme drought actions (level 3b)	Prepare extreme drought actions (level 3b). Consider emergency drought orders (level 4)
Severe drought in spring of year 3	Reservoir storage in level 3b band approaching level 4 band	Level 1 to 3a and extreme drought actions (level 3b) in place	Continue enhance conservation campaign and increased leakage control	Extreme drought options in use (Level 4)

Table 3-1 Yorkshire Water drought scenarios and actions for the Grid zone

4 Worked examples of drought scenarios

4.1 May 2017 prolonged dry weather

In May 2017 regional reservoir stocks were close to the EACL, and we held our first Environment Agency liaison meeting in mid May. This followed a dry winter, and regional reservoir stocks were only 80 per cent at the start of the year. Some recovery occurred towards the end of February, but stocks remained relatively low, and recharge was slow due to the extremely dry conditions. We produced forecasts of reservoir stocks, which are shown in Figure 4-1. The forecast showed that we could expect a TUB to be triggered in autumn 2017 in the south west area if we had a repeat of the 1995-1996 inflows drought at 1300Ml/d demand. However, in practice we would not impose restrictions if a TUB was forecast in only one area. In this scenario, a TUB was triggered in only the south west area, and we did not apply for any demand restrictions, although we implemented our Company Risk Management Team (now Bronze Risk) and met with the Environment Agency in May once regional stocks crossed the EACL.

Our normal water saving campaign promoting advice and free water saving devices was live as usual throughout the summer. As the weather warmed up we increased the level of promotion and instigated our media communications to heighten awareness of the dry weather. Our level of communications to customers, albeit heightened, did not cross into any more serious messages of do not use as regional stocks were only below the EACL for a few weeks. The situation was monitored closely internally and communications were prepared and ready to be activated should the situation have escalated.

Figure 4-2 shows the forecast assuming proactive management of the situation to avoid a TUB, by increasing the use of rivers and using reservoirs groups in areas with higher stocks.

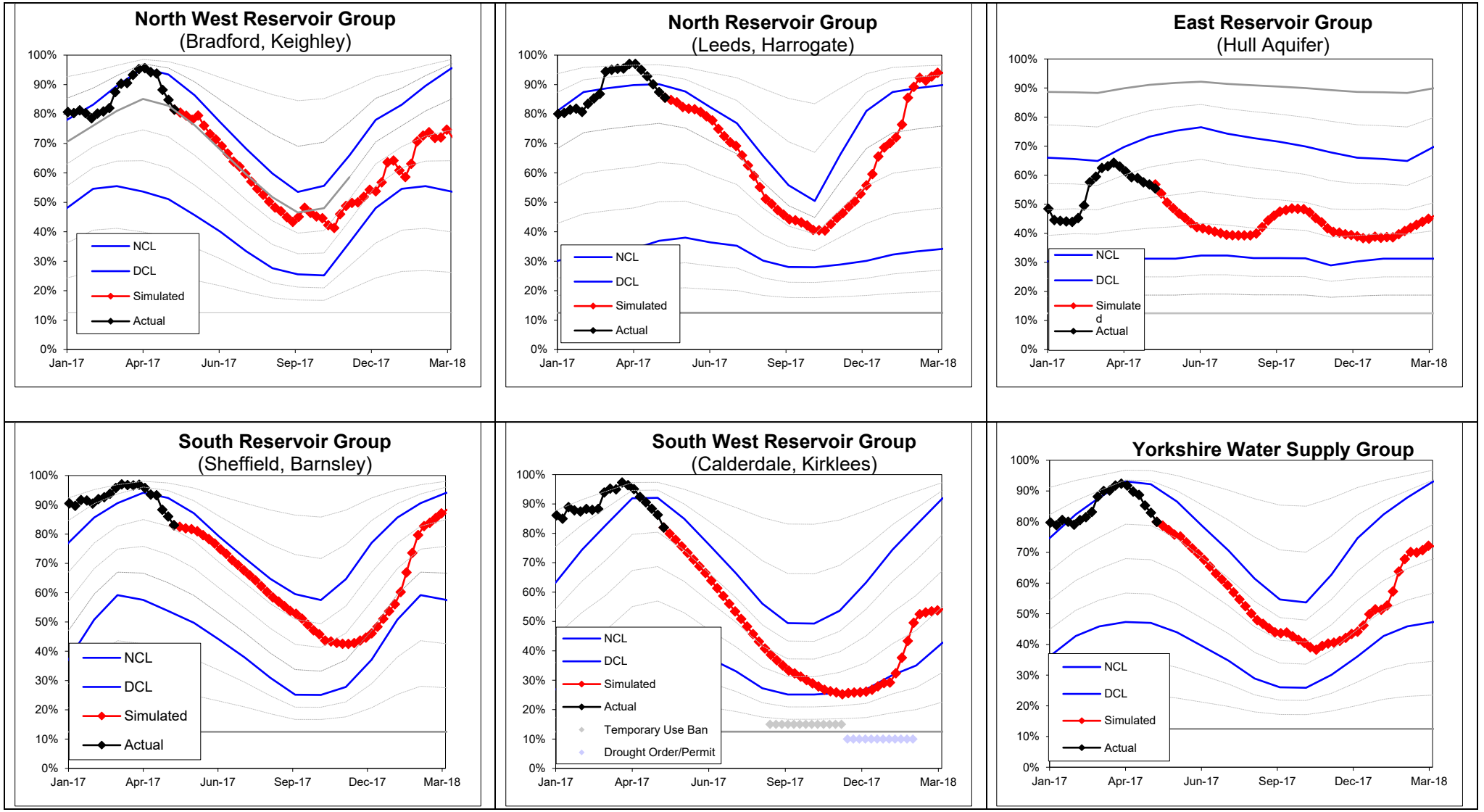

Figure 4-1 Regional reservoir group stocks and forecasts (WRAPsim-in 2017- Starting May 2017 with 1995 inflows)

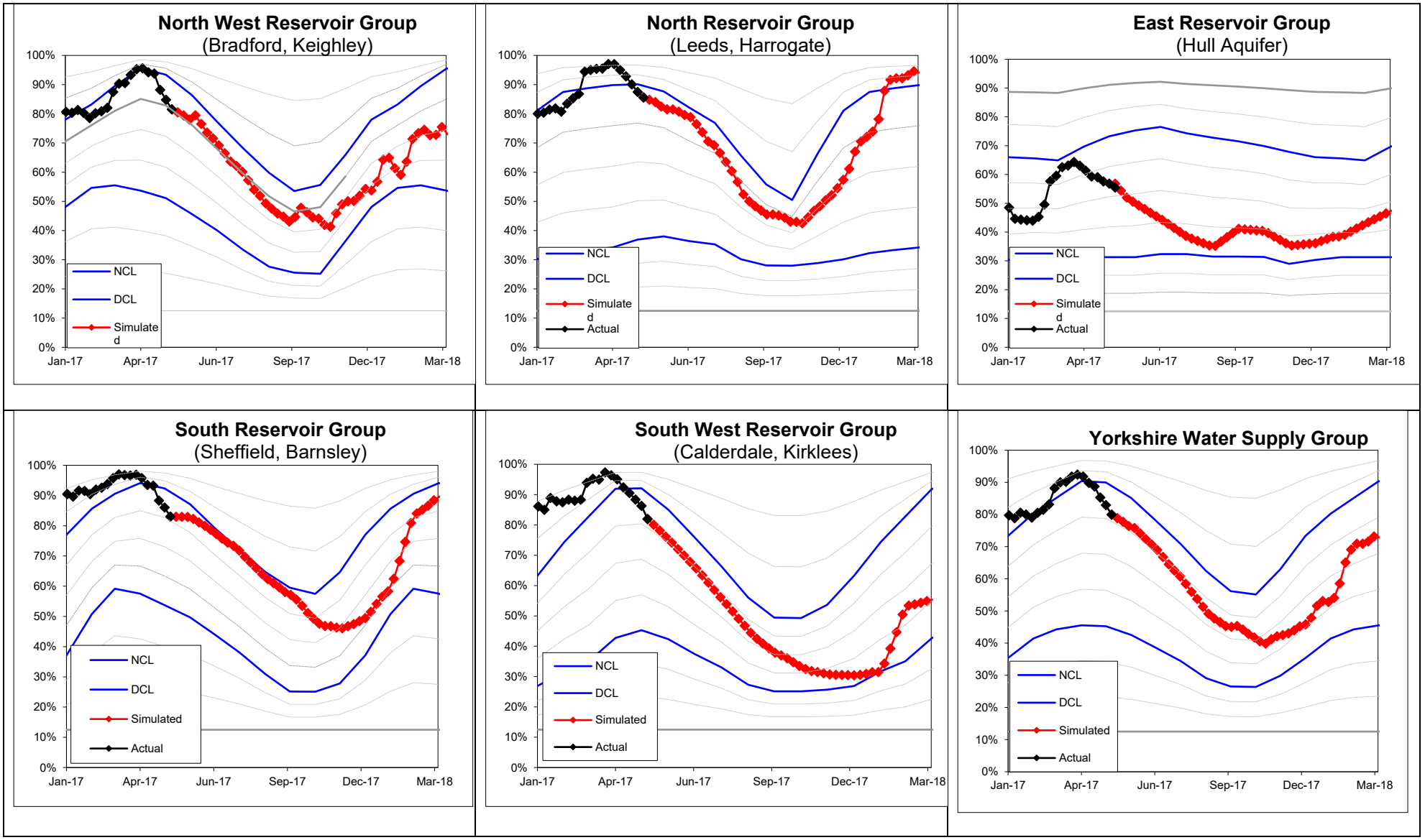

Figure 4-2 Regional reservoir group stocks and forecasts (WRAPsim - Starting May 2017 with 1995 inflows and proactive management)

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Our WRAPsim water resources simulation model was calibrated so that in our WRMP Deployable Output scenario we meet our levels of service of no more than three TUBs and one drought order / permit triggered in each reservoir group in our period of record. When we are experiencing a particular drought event, we will optimise our operations in response to the conditions of that drought, balancing stocks across the region as far as possible. If stocks are falling quickly in one area, we will reduce the use of reservoirs in that area and increase support from other areas and from river abstractions. For WRMP24, our new PyWR model has been similarly calibrated, and then we have attempted to balance failures for the stochastic simulations, but have focused on the Yorkshrie Regional Group outputs, assuming other areas could be balanced based on individual circumstances if they were to occur.

4.2 1995-1996 drought

The figure in Annex 1.1 shows the predicted reservoir storage under a repeat of 1995-1996 inflows at an average annual demand of 1300Ml/d, with a dry year monthly demand profile. The simulation shows no TUB, with stocks remaining in the level 1 band or above because our service has improved since 1995-1996. In practice, during 1995-1996 we had drought orders throughout the region, and demands were far higher due to higher leakage levels. The improved service, compared to the actual situation in 1995-1996, is due to the significant investment that we have made over the last 25 years, in reducing leakage and improving our grid network. This scenario shows no TUB as it is based on the entire 1995-1996 period, and the start of 1995 was relatively wet. The scenario shown in Figure 4-1, with forecasts for 1995-1996 inflows starting in May 2017 shows TUB triggered in some areas because the start of 2017, was far drier than the start of 1995.

When January 1995-December 1996 inflows are repeated at a higher annual average demand of 1380Ml/d, a TUB is triggered. Since 2016, annual average demands have ranged from 1246Ml/d (2019) to 1329Ml/d (2025), with an average of 1293Ml/d, so a 1380Mld annual average demand represents a high demand scenario. In 2018 we had a prolonged period of high demands, which was unprecedented in recent years. Average demand in 2018 was 1303Ml/d, with monthly demands of 1315Ml/d in May, 1342Ml/d in June and 1399 Ml/d in July. For much of this summer period the regional demand

followed our high demand profile, which we used for forecasting in our scenario modelling.

The 1995-1996 event is the only two-year drought we have in our period of record. Rainfall totals for the 20 month period from March 1995 to October 1996 are just 67 per cent of the long-term average. Using the SPI analyses recommended for the demonstration of Exceptional Shortage of Rainfall (ESOR), this period has an SPI of -2.97, and is well below the -2 threshold for extremely dry. Based on the ranking of the 20 month periods ending in October (ranked number 1 in a 154 year long record), based on the Cunnane distribution, this period is classified as exceptionally low for rainfall. However, because the drought was preceded by and followed by relatively wet periods, if the entire two years 1995 and 1996 are analysed, the SPI in this period is -1.89, and classified as only severely dry, and the rainfall is ranked 5th in the record, so still classified as exceptionally dry using the cunnane distribution.

4.3 Single season drought: 1929

The figures in Annex 1.2 show the predicted reservoir storage under a repeat of 1929 inflows when demand is at 1460 Ml/d. Regional stocks fall into the level 2 band, with stocks in the 3a band in East Area, and in the 3b band in the North West Area.

In this scenario the regional reservoir stocks fall into the level 1 band in April, and at this stage we would have started meetings with the Environment Agency and our escalated to Bronze Risk through our internal Incident Management Process as part of our water supply escalation plan. We would increase agile communications with our customers from May with enhanced messages, requesting voluntary reductions in use. Further triggers and actions are described in Annex 1.2. We would consider imposing a TUB in late September. However, when rainfall resulted in the recovery of reservoirs in October we would not proceed with our supply-side drought permit / order applications and non-essential use ban drought order application.

The table in Annex 1.2 show a timeline of triggers and actions (plotted in relation to regional reservoir stocks), and also indicate the likelihood of this event using different return period analysis techniques.

When the same scenario is run at a more realistic, but high, average annual demand of 1380Ml/d, TUBs are triggered in the north west and north areas (Annex 1.3). When run at an average annual demand of 1300Ml/d, no temporary use bans are triggered.

We have carried out analyses on the minimum modelled reservoir stocks and on rainfall amounts for this event. SPI analyses classify the regional rainfall from February to September as extremely dry (SPI -2.76), and this period is the 2nd ranked 8 months ending in September, classified at extremely dry using Cunnane analyses. Extreme value analyses of the 6 months rainfall ending in August (as used for the drought response surface analyses) give a return period of about 1 in 100 years for the 1929 event.

4.4 June 2018-March 2019 drought

In 2018 we experienced exceptionally high demand and low rainfall, which led to our worst drought since 1995-1996. During dry weather we aim to maximise use of river sources to conserve reservoir stocks for longer. We used our regional reservoir stocks graph to monitor the resource position and when pre-determined control lines were crossed it triggered drought actions. In the most recent dry years (2003, 2006 and 2011) prior to 2018 we crossed our NCL and EACL but did not experience the same high demands as in 2018.

We applied for and were granted two drought permits in 2018-2019 which were not options in our previous Drought Plan. These permit applications were identified in 2018 following the unprecedented high demands that required reservoir and river supplies to be used simultaneously for a substantial period. We identified them as being the best option to allow us to increase river abstractions and preserve reservoir stocks if dry conditions continued over the winter and we experienced exceptionally high winter demand, similar to 2018 winter demand.

At times during 2018, we had to maximise use of rivers and reservoirs simultaneously and during periods of low river flow we had to rely on reservoir supplies. We balance the drawdown of reservoirs across the region through use of our grid system. This makes our supply system more resilient to supply risks but following exceptional weather conditions during 2018, stocks in the reservoirs across our region were lower than average and we'd used more of our river abstraction licence allowance than we had in

previous dry years. This led to the crossing of reservoir control lines, which triggered a number of our drought actions. Figure 4.3 shows the 2018 reservoir stocks with key actions highlighted compared to the 1995 reservoir stocks.

In May 2018 our reservoirs stocks crossed our NCL, which triggers a change to operations to conserve reservoir supplies. At this stage we were implementing our summer campaign for water saving. In June 2018 we started to model the potential for reservoir stocks to cross further control lines, which would trigger further drought actions. Reservoir stocks crossed the EACL on 6 July 2018. We continued to operate to maximise river sources where possible and enhanced our messages for encouraging customers to reduce their use voluntarily.

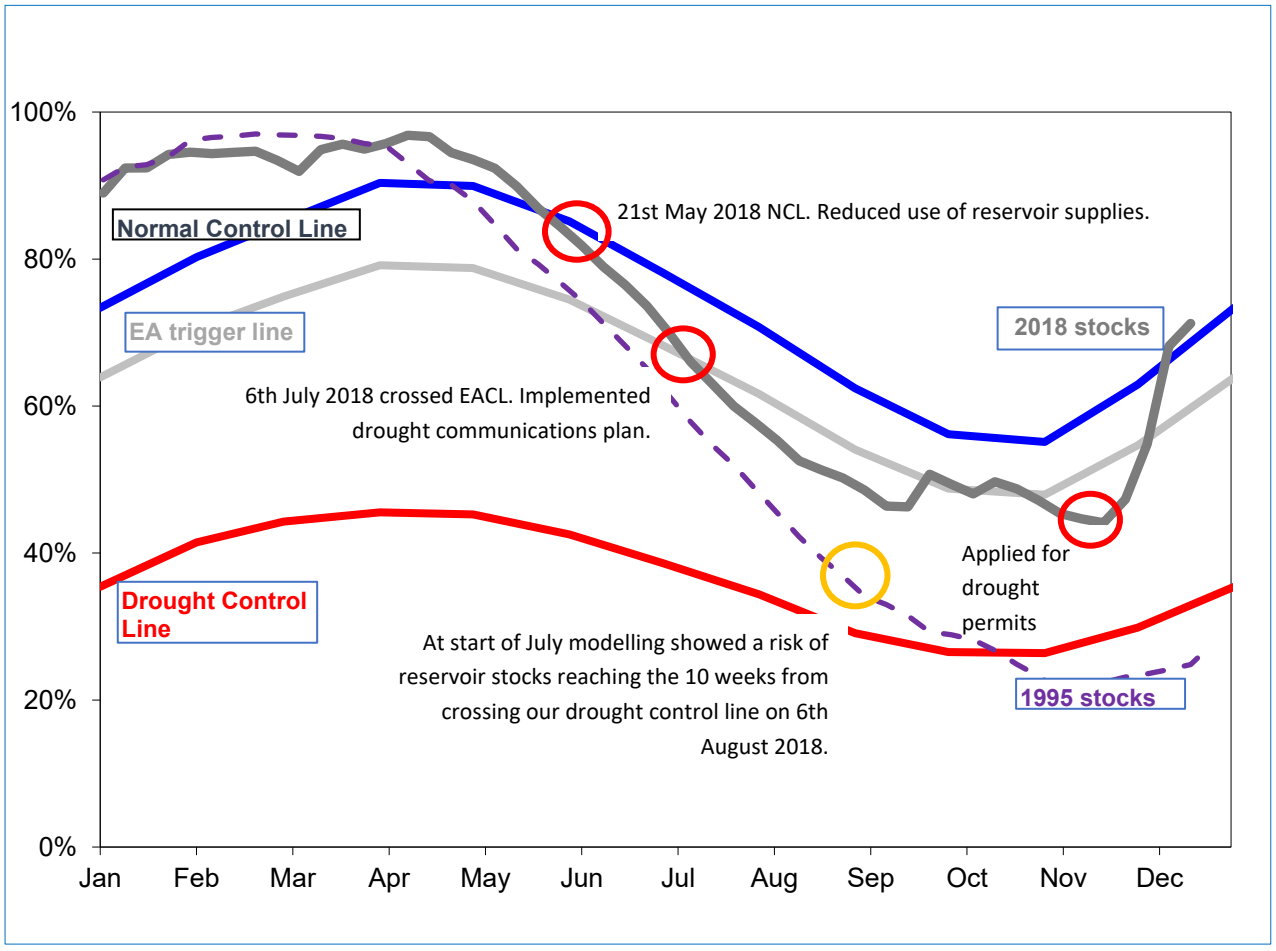


Figure 4-3 Regional reservoir stocks in 2018

The demand experienced in June and July 2018 was unprecedented in our region and led to significant use of both reservoir and river resources simultaneously. Throughout the summer we continually modelled and

monitored our water resources situation, including estimates of the likely dates that TUB and drought permit triggers could have been crossed. Early in the summer, our forecasts indicated that in the worst-case scenario our TUB trigger could have been reached during August and September in some areas. In reaction to this we enhanced our customer communications using more media channels to request water conservation. This included information for water retailers to ensure they were informed in case of any queries they may receive from their non-household customers. As the summer progressed, small amounts of rainfall meant we did not reach triggers linked to a TUB. In line with our Drought Plan a TUB would only be implemented in the summer months (April-September inclusive).

In August 2018 we started preliminary work for permit applications, including onset of drought walkovers to gather information for environmental assessments. Our modelling indicated that in the majority of scenarios neither a TUB nor drought permits / orders would be needed. However, in any drought, we plan for the worst-case scenario.

During August demand reduced closer to normal levels but rainfall was still below normal, and whilst we received average rainfall in September (largely due to a single storm event towards the end of the month), rainfall in October and the start of November was below average. Reservoirs stocks continued to decline through most of the autumn, at a time when we would usually see recovery.

At the beginning of November 2018 reservoir stocks were still below the EACL and our water resource modelling (19 November 2018) indicated that, if we had a repeat of 1995-1996 inflows over the winter and we experienced high winter demands, we could cross drought permit triggers (our DCL) in three of our five operating areas by January 2019. At this time our scenario modelling of below average rainfall from December 2018 to March 2019 with a repeat of high winter demands due to freeze-thaw over the winter of 2018/19 showed a risk our reservoirs would not refill in time for summer 2019.

In reaction to this risk we took the decision to submit drought permits applications in November 2018, before crossing the trigger for applications. This was to aid winter refill of reservoirs to ensure we were in the best position possible by spring 2019 if it remained dry. By implementing the permits during winter, we would have had less environmental impact than if we implemented them in the summer if reservoir stocks did not receive

sufficient refill through rainfall alone. Furthermore, by maximising our prospects for winter recovery, we would have decreased the likelihood of requiring permits in the following year during the more environmentally sensitive spring and summer periods.

Throughout the process of producing the applications, starting in August 2018, we reviewed the need for the permits and the prioritisation based on the rate of reservoir drawdown and the volume of rainfall received. This led to some changes to the order for submitting the applications, for example we originally intended to submit the South West Area applications first, but this was later the lowest priority.

In November and December 2018, we applied for drought permits to reduce reservoir compensation releases in our south area and to increase our annual abstraction limits for two river abstractions. We also submitted a "pre-application" for two reservoirs in our north Area and were intending to submit applications for a number of reservoirs in our north west and south west areas.

Significant rainfall in late November and early December 2018 led to a rapid increase in regional reservoir stocks from below the EACL to above the NCL. This was an unprecedented 26% increase in just three weeks. Drought permit applications for the River Wharfe and south area had been submitted and the consultation period closed. As a result of the recovery in stocks we withdrew the south Area applications and did not submit any more reservoir permit applications.

However, we continued with the River Wharfe and River Derwent permit applications as a precautionary measure as, although our reservoirs had received significant recovery, there was a risk we would not have sufficient licenced river resource available to meet a high winter demand. However, we operated to retain enough licence capacity to meet a three-week period of high winter demand, so we would have only needed to implement the permits if an extreme cold spell had occurred. Demand during the winter of 2019 was relatively stable and we did not implement either permit. The first half of 2019 was mostly drier than normal, and with baseline river flows low due to the previous dry year, we monitored the situation carefully.

If our new triggers had been in operation in 2018, regional stocks would have fallen into the level 1 band, as shown below in Figure 4-4. TUBs and drought

permits would not have been triggered, although, drought escallation, demand savings and modelling to determine the likelihood of stocks falling into bands 2 and 3, and chances of winter recovery.

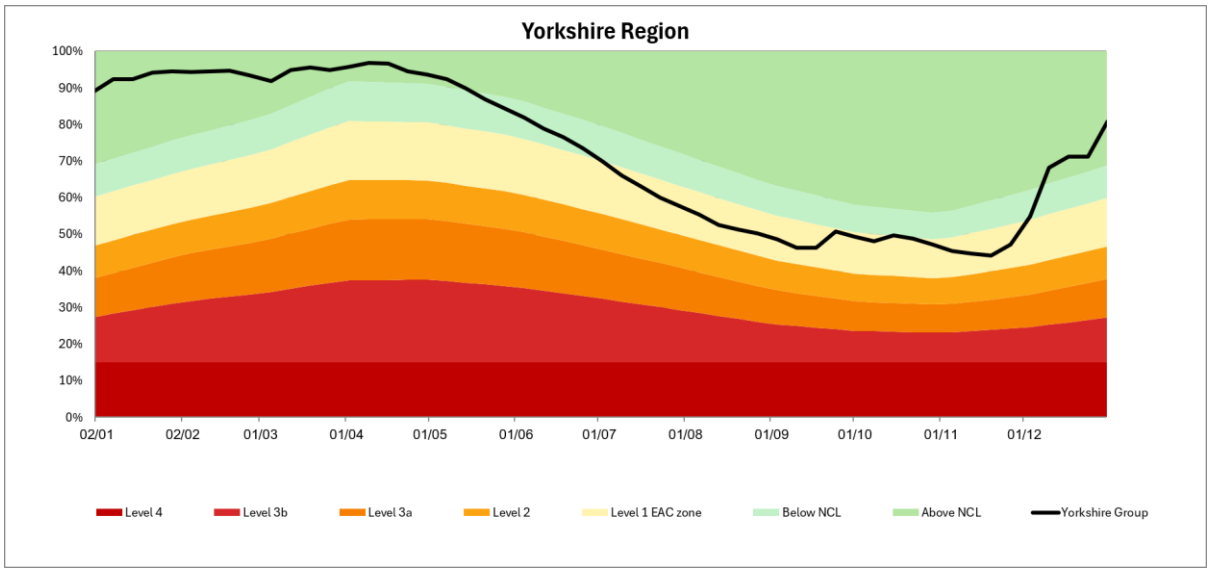


Figure 4-4 Regional reservoir stocks in 2018 with new triggers

4.5 Spring 2020 dry weather and high demand (Covid-19)

In spring 2020, conditions were hot and dry. February 2020 was one of the wettest months ever recorded, and March started wet, but became drier, with only 70% of the long term average rainfall overall. April had only 17% of long term average rainfall, and by mid April reservoir stocks were falling rapidly, with no significant rainfall in the weater forecasts for the coming weeks. We initiated our water resources Client Relationship Management Team (CRMT[4]) in April, despite the fact that reservoir stocks had not yet crossed the EA control line. We did this because stocks were falling faster than at this time in other years, and because demands were high and unpredictable due to the Covid-19 lockdown. We also recognised that, because of the other operational pressures that we were facing at that time relating to Covid-19, such as changes to working practices to ensure colleague safety, and the need for social distancing, that it was prudent to escalate early and ensure that we were proactively managing our supply position from very early on.

[4] It should be noted that in January 2021 we updated our Company Incident Management Plan. Bronze Risk is now used in place of CRMT within our escalation procedures; Company Incident Management Team (CIMT) is replaced with Silver; and Crisis Management Team (CMT) is replaced with Gold.

May 2020 had only 26% of long term average rainfall, and this, coupled with some exceptionally high demands due to hot dry weather, led to rapidly decreasing reservoir stocks. By the middle of May we crossed the EACL and were forecasting TUBs being triggered in 3 areas by the end of August if we had a repeat of the inflows from 1995-1996, and we were making preparations for applying for drought permits. We ran various modeling scenarios, and developed a new demand profile to reflect the changes in the spatial patterns in demand we were seeing due to lockdown (greater residential demands, lower business demand), and the increased volatility of demand during some of the extremely hot dry weather we experienced. We saw peaks in demand similar in magnitude to those in the summer of 2018, but whereas in the past the biggest peaks only occurred at weekends, in 2020 they could occur on any day, as people working from home or on furlough watered their gardens or filled paddling pools for childen who were not at school.

Our forecasts for the triggering of TUBs and drought permits were based on our driest years, but we also produced forecasts based on historical data for other years. During the development of a drought we use many tools to forecast future reservoir stocks and assess our current risk in relation to past and future rainfall. Below are 2 plots which we used during the period of dry weather in 2020.

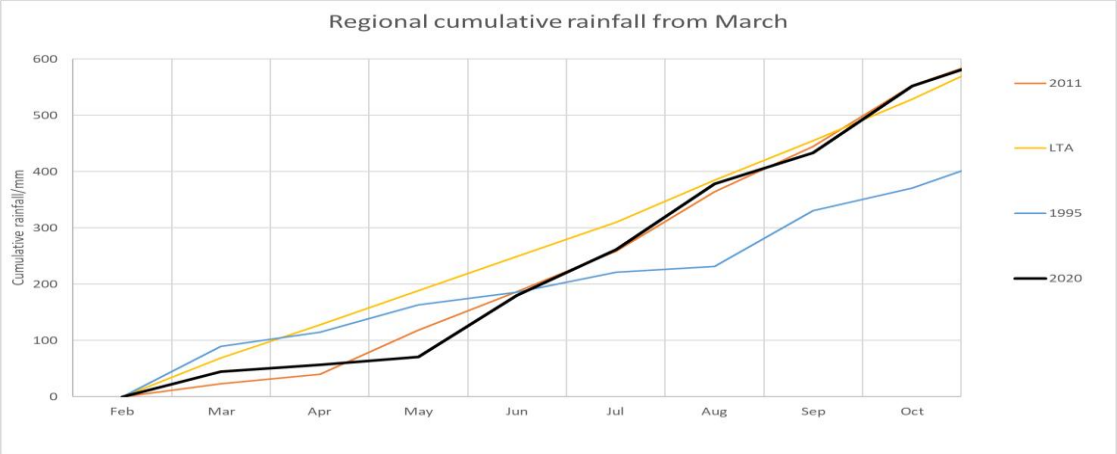


Figure 4-5 Plot of cumulative rainfall

Figure 4-5 shows the cumulative rainfall from March for 2020, the long term average, and selected drought years. It shows that March 2020 was relatively dry, (although wetter than 2011), but by May rainfall was significantly lower than 2011 (which had been a very dry spring) and 1995. At

this stage we were planning for restrictions if we then had a repeat of 1995 rainfalls.

We made projections of the likely timing of triggers for a TUB and drought permits /orders based on a repeat of 1995 inflows but also looked at the likelihood of this by making forecasts for other years.

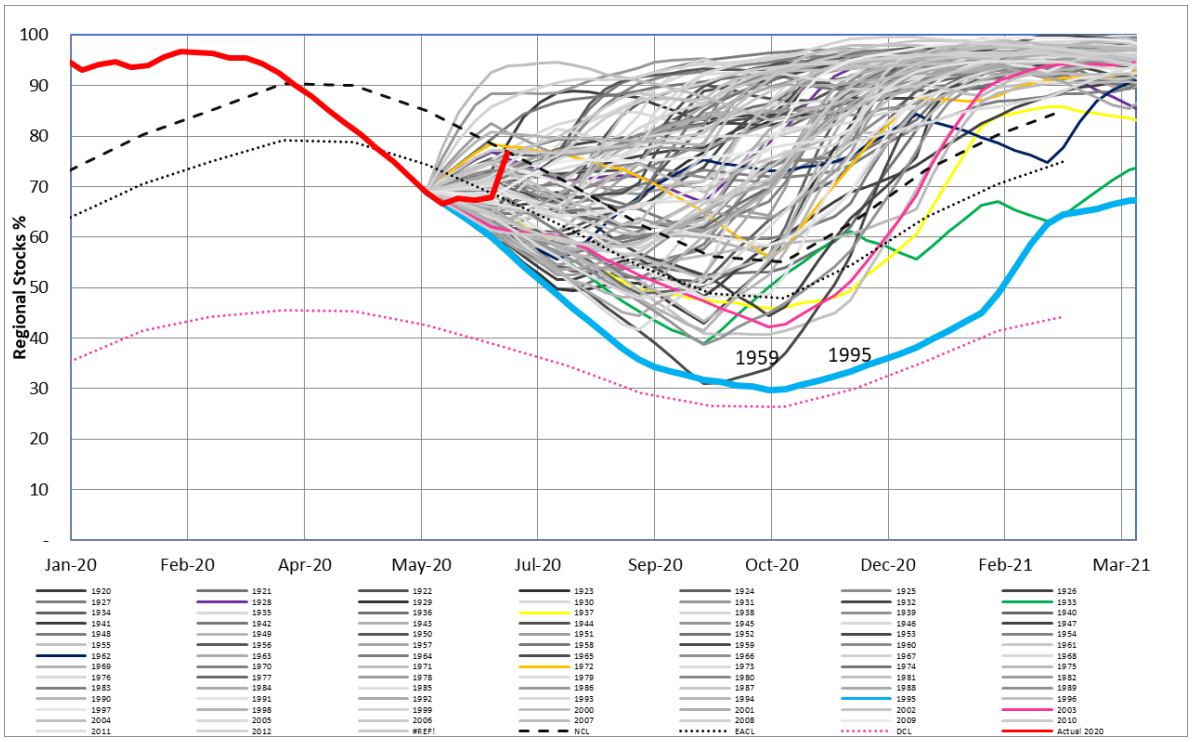


Figure 4-6 Plot of actual and forecast regional reservoir stocks in June 2020

Figure 4-6 shows the "spaghetti plot" of forecasts made at the start of June 2020. The actual stocks are shown throughout June, although the forecasts are shown from the start of June. It shows that for the first week, the actual stocks followed the worst case 1995 forecast almost exactly, but then in the following weeks, rainfall meant that actual stocks recovered to above the NCL, diverging from the forecasts for drought years. Forecasts produced in following weeks predicted no TUB or drought permits / orders triggered, but until stocks had recovered sufficiently, we continued to plan for the worst, whilst recognising it was unlikely, as failure to do so would have meant there was insufficient time to act if the situation did worsen.

4.6 Summer 2022 dry drought and heatwave

Our Grid zone has an interconnected network (grid system) that enables highly effective conjunctive use of the available water resources using raw and treated water pipelines. During dry weather we aim to maximise use of

river sources to conserve reservoir stocks for longer. However, during 2022 we experienced exceptionally low rainfall as well as periods of very high demand; this led to greater draw down of reservoirs, and the below average rainfall has meant reservoirs have not refilled.

Rainfall over the winter period of 2021-2022 was very variable, it was dry until January with reservoir stocks at 87% full at the start of the year. A very wet February meant that stocks recovered to 95% full by the end of February 2022. However, rainfall was significantly below long term average (LTA) in March and April, with stocks falling to 87% at the end of April.

Reservoir stocks crossed our 'NCL' in mid-March 2022. This triggered additional activity to manage water resources and to abstract, treat and distribute more water from rivers to reduce our draw on reservoir stocks. This activity continued during the summer until winter when the water resources position recovered. We used our grid system to move water up to 70 miles from river sources to areas in the south and west of the region which are usually supplied by local reservoirs. Throughout this period, we managed reservoir levels to ensure, as far as possible, that stocks are drawn down evenly across all areas.

In June and July, we experienced high customer demand due to ongoing dry weather coupled with a period of high (and very high) temperatures. The very high temperatures were unprecedented, with the highest temperatures ever being recorded across the UK, and the first Met Office Red weather warning for heat being issued. At times we had to maximise use of rivers and reservoirs simultaneously to meet customer demand, and during periods of low river flow we had to rely on reservoir supplies more than would normally be the case.

This led to our reservoir stocks depleting at a much faster rate and if the dry weather continued there was a risk, we would not be able to maintain supplies in some areas or receive sufficient refill for levels to return to normal in the autumn. Areas of our north west reservoir group were particularly vulnerable, with the Worth Valley being a particular area of concern. Stocks in the Worth Valley reservoirs fell to extremely low levels, and there was a risk of being unable to continue to meet demand and make compensation

releases. Stocks in the Worth Valley declined more rapidly than in previous drought scenarios.

Permits were applied for in a number of areas, and supplies were managed to try to balance stocks as much as possible. If reservoir stocks in one area were falling through the control lines at a faster rate than another area, supplies were reduced from that area and increased in others. Forecasts were made weekly using the WRAPsim model to test different modes of operation for different rainfall scenarios.

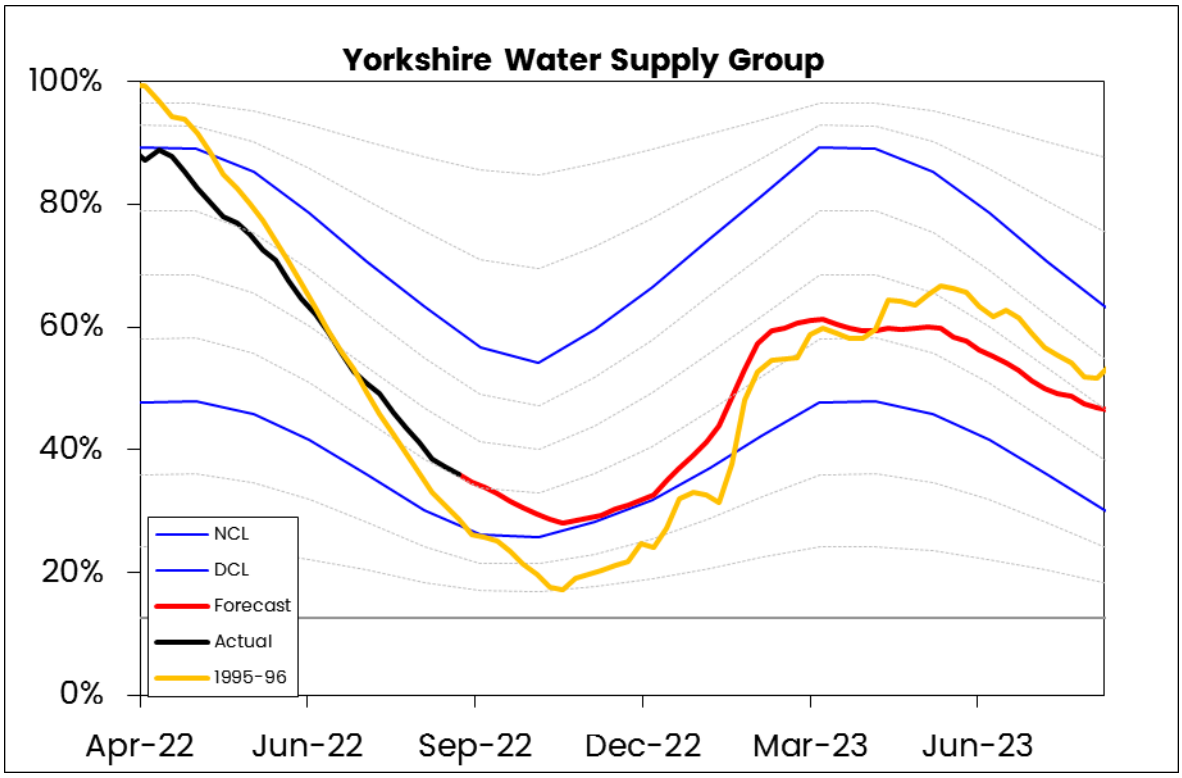


Figure 4-7: Regional reservoir stocks and forecasts

Figure 4-7 shows regional reservoir stocks as part of the output of our Water Resources Planning Report (WRPR) which we generally produce monthly during the summer but is produced weekly when drought conditions occur. We use it to forecast expected reservoir stocks based on current and future asset availability. This shows the results for a repeat of 1995-1996 inflows, at an annual average demand of 1295Ml/d. As well as the regional picture, we also produce graphs of area stocks and predict WTW outputs which we use to inform our weekly production planning process. This forecast does not show regional stocks crossing the DCL, but stocks do fall below the DCL in some areas, and some of our previous model runs showed regional stocks falling below the DCL.

The water supply situation at the time was a result of the exceptional shortage of rainfall described in the Exceptional Shortage of Rainfall evidence, August 22 report submitted to the Environment Agency in support of drought permit applications. As well as the exceptional shortage of rain, the water stocks situation had been exacerbated by exceptionally high temperatures, which resulted in very high demand for water during summer 2022. Reservoir stocks were depleted and to reduce the risk to supplies and the environment, we prepared for the possibility of continued dry weather by taking actions in line with our drought plan. There were specific hot-spots (for example, Worth Valley), where stock levels were declining more rapidly than the average regional level and this resulted in higher levels of risk which were a cause for increased concern, prompting additional measures in those areas.

Throughout the spring and summer, we continually modelled and monitored our water resources situation, including estimates of the projected dates that a TUB and drought permit triggers could have been crossed. Since early June, our modelling consistently showed that if we had a repeat of 1995-1996 inflows, we would expect to meet TUBs triggers in late August or early September 2022, and drought permit triggers (our DCL) regionally in the winter. Although our modelling showed that in most scenarios these permits would not be required, the fact that the rainfall patterns for 2022 were similar to those in 1995 and the rainfall quantities for the January to July period had been similar, meant that we needed to plan for this worst-case scenario.

We operated according to the high-level strategy outlined in our drought plan, increasing the use of river sources as reservoir stocks fell through control lines. The continued low reservoir stocks led us to plan for these permits to reduce compensation flows in order to reduce the rate of reservoir decline.

The potential threat to water supplies was a direct result of the weather conditions during this spring and summer. The threat would only have occurred if the conditions continued to be dry, or if there was a prolonged period of high demand. We acted in line with our drought plan triggers, preparing for TUBs in the summer when models suggested they would be required, and implementing TUBs, in line with our drought plan and model forecasts, from 26th August 2022.

We modelled many scenarios for both inflows and demands and selected the permits which we believed would give the most benefit and put us in the best position possible for winter 2022 and for 2023 if the dry weather continued.

Customer water use tends to increase in summer as a result of increased garden watering, jet washing, showering and use of paddling pools and hot tubs. In the summer of 2022, we saw a large uplift in water use.

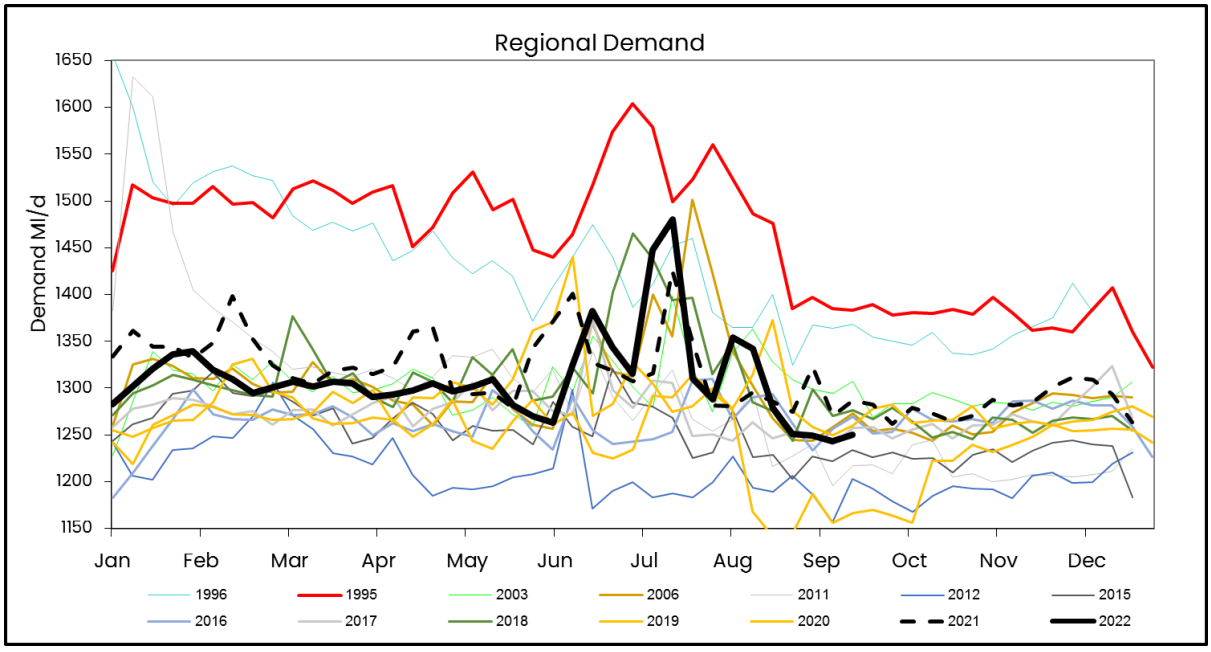


Figure 4-8: Regional Weekly Demand (from Weekly Water Situation Report)

Figure 4-8 shows the high demands experienced in 2022 compared to the preceding five years and other years selected to represent previous high demand years. This shows that in 2022 we had one of the highest weekly summer peak demands we have ever seen, except for 1996, although it should be noted that a higher proportion of the 1996 demand was due to leakage. Demand was close to levels seen in 2018, but high demand did not occur for as long. We had a weekly peak demand of 1480 Ml/d in the week of 20th July, and peak day demand of 1573 Ml/d on 19th July. This high demand had been driven by exceptionally high temperatures and dry weather, with the first ever Met Office Extreme Heat red weather warning issued on the 15th July 2022 for the 18th–19th July 2022. Further demand peaks occurred in August with an amber weather warning for extreme heat from 11th–14th August.

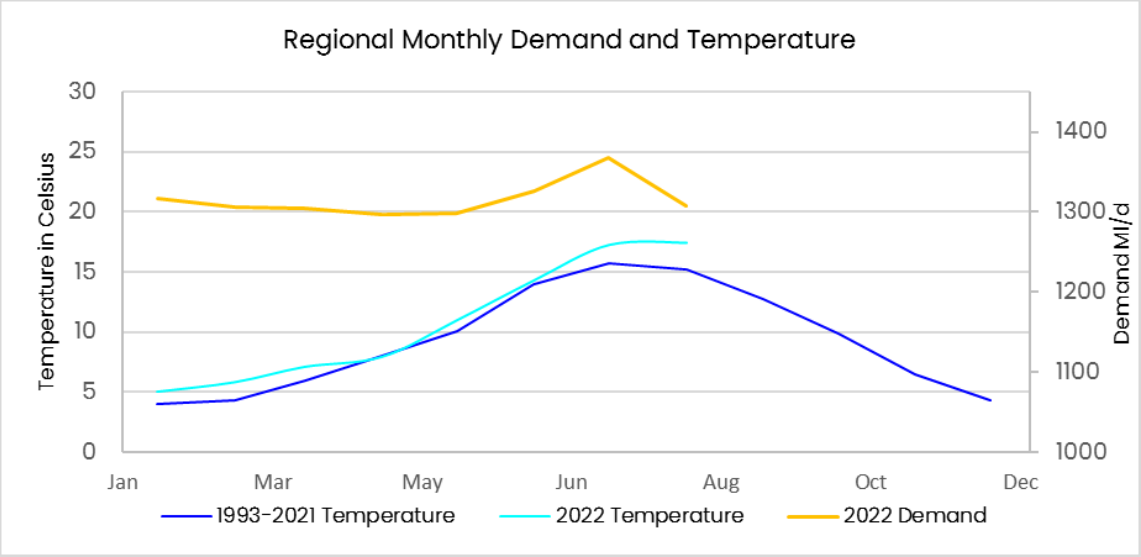


Figure 4-9: Regional Monthly 2022 Demand and Temperature

Figure 4-9 shows monthly 2022 regional demand plotted alongside monthly average temperatures (calculated from weekly MORECS data), for the 1993-2021 average and for 2022. The peak demand in July corresponds to the far higher than average temperatures.

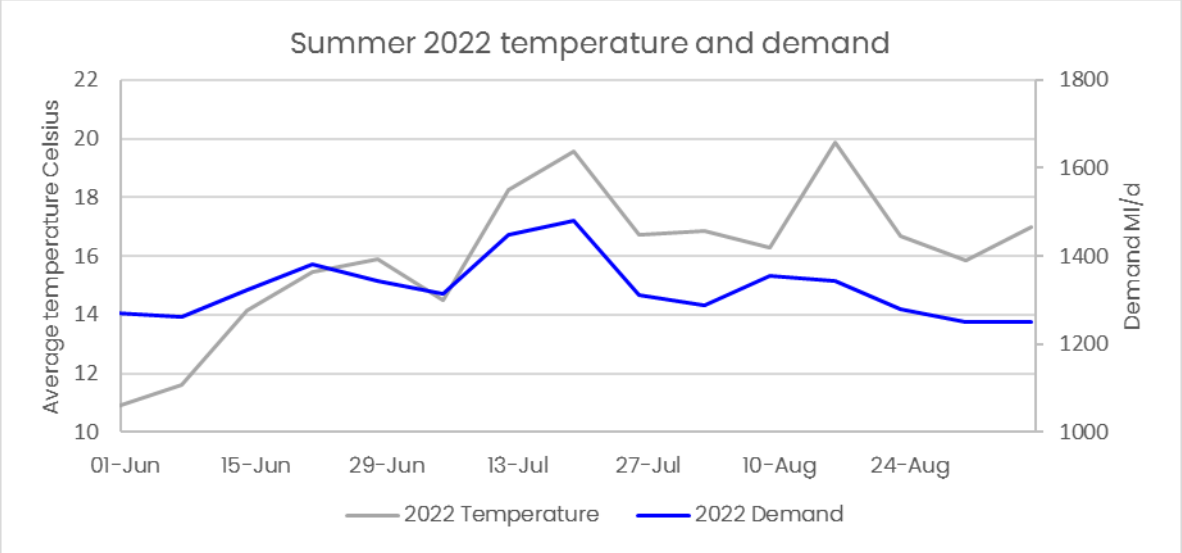


Figure 4-10: Relationship between average temperature and demand

Figure 4-10 shows weekly regional demand plotted alongside average weekly temperature, and Figure 4-11 shows weekly 2022 regional demand plotted alongside average weekly sunshine hours. Both show that demand increases in relation to high temperatures and longer sunshine hours.

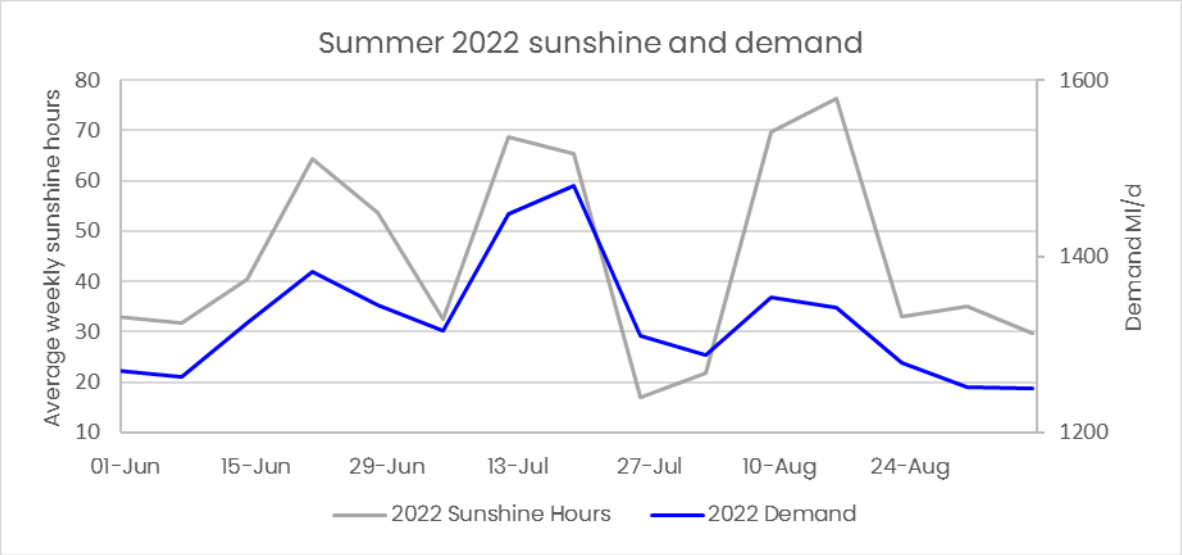


Figure 4-11: Relationship between average hours sunshine and demand

Figure 4-12 shows the regional reservoir stocks in 2022 with the new drought bands. It shows stocks entering level 1 in May and level 2 in July. It is likely that triggers and actions would be similar to those in 2022.

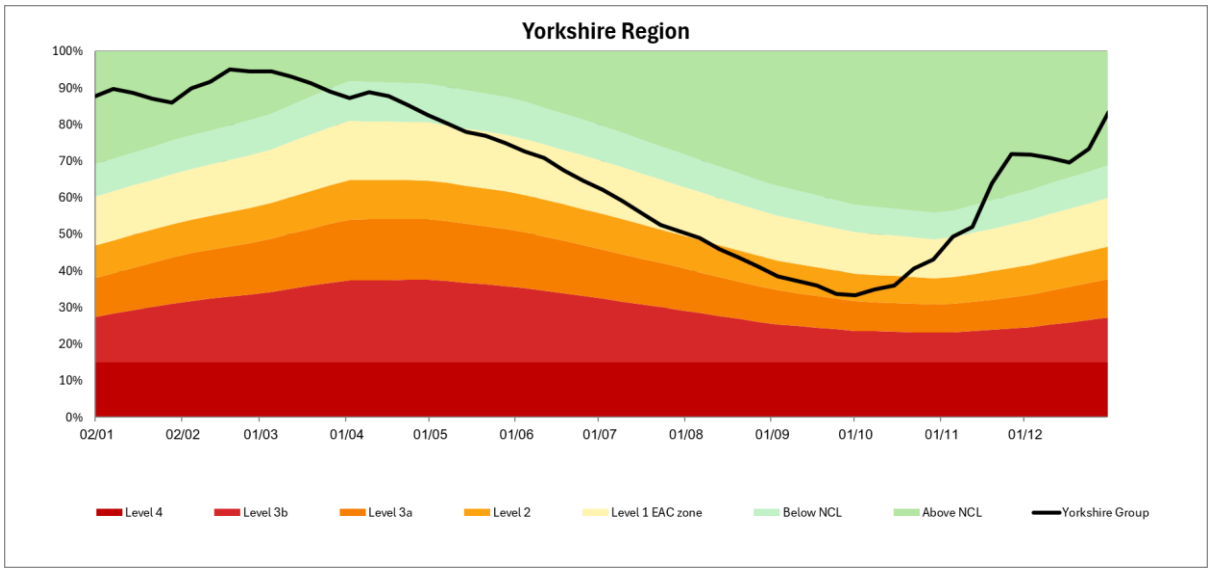


Figure 4-12: Regional reservoir stocks in 2022 with new triggers

4.7 2025 drought

Rainfall in January was slightly above average, and regional reservoir stocks were at 95.6%. Rainfall was then below average from February, and throughout the spring and summer, as shown in Figure 4-13. Rainfall in April was particularly low, at just 20% of the LTA, and rainfall did not return to significantly above averge until September. The February-August period was the driest since 1887.

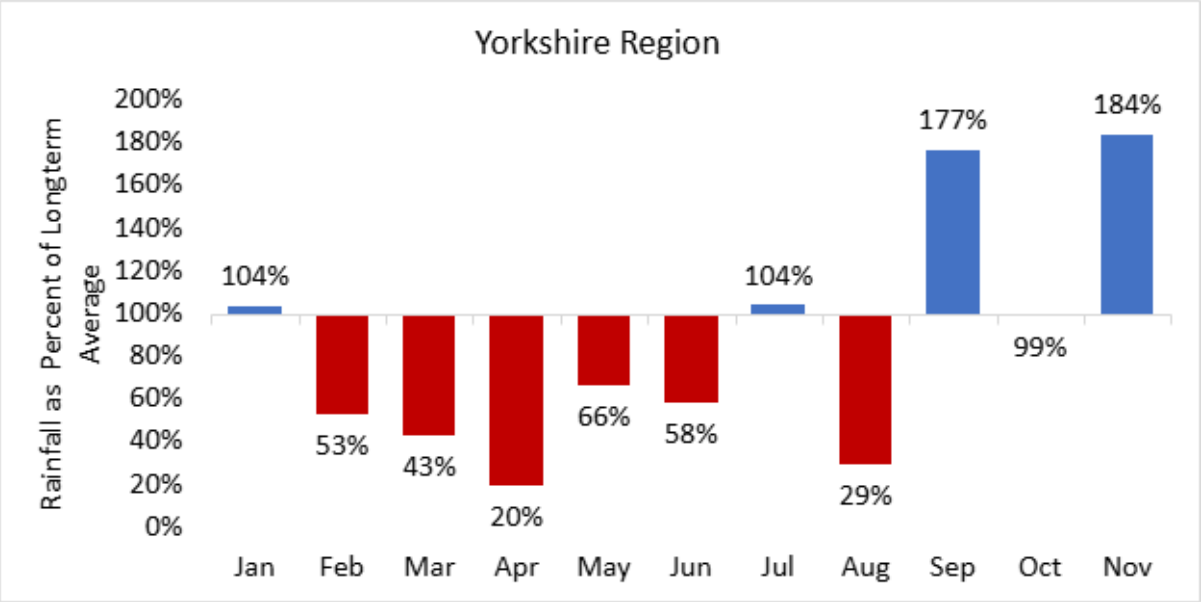


Figure 4-13: Rainfall as percentage of Long term average

Regional reservoir stocks crossed the NCL early in the year on the 25th March, activating the usual operational responses of increasing river abstractions and reducing reservoir abstractions. Due to the steep rate of fall and the dry conditions at a usually wet time of year, Bronze incident management team convened early on 3 April 2025, and Level 1 drought actions were implemented. When the EACL was crossed, the incident response level was raised to Silver, and on 12 May this was escalated to Gold. Yorkshire officially entered drought status on 12 June.

Forecasts made in early June indicated a TUB may be required in June with reservoir stocks likely to cross the DCL during September if stocks continued to fall at the same rate. Slight increases in rainfall in May and June resulted in stocks levelling off a little before continuing to fall steeply, and a TUB was advertised on 8 July and implemented on Friday 11 July before a heatwave weekend was expected.

Figure 4-14 shows the regional resrevoir stocks and triggers and actions from the 2025 drought. The dashed lines for permit applications and implementation show the changes in this drought plan, where the permit applications would be made from 72 hours after TUBs implementation, and therefore would be implemented up to 10 days earlier.

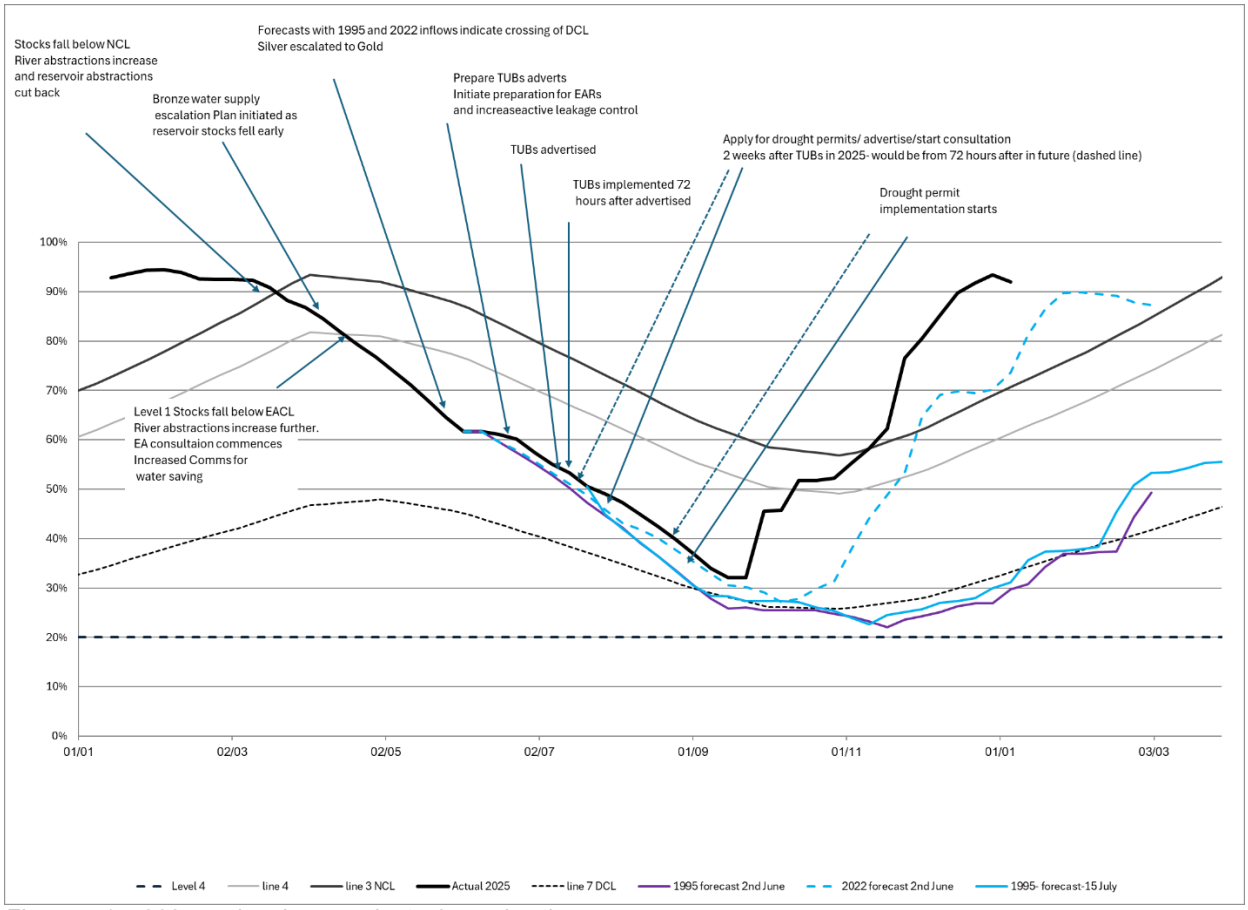


Figure 4-14: 2025 regional reservoir stocks and actions

The TUB implemented on 11 July was rescinded on 10 December 2025. We applied for 44 drought permits and one order, and implemented 24 permits and one drought order. Further details are provided in Appendix 9.

Figure 22 in Appendix 9-2 drought plan document (repeated here in Figure 4-15), shows the 2025 regional stocks, with our new triggers. It confirms that the timings of triggers and actions remain similar, but are just simplified, with levels now based on bands rather than forecast crossing of lines.

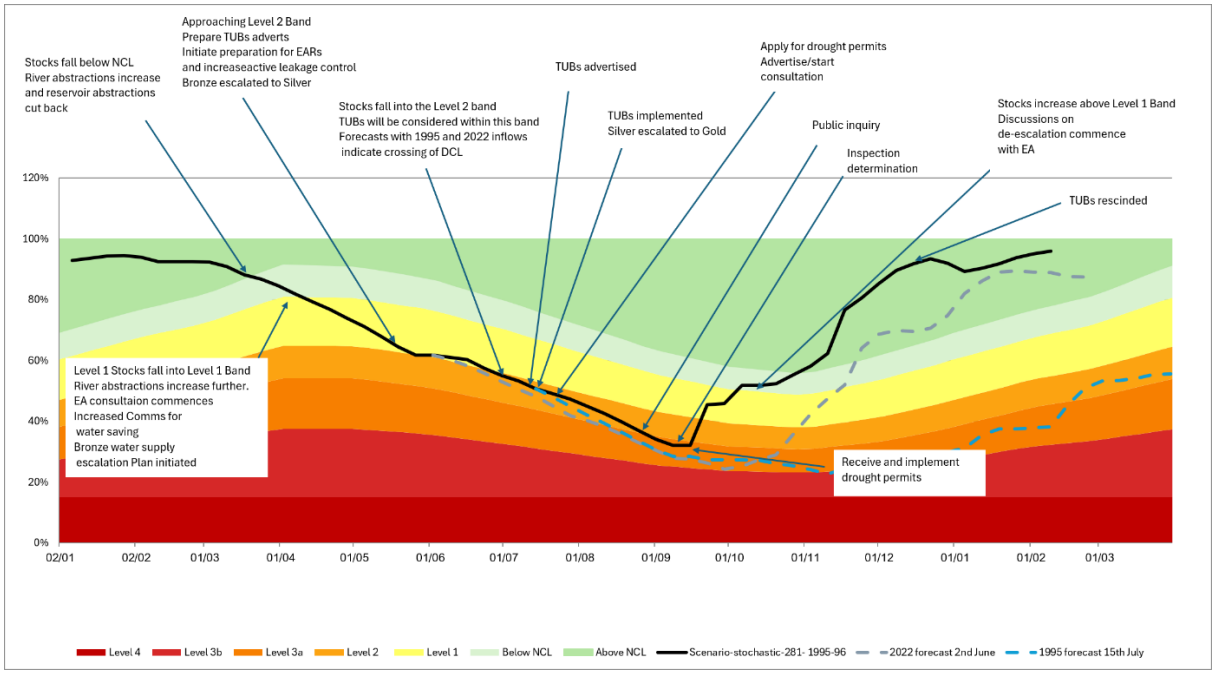


Figure 4-15: 2025 regional reservoir stocks and actions

4.8 Serious two-year drought

Annex 1.4 shows the predicted reservoir storage in a serious two-year drought. This is based on the 1995-1996 drought in a single stochastic replicate (replicate 281), run at a demand of 1400 Ml/d. In this scenario, stocks fall into the level 2 band in several areas in year 1, and stocks fall into the level 3a band in some areas, triggering drought permits and orders.

When stocks fall into the level 1 band in June of year 1 we would have started meeting the Environment Agency and convened our water supply escalation at bronze risk in our company incident management plan. We would also have requested voluntary reductions in demand, and escalated our summer efficiency campaign, as part of our agile communications strategy.

Stocks fall into the Level 2 band in most areas in July or August in year 1, and TUBs would have been implemented in mid to late August when regional stocks continued to fall within the Level 2 band. We would also carefully monitor the situation, and actively promote demand reduction and efficiency measures, and maximise leakage reduction.

In line with our normal operating policy, with reservoirs below the NCL we would maximise river abstractions and minimise use of reservoirs wherever possible. In this situation we would operate to rebalance reservoir stocks as

far as possible and minimise the use of reservoirs in the north and north west. The modelling shows stocks healthier in the south west area in year 1, but in reality we would have increased abstractions from this area and reduced abstractions in the south, north and north west. If stocks in the north and north west had been significantly lower than the other areas in year 1, we would have started applying for compensation reduction drought permits in September in these areas. In this situation we would consider applying for winter drought permits to increase annual abstraction limits on rivers if we were likely to exceed our annual limits if abstractions were maximised according to daily limits and relevant river flow thresholds. We may also have applied for winter permits to reduce compensation flows in areas where we were concerned about reservoir recovery and where we thought this would provide a benefit. Prior to applying for any permits we would have updated environmental assessment reports as part of permit pre-application process (section 3.4.3 in main DP27 report) and liaised with Natural England and the Environment Agency.

Over the winter period, if minimal winter refill had occurred, we would prepare our applications for compensation reductions drought permits, including the update of environmental assessment reports and liaison with Natural England and Environment Agency. With the slight recovery of reservoir stocks over the winter period, we would have continued to monitor the situation, and considered applying for a drought order for a non-essential use ban and supply side drought permits or orders in May of year 2, with a view to implementing them by the start of July. During this time, we would have been continuously reassessing the situation and would have been performing scenario modelling.

During the summer of year 2 when we were applying for or renewing supply-side drought permits and a drought order for a non-essential use ban we would also be carrying out environmental assessments required for our long-term drought options, and assessing which options would be the most beneficial with respect to our current water resources position, as well as which were best in terms of the environment.

In this scenario non-essential use ban drought orders and supply-side drought orders or permits are implemented and stocks fall into the level 3a band. We implement the drought options in order to preserve reservoir stocks as much as possible in preparation for a second dry winter.

This scenario is based on our 1995-1996 inflows, and its position on the drought response surface (DRS- see Appendix 3 – Drought Vulnerability Assessment) is shown as being on the border of having stocks below the DCL (within the level 3a band) for the 18 month duration ending in August. In reality, the 1995-1996 drought continued until October. It should also be noted that the DRS is for only the regional reservoir group, whereas the drought actions we have described relate to both regional and area groups. We manage our resources to balance stocks across the region as much as possible, so believe the regional DRS does offer an accurate reflection of our drought risk.

4.9 Extreme three-year drought

We commissioned a report[5] which estimated the return period of a two-year drought to be 40-70 years in the south of the region. The return period is greater in the north (that is, the event is rarer). This same report estimated that return periods for a three-year drought are greater than 400 years. However, the frequency of such long duration droughts may increase to as little as 1 in 100 years under extreme (10th percentile) climate change scenarios. This report analysed historical climate data (rainfall and temperature) and assessed the impact of future climate projections.

In the unlikely event that a drought was to extend into a third consecutive year, storage in each of the reservoir groups could be severely depleted, falling below and remaining below the 3a drought level for several months (as demonstrated in Annex 1.5). This is a scenario only; a three-year drought has never been experienced in the Yorkshire Water region since reliable records began, and there is a very low probability of such an event occurring.

Annex 1.5 shows the predicted reservoir storage during an extreme three-year drought. This is based on stochastic replicate 281, years 1995-1997. This again represents a more extreme position than has been experienced in Yorkshire in our period of record.

In this example, we would have escalated to bronze risk in our company incident management plan in June of year 1 when regional reservoir stocks crossed the EACL into the Level 1 band, at the same time as starting liaison

[5] Duration Modelling - impact of multi - year drought events on resources and assets, WRC 2012

with the Environment Agency. We would also have escalated our summer water saving campaign, and requested voluntary reductions. Over the summer we would have continually reviewed the situation, and we would have prepared our temporary use bans advertisements when regional stocks fell into the Level 2 band, and would have implemented a TUB in early September of the first year of the drought.

Stocks in the north west reservoir group entered the Level 3a band in the first winter, and even dipped into the 3b band. During the winter we would have prepared our applications for drought permits and orders to reduce compensation flows. In the spring of year 2, with some recovery, but with reservoir stocks still well below normal, we would have continued preparations for drought permit applications. In the summer of year 2 we would apply for a non-essential use ban and for ordinary supply-side drought permits / drought orders to reduce compensation flows, and to increase river abstractions in low flow bands, implementing them soon after regional stocks fell into the Level 3a band.

During the summer of year 2 when we were applying for ordinary supply-side drought permits and a non-essential use ban we would also be carrying out environmental assessments required for our extreme drought options. At this stage we would explore alternative pathways for potential extreme drought options, assessing which options would be the most beneficial with respect to our current water resources position, as well as which were best in terms of the environment. With the drought ongoing, we would decide which extreme drought options to implement depending on resource and environmental investigations, and commence the process of construction of extreme drought drought options (for example River Ouse abstraction increase, River Aire abstraction). Depending on the time taken to construct the extreme drought option, the additional resource would be available sometime during year 3. The figure shows modelled reservoir stocks with TUBs, NEUBs and compensation flow reduction and river abstraction increase drought permits and drought orders.

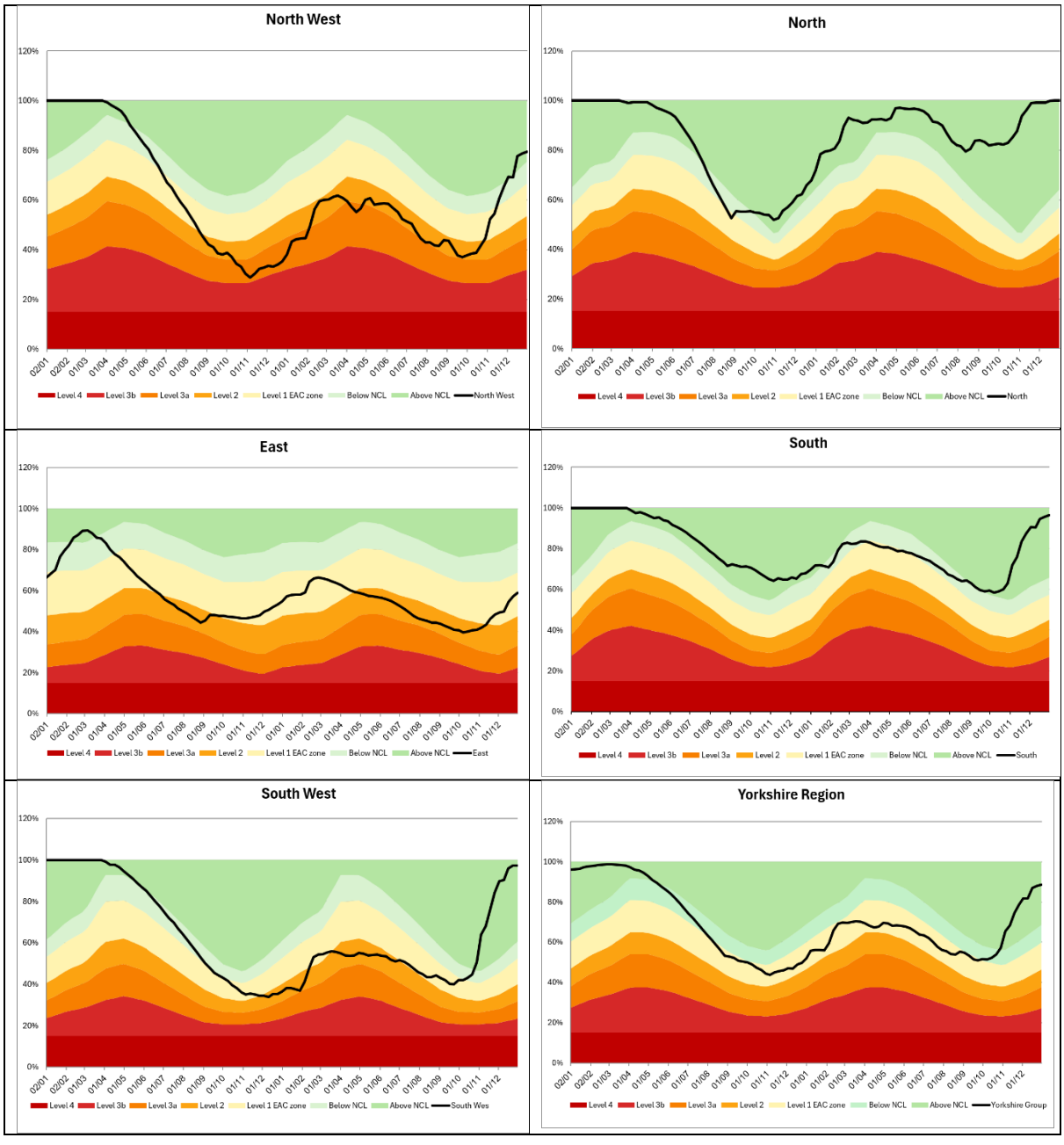
In the third year, we may have received additional benefits from extreme drought options such as the use of the River Aire abstraction (up to 40Ml/d), and an additional abstraction of 40Ml/d from the River Ouse (shown in the figures in Annex 1.5 from August in year 3). We would keep a decision to implement one of these options under continuous review. In this scenario,

during the second year of the drought we would have decided to progress with the option, with it becoming operational sometime during the third year.

There is some uncertainty as to when these extreme drought options could be implemented, and their benefit has not been shown in the plots, but depending on when implemented, they could have increased minimum stocks or decreased the time for stocks recovery.

Annex 1 Example control curves plus scenario lines

Annex 1.1: Drought Planning in Weekly Water Situation Report: 1995-96 baseline scenario 1300Ml/d demand



YorkshireWater

Commentary

Regional stocks first cross into the Level 1 band in August 1995; this would trigger a Bronze Risk response in our company Incident Management Plan, and liaison with the Environment Agency. The abstractions in the North West and South West areas would have been reduced in summer 1995 when stocks fell faster in those areas than others, and these areas would have been supported by grid transfers.

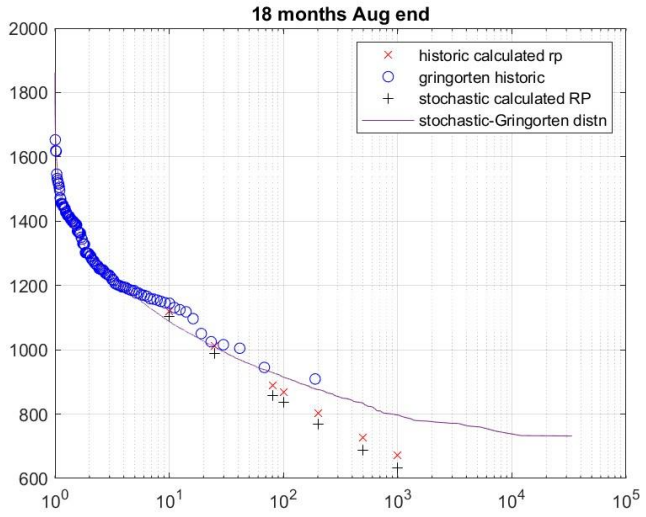
The figure above shows the predicted reservoir storage under a repeat of 1995-1996 inflows at an average annual demand of 1300Ml/d, with a dry year monthly demand profile. The simulation show stocks falling into the Level 2 band in only the north west, east and south west areas, although in the south west this occurs in late November. Because only 2 areas fall into the level 2 band in the April-September TUBs season, and the regional stocks do not enter the level 2 band, it is likely that no temporary use bans would have been implemented as attempts would have been made to rebalance stocks across the Yorkshire region, and TUBs would only be implemented if triggered regionally. In practice, during 1995-1996 we had drought orders throughout the region. The improved service, compared to the actual situation in 1995-1996, is due to the significant investment in leakage control and the grid network that we have made in the last 25 years.

When the January 1995-December 1996 inflows are run at a higher annual average demand of 1380Ml/d, temporary use bans are triggered. Since 2016 annual average demands have ranged from 1246Ml/d to 1329Ml/d, with an average of 1293Ml/d, so a 1380Mld annual average demand represents a high demand scenario.

The 1995-1996 event is the only two-year drought we have in our period of record. Rainfall totals for the 20 month period from March 1995 to October 1996 are just 67 per cent of the long-term average.

Scenario

Demand:1300Ml/d
Inflows: Jan 1995-December 1996
Return periods of regional rainfall
Analysis of minimum historic inflows: Generalised Pareto Distribution (GPD) of 18 months ending in August 60% of average year, Return period approximately 1 in 100 to 1 in 200 years.
Analysis of historic rainfall- 189 year return period for 18 months ending in August 1996 (Gringorten plotting position, based on top ranked event in the period), although when a distribution is fitted, this event is an outlier, and the return period for an event of this size is only 65 years.
Analysis of stochastic rainfall gives rainfall of this magnitude return period of 112 years based on the 18 month rainfall totals, and only 50 years when a distribution is fitted (again showing the difference between the fitted distribution and the raw rainfall data)

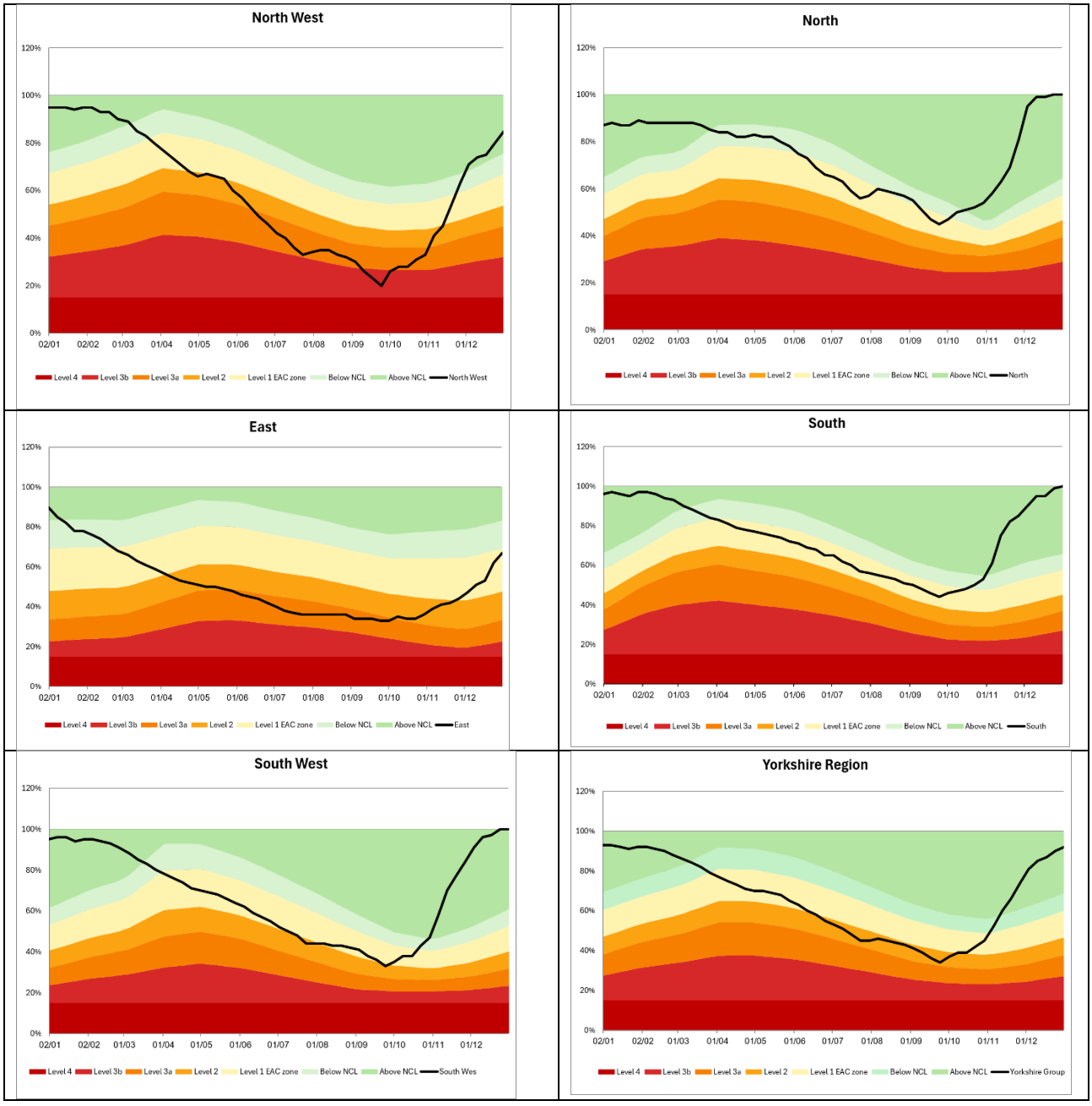


Timeline

Trigger	Date	Actions
Level 1 EA trigger line crossed in East area	End of April 1995	
	May 1995	Usual summer conservation campaign commenced.

Regional stocks cross into NCL band	End of May 1995	Reservoir abstractions reduced and rivers maximised.
Level 1 EA trigger crossed in NW	July 1995	
Level 1 EA trigger crossed in regional, and north groups	August 1995	Rapidly falling areas supported by grid transfers. Increased leakage control Increased voluntary water efficiency media communications Escalated to Bronze Risk in line with company Incident Management Plan EA liaison commenced
Temporary Use Bans Triggered	None	Regional stocks do not fall into level 2 band. Stocks fall into level 2 band in June in the East area, and in August and December respectively in the North West and South West groups.
Drought Orders	None	

Annex 1.2: Drought Planning in Weekly Water Situation Report: 1929 one season drought scenario at 1460Ml/d demand



Commentary

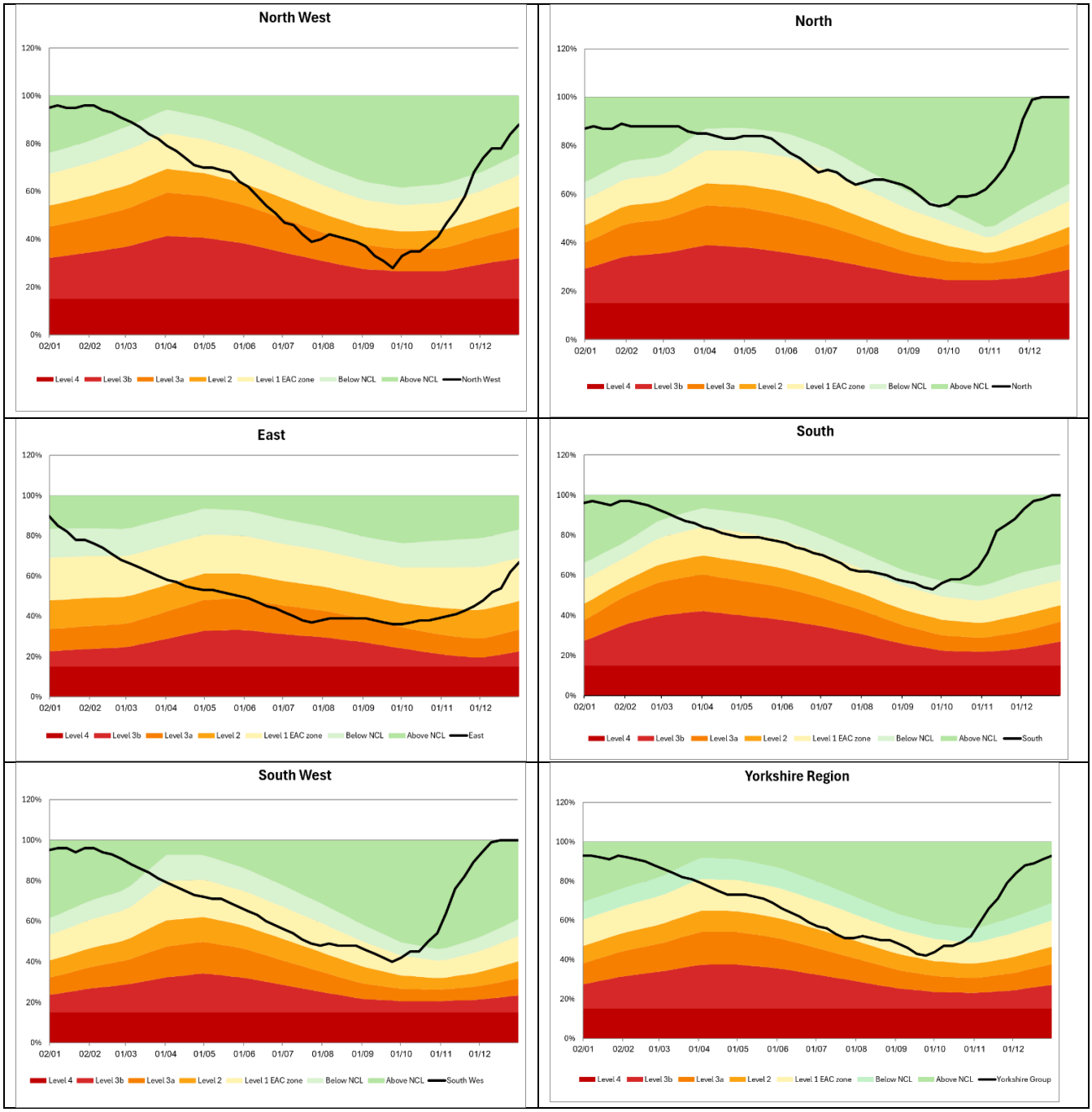
In this scenario regional stocks fall into the level 1 band in April, and at this stage we would have started meetings with the Environment Agency and escalated to Bronze Risk in line with our company Incident Management Plan. We would implement our summer water efficiency program starting in May. Regional stocks fall into the Level 2 band in late June. With model forecasts indicating the risk of stocks continuing to decline rapidly, we would

have begun preparation of our temporary use ban adverts in July and advertised and implemented them in August or September. At the same time as preparing the TUBs adverts, we would have started to consult the Environment Agency and Natural England on supply side drought options and begun preparation of our supply side drought permit applications and non-essential use bans. Rainfall resulted in the recovery of reservoirs and by October, we would have made the decision not to proceed with our supply side drought permit applications and non-essential use bans.

Scenario: Demand: 1460 Ml/d Inflows: Historic January to December 1929 Return Period analysis February-September regional rainfall 8 months, classified as extremely and exceptionally dry using SI and Cunnane ranking analyses respectively. Analysis of minimum modelled reservoir stocks give a return period of 50-100 years (Generalised Pareto Distribution extreme value analysis of lowest stocks). Analyses for drought response surface 6 month drought ending in August - 50-100 year return period using Generalised Pareto Distribution extreme value analysis of lowest inflows, and 20-30 years based on rainfall analyses of both historic and stochastic data.		
Timeline		
Trigger	Date	Actions
Regional NCL crossed.	March 1929	Reservoir abstractions reduced and rivers maximised.
Regional group stocks fall into level 1 band. Stocks in East reservoir group fall into level 2 band	April 1929	Bronze Risk escalation instigated. EA liaison commenced. East area supported by grid transfers
Regional group stocks continue falling and remain in level 1 band. Stocks in North West Reservoir groups fall into level 2 band.	May 1929	Summer efficiency campaign started. Bronze Risk escalated to Silver. North West and East areas supported by grid transfers.
Regional group stocks fall into level 2 band.	July 1929	Silver Risk escalated to Gold Escalate summer water saving campaign.

Stocks in North West are in band 3b.		Preparation of TUBs advertisements. Consultation with EA and NE.
Regional stocks remain in band 2, with recovery in some weeks.	August 1929	Analysis of regional and area rainfall to prove exceptional shortage
Regional stocks remain in band 2 and continue to fall. Stocks in North West fall into band 3b.	September 1929	Initial preparation of non-essential use ban and supply side drought orders and permits
	Mid-late September 1929	Tubs advertised and TUBs imposed 72 hours later. Submission of first drought orders or permits Continued preparation of remaining permits.
Rainfall leads to recovery of reservoir stocks	October 1929	Continued preparations to submit supply side drought permits and demand side drought orders for non-essential use bans would have been made, but then significant rainfall occurs. Continue maximising river abstractions until reservoir stocks are above NCL
Reservoir stocks recover above NCL	November 1929	Return to normal operation
Drought Orders	None	

Annex 1.3: Drought Planning in Weekly Water Situation Report: 1929 one season drought scenario at 1380 Ml/d demand



Commentary

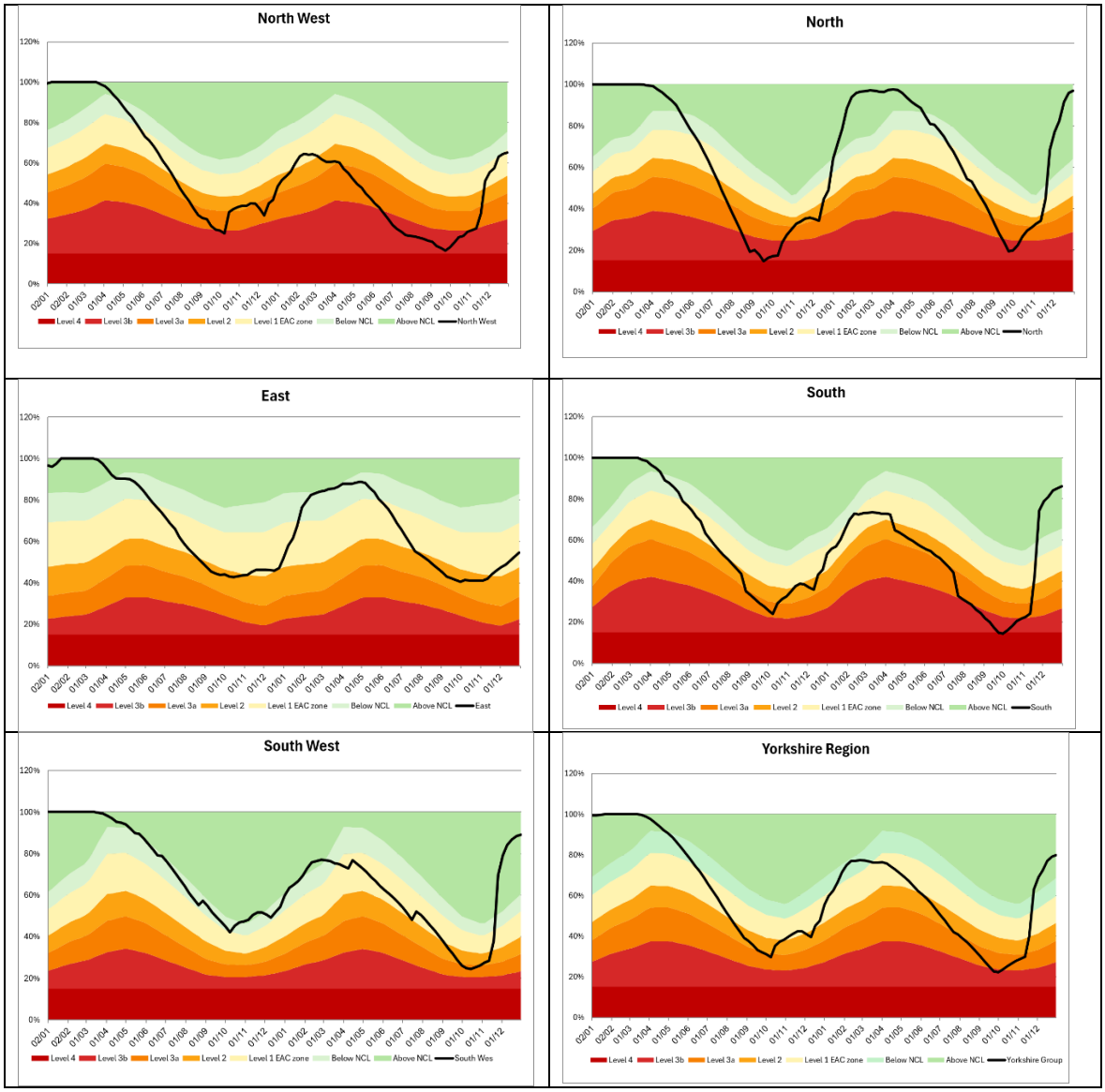
This scenario uses the 1929 inflows, but with a high realistic annual average demand of 1380Ml/d instead of the high demand of 1460Ml/d. TUBs are triggered in 2 areas, but none are implemented.

Timeline

Scenario:
Demand: 1380 Ml/d
Inflows: Historic January to December 1929
Return Period analysis
Feb-September regional rainfall 8 months, classified as extremely and exceptionally dry using SPI and Cunnane ranking analyses respectively.
Analysis of minimum modelled reservoir stocks give a return period of 50-100 years (Generalised Pareto Distribution extreme value analysis of lowest stocks).
Analyses for drought response surface 6 month drought ending in August - 50-100 year return period using Generalised Pareto Distribution extreme value analysis of lowest inflows, and 20-30 years based on rainfall analyses of both historic and stochastic data.

Trigger	Date	Actions
Regional NCL crossed	March 1929	Reservoir abstractions reduced and rivers maximised
Regional group stocks fall into level 1 band	April 1929	Bronze Risk escalation instigated EA liaison commenced
	May 1929	Summer efficiency campaign started as part of agile communications.
East group and North West Reservoir group fall into level 3a band	May 1929	East and North West areas supported by grid transfers Escalate water saving campaign No TUBs imposed as only triggered in 2 areas and managed by support from other areas and river abstractions.
	June-October 1929	Scenario modelling carried out. Supplies balanced across region. Rainfall, reservoir stocks and demands monitored.
Rainfall leads to recovery of reservoir stocks	October 1929	Rivers still maximised as regional stocks below NCL
Reservoir stocks recover above NCL	November 1929	Return to normal operation
Drought Orders	None	

Annex 1.4: Drought planning in Weekly Water Situation Report: Two year drought at 1400Ml/d demand-stochastic replicate 281



Commentary

When stocks fall into the level 1 band in June of year 1 we would have started meeting the Environment Agency and escalated to Bronze Risk in line with our company Incident Management Plan. We would also have requested voluntary reductions in demand and escalated our summer efficiency campaign as part of our agile communications plan.

Our modelling from June shows stocks likely to fall into the level 2 band in August in the North and North West reservoir groups, with triggers crossed in late September in the east group and regionally. Stocks fell into the level 2 band in August, and TUBs would have been implemented in

September. We would also actively promote demand reduction and efficiency measures and maximise leakage reduction. In line with our normal operating policy, with reservoirs below the NCL we would maximise river abstractions and minimise use of reservoirs wherever possible. In this situation we would operate to rebalance reservoir stocks as far as possible and minimise the use of reservoirs in the North and North West. We would consider applying for winter drought permits to increase annual abstraction limits on rivers if we were likely to exceed our annual limits if abstractions were maximised according to daily limits and relevant river flow thresholds. We may also have applied for winter permits to reduce compensation flows in areas where we were concerned about reservoir recovery and where we thought this would provide a benefit. Prior to applying for these permits we would have prepared environmental reports and liaised the Environment Agency and other relevant stakeholders.

If no winter permits had been applied for, over the winter period, if minimal winter refill had occurred, we would prepare our applications for compensation reductions drought permits, including the preparation of environmental reports and liaison with Natural England and Environment Agency. Temporary use bans would be re-advertised in March of year 2, so that they were in place by April, coinciding with the start of the growing season. With the slight recovery of reservoir stocks over the winter period, we would have continued to monitor the situation and applied for non-essential use bans and supply side drought permits or orders in May of year 2, with a view to implementing them by the start of July. During this time, we would have been continuously reassessing the situation and would have been performing scenario modelling, and with a repeat of 1929 inflows from March 1996, regional reservoir stocks would have been forecast to fall below the DCL at the start of July 1996.

During the summer of year 2 when we were applying for supply-side drought permits and non-essential use bans, we would also be carrying out environmental assessments required for our long-term drought options and assessing which options would be the most beneficial with respect to our current water resources position, as well as which were best in terms of the environment.

This scenario is based on the 1995/96 inflows for a single stochastic replicate, and for the 18 month duration ending in August, the return period is approximately 1 in 100 years in the stochastic rainfall record.

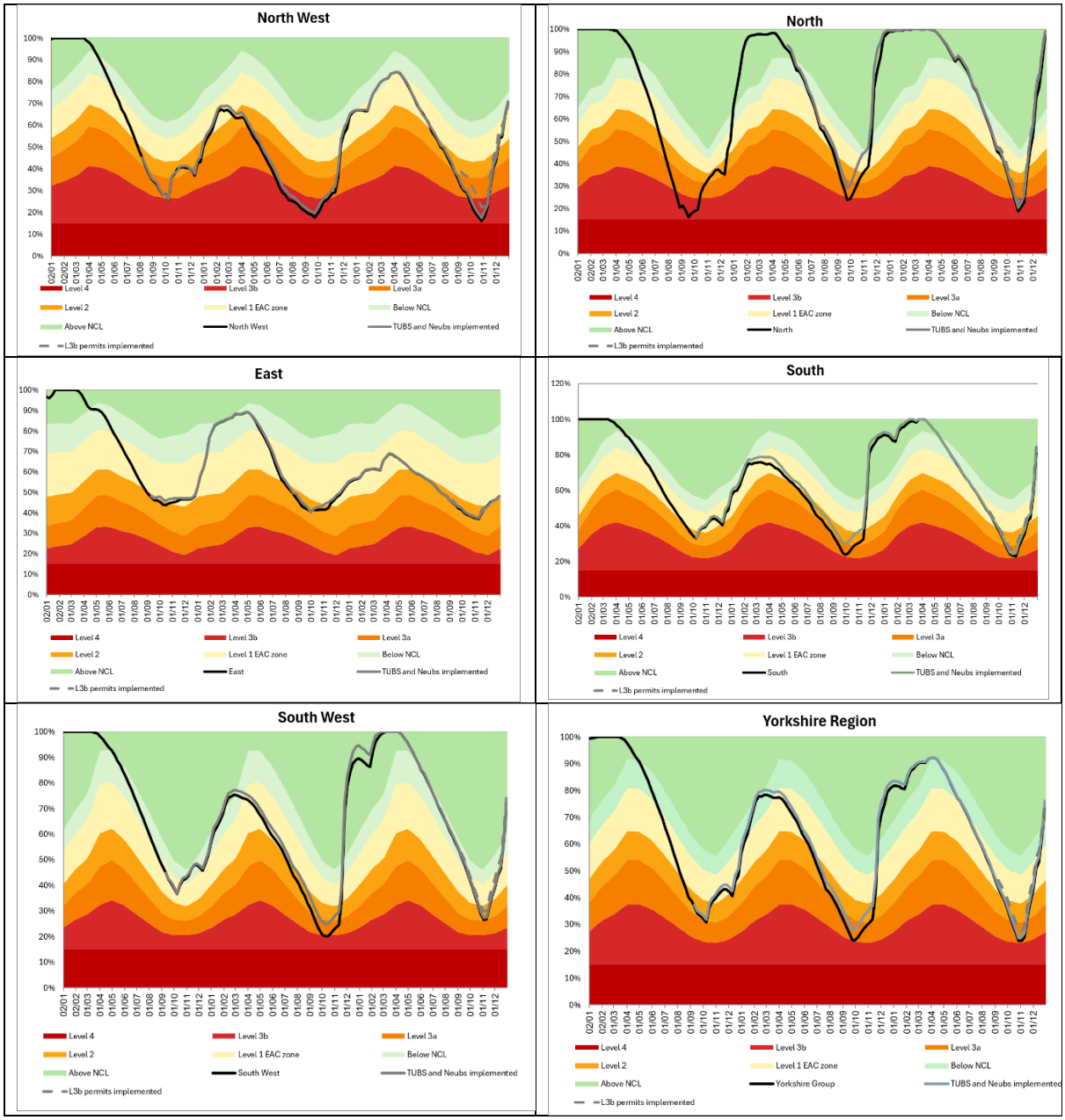
Scenario: Demand: 1400Ml/d Stochastic replicate 281- years 1995-96 Analysis of stochastic rainfall gives rainfall of this magnitude return period of 108 years for the 18 months ending in August, or of 50 years when the fitted distribution is used.		
Timeline		
Trigger	Date	Actions
Regional NCL crossed	April 1995	Reservoir abstractions reduced and rivers maximised Summer efficiency campaign started as part of our agile communications plan.
Level 1 trigger crossed in regional group	June 1995	Bronze Risk escalation instigated EA liaison commenced Analysis to determine exceptional shortage of rainfall commenced.
Level 2 band entered in some reservoir groups.	July 1995	Bronze Risk escalated to Silver Increase leakage management. Increase water saving awareness campaigns as part of agile comms. Increased efficiency measures. Continue to monitor the situation carefully. Continue rainfall analyses. Prepare TUBS advertisements
Level 2 band entered in regional reservoir group.	August 1995	North West and North areas continue to be supported by grid transfers
Stocks continue to fall in Level 2 band. Drought Control Line forecast to be crossed in October regionally.	August 1995	Advertise TUBs Continue with: • Increased leakage management

North and North West stocks fall into Band 3a (although in reality previous operations would have balanced stocks between areas more). Rainfall analysis shows high return period event.		• Increased water saving awareness campaigns • Increased efficiency measures Monitor water resources position Continue with preparation of demand side drought permits/orders to restrict non-essential use, Environmental Assessment Reports and supply side drought order/permit applications TUBS implemented. Silver escalated to gold. Consider whether winter permits to reduce compensation flows would benefit reservoir stocks. Consider whether increase in annual licence drought permits would be required. Prepare and submit permit applications for North and North West areas.
	September 1995	Continue permit preparations and submissions for south area, implement permits in north and north west.
Lack of winter refill	December 1995	Considering very low reservoir stocks, maximise support by grid transfers to areas most in need.
Limited winter refill, exceptional shortage of rainfall, and scenario modelling using historic inflows predicts triggers being crossed again. Reservoir stocks start to fall again.	March 1996	Liaison with EA and NE Initial preparation of demand side drought permits/orders to restrict non-essential use, Environmental Assessment Reports and supply side drought order/permit applications Continue with preparation of demand side drought permits/orders to restrict non-essential use, Environmental Assessment Reports and supply side drought order/permit applications Rainfall and inflow analyses to demonstrate exceptional shortage of rainfall.
Stocks in Band 1 and falling	April 1996	Continue to: Prepare non-essential use ban drought orders or permits

Scenario modelling (using 1929 inflows) indicates regional stocks falling below DCL in July		Prepare compensation reduction drought permits or orders Prepare increased river abstractions/HOF reduction drought orders
Reservoir stocks continue to fall steeply, entering band 2 in June	May-July 1996	Start to re-submit supply side drought permits (compensation reduction and increased abstraction/HOFs) and demand side drought orders for non-essential use bans. Start to discuss long term drought options with EA, NE and other stakeholders. Depending on location of drought, identify most beneficial long-term drought options, and prepare environmental assessments.
Regional stocks enter band 3a	August 1996	NEUB and supply side drought permits/orders obtained and implemented. Continue investigations and environmental assessment work on long term drought options. Liaise with Environment Agency and Natural England. Progress plans for long term options abstraction on River Aire, and increase in abstraction at Ouse Water Treatment Works, as flows in the North and North West areas are healthier than those in the South and South West.
Reservoir stocks start to recover	October 1996	Continue with compensation reduction drought permits and non-essential use bans but no longer implementing increased abstraction/HOFs drought permits.

Reservoir stocks recover above NCL	November 1996	Return to normal operation

Annex 1.5: Drought planning in Weekly Water Situation Report: Three-year drought at 1995-1997 in stochastic replicate 281 at demand of 1380Ml/d



Commentary

This is based on stochastic replicate 281, years 1995-1997. This represents a more extreme position than has been experienced in Yorkshire in our period of record. Although there is considerable recovery in some areas in the winter of 1996, stocks do not fully recover, and areas continue to implement drought restrictions.

In this example, we would have escalated to Bronze Risk in our company Incident Management Plan in June of year 1 when regional reservoir stocks crossed into Band 1, at the same time as starting liaison with the Environment Agency. We would also have escalated our summer water saving campaign, and requested voluntary reductions. Over the summer we would have continually reviewed the situation, and we would have prepared our temporary use bans advertisements, and would have implemented temporary use bans when they were first triggered in early September of the first year of the drought.

Regional stocks just touched the top of the level 3a band in the summer of year 1, and stocks in the North West reservoir group just hit the top of the 3b band. During the winter we would have prepared our applications for drought permits and orders to reduce compensation flows. In the spring of year 2, with some recovery, but with reservoir stocks still well below normal, we would have continued preparations for drought permit applications. In the summer of year 2 we would apply for non-essential use bans and for ordinary supply-side drought permits to reduce compensation flows, and to increase river abstractions in low flow bands.

During the summer of year 2 when we were applying for ordinary supply-side drought permits and non-essential use bans we would also be carrying out environmental assessments required for our long-term drought options, and assessing which options would be the most beneficial with respect to our current water resources position, as well as which were best in terms of the environment. With the drought ongoing, we would decide which long term options to implement depending on resource and environmental investigations, and commence the process of construction of long-term drought options (for example River Ouse abstraction increase, River Aire abstraction). We would also assess the need for emergency drought orders from the summer of year 2 and would continually review the requirements (and benefits) of these.

Depending on the time taken to construct the long term option, the additional resource would be available sometime during year 3. The figure shows modelled reservoir stocks for no drought options, and with the "ordinary" drought options of TUBs, NEUBs, compensaiton only drought options, and abstraction increases options artificialy being applied from the summer of year 1, with level 3b options of the River Aire abstraction being implemented in the autumn of year 3. The implementation of drought options has a small impact regionally on reservoir stocks, with a greater impact in some reservoir groups with large compensaiton releases. This does not necessarily reflect the timing of drought options, but gives a good illustration of potential impacts.

Scenario: 3 year drought
Demand: 1380Ml/d
Inflows: January 1995-December 1997 for stochastic replicate 281
Return Period Analyses
Return period analyses of the stochastic time series gives a return period of about 120 years for the rainfall totals for the 30 months ending in August. There are, however, only 0.25% of occasions when there are 3 consecutive years where reservoirs stocks fall below 40%.

Timeline

Trigger	Date	Actions
Regional NCL crossed	April 1995	Reservoir abstractions reduced and rivers maximised Summer efficiency campaign started.
Regional stocks fall into Level 1 band.	June 1995	Bronze Risk escalation instigated EA liaison commenced Analysis to determine exceptional shortage of rainfall commenced.
Regional stocks fall into Level 2 band. NW group stocks fall into level 3a band.	August 1995	Bronze Risk escalated to Silver Increase leakage management Increase water saving awareness campaigns Increased efficiency measures Continue to monitor the situation carefully. Continue rainfall analyses.

Regional stocks in Level 2 band and continue to fall.	Late August 1995	Advertise TUBS
Regional stocks in Level 2 band and continue to fall, approaching level 3a band.	September 1995	North and North West areas continue to be supported by grid transfers Continue with: • Increased leakage management • Increased water saving awareness campaigns • Increased efficiency measures Monitor water resources position Continue with preparation of demand side drought permits/orders to restrict non essential use, Environmental Assessment Reports and supply side drought order/permit applications TUBS implemented. Silver escalated to gold.
Lack of winter refill South and South West stocks fall into level 3b band.	December 1995	Continue to support all areas with grid transfers as needed.
Limited winter refill, exceptional shortage of rainfall, and scenario modelling using historic inflows predicts triggers being crossed again.	March 1996	With reservoir stocks failing to recover, re-advertise TUBs. Liaison with EA and NE Initial preparation of demand side drought permits/orders to restrict non essential use, Environmental Assessment Reports and supply side drought order/permit applications Continue with preparation of demand side drought permits/orders to restrict non essential use, Environmental Assessment Reports and supply side drought order/permit applications Rainfall and inflow analyses to demonstrate exceptional shortage of rainfall.
Regional stocks in band 1. Scenario modelling indicates regional stocks falling below band 3a in July	April 1996	Continue to: Prepare non-essential use ban drought orders or permits Prepare compensation reduction drought permits or orders Prepare non-essential use ban drought orders or permits

		Prepare increased river abstractions/HOF reduction drought orders
Reservoir stocks start to fall again	May 1996	Submit supply side drought permits (compensation reduction and increased abstraction/HOFs) and demand side drought orders for non-essential use bans. Start to discuss long term drought options with EA, NE and other stakeholders. Depending on location of drought, identify most beneficial long term drought ("more before 4") options, and prepare environmental assessments.
	July 1996	NEUB and supply side drought permits/orders obtained and implemented. Continue investigations and environmental assessment work on long term drought options. Liaise with Environment Agency and Natural England. Progress plans for long term options abstraction on River Aire, and increase in abstraction at Ouse Water Treatment Works, as flows in the North and North West areas are healthier than those in the South and South West.
Limited recovery of reservoir stocks	October 1996	Continue maximising rivers when available. Prepare for second dry winter Continue planning and construction work on long term options.
Increased abstraction capacity available at Ouse Water Treatment Works	April 1997	Increased abstraction available at Ouse Water Treatment Works, but pipeline still under construction. We can increase abstraction slightly at Ouse Water Treatment Works and increase treatment there temporarily, allowing water usually supplied from Elvington to be used elsewhere.

Pipeline from Acomb to Derwent Water Treatment Works complete. River Aire abstraction complete,	July 1997	Able to use full licence at Ouse Water Treatment Works and transfer to Derwent Water Treatment Works for treatment.
Reservoir stocks recover above NCL	December 1997	Return to normal operation as stocks recover above NCL Continue to review the situation.

Thank you