Draft Water Resources Management Plan

Technical Appendix H –

Dry Year and Critical Period Forecasting

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Background and Introduction

Scenario forecasting

H.1 Demand for water in any given year is a function of the prevailing weather conditions in that year; cold winters drive up leakage and hot, dry summers increase usage. We can use models of weather-dependent demand coupled with long histories of weather data to derive the range of possible demand scenarios that may have been observed had the weather conditions been different. Understanding the range of demand in these scenarios allows us to produce distribution input (DI) forecasts for Dry Year Annual Average (DYAA) and Dry Year Critical Period (DYCP) scenarios as required by Section 4.8 of the Water Resource Planning Guidelines.

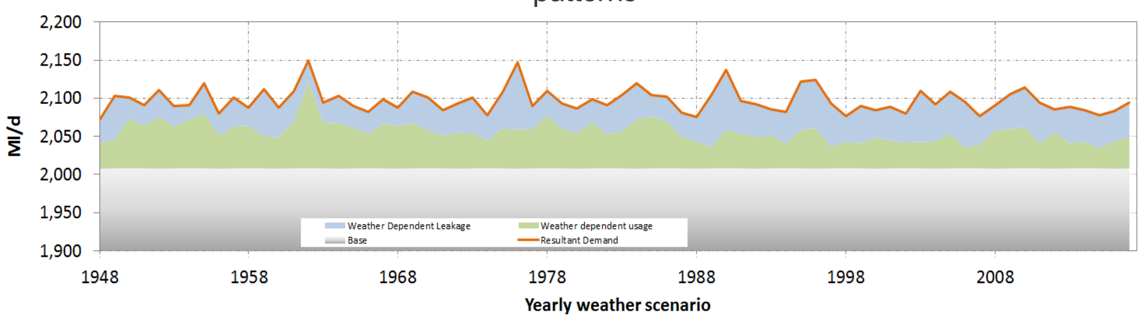
H.2 This section describes how the above may be estimated using the weather-dependent characteristics of demand and its sub-components of leakage and water delivered.

Modelling variability in demand due to the weather

H.3 The prevailing weather conditions for any given year affect the out-turned levels of leakage and usage and hence overall demand. Mechanisms have been developed (using weather-dependent models) that allow the observed demand, usage and leakage for any given year to be placed in the context of a range of other (historically observed) weather conditions.

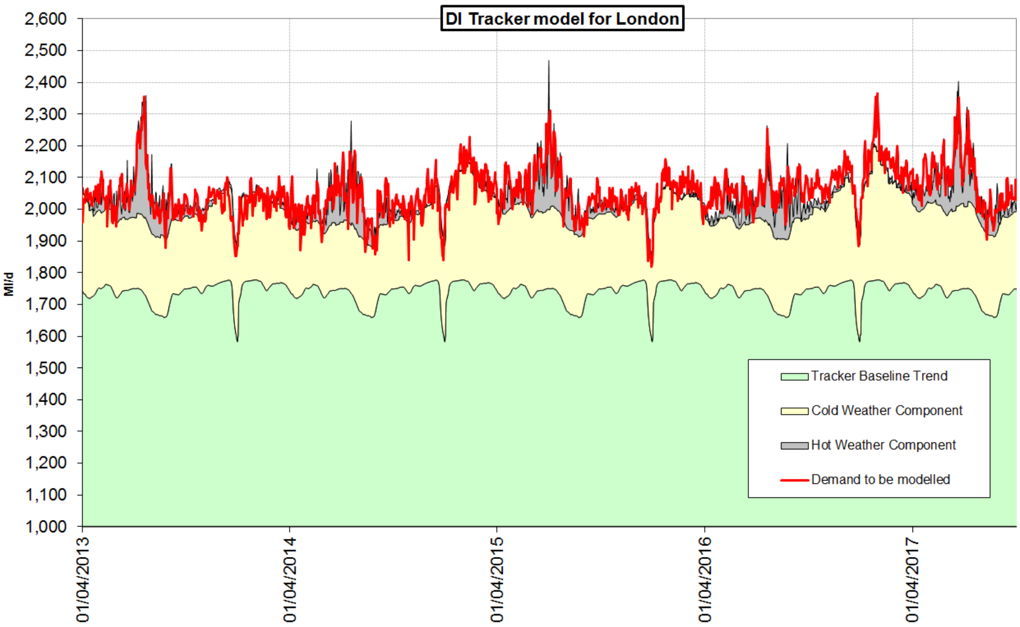
H.4 Figure H - 1 shows the range of DI estimates of the level of demand based on weather that was observed in previous years.

Figure H - 1: Illustrative demand scenarios (London) generated based on historic weather patterns



H.5 The annual average (AA) figures plotted in Figure H - 1 have been aggregated up from a weather dependent model with daily resolution as shown in Figure H - 2 below. The daily model explains over 90% of the variability in summer demand and accurately tracks both the timing and amplitude of the peaks in demand. This model is used in the quantification of both dry-year AA demand and that of the critical period maximum rolling seven day demand.

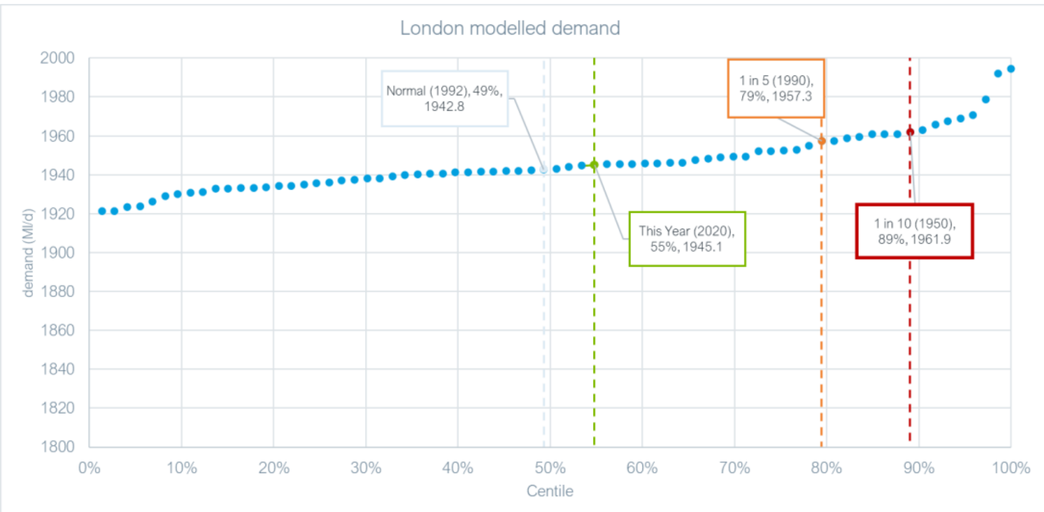
Figure H - 2: Illustrative daily demand plotted with a daily weather-dependent model



H.6 As discussed, total demand is composed of usage and leakage, both of which are affected by the extremity of the weather conditions; AA usage is dependent on summer weather conditions whilst leakage is dominated by the severity of the winter. If the high demand as modelled from 1976 was predominately driven by an extremely hot and dry summer that would have driven high summer usage, whilst the high demand in 1962/63 was due to the prolonged extremely cold winter, driving high levels of leakage.

H.7 When ranked in ascending order according to overall demand, the resultant curve (as shown in Figure H - 3) can be used to help understand the likelihood of experiencing certain levels of demand.

Figure H - 3: AA demand scenarios (London, post MLE) ranked in ascending order (Cumulative Density Function)



H.8 For illustrative purposes, taken at face value, the yearly average curve shown in Figure H-3 suggests:

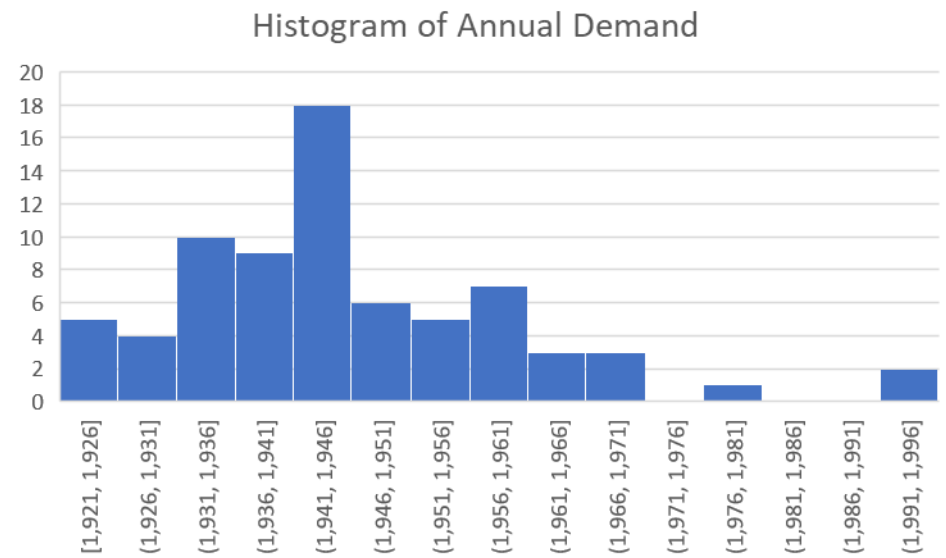
- Demand in London can range between 1,920 and 2,000 Ml/d as a function of weather[1]. Most scenarios show demand below 1980 Ml/d
- Between the two extremes, the probability of demand not exceeding a given level can be read from the position along the x-axis, and vice-versa. Moving from left to right on the curve, there is a 0% probability that demand will be below 1920 Ml/d, there is a 100% probability that demand will be below 2,000 Ml/d
- Normal (1 in 2) Year: The demand at the mid-point (50th percentile, or median) is where there is an equal probability of demand being higher or lower than this value
- 1 in 10 Year: The demand at the 90th percentile is taken to represent the largest value that demand may rise to with a 1 in 10 year return period

H.9 We use curves such as that shown in Figure H-3 to derive levels of usage, leakage and demand that would be expected under normal and dry conditions. The dry-year demand is reported as the combined impact of the joint contribution of 1 in 5 year levels of leakage and usage.

Characterising variability in demand due to the weather

H.10 The data in Figure H - 3 can be re-presented as a probability density function as shown in Figure H - 4 below showing the relative likelihood of various demand scenarios more clearly.

Figure H - 4: Empirical PDF[2] showing likelihood of various ranges of demand in London

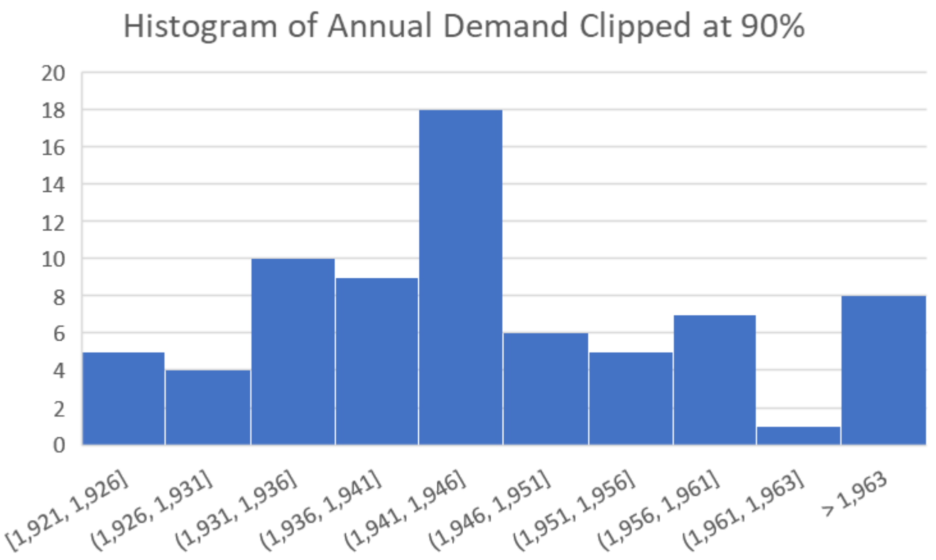


H.11 During droughts, we can intervene to deploy specific measures (such as Temporary Use Bans). Under these conditions, demand becomes artificially constrained and the unconstrained model is no longer valid. In reality, during the weather conditions that would drive the highest demand (at return periods of about 1 in 20), interventions would be brought to bear to manage demand down.

[1] The minimum demand of 2,060 Ml/d is under mild summer and winter conditions, the higher scenarios are a mixture of either extreme winters or extreme summers, rarely both together.
[2] Probability density functions

In this analysis we assume that demand would effectively be “clipped” at levels observed at the 90th percentile, resulting in demands greater than 1,963 Ml/d being moved into that bin. The adjusted probability distribution would look something like the one shown in Figure H - 5.

Figure H - 5: Empirical PDF of demand in London with extreme high values clipped to 1-in-10



H.12 The distribution of weather-dependent demand shown in Figure H - 5 is positively skewed and is biased towards high values and has a broader than normal peak. These properties make the median and average of the curve different and have implications when estimating the long-run average demand.

Dry year figures

H.13 As described in Section H.A, one can articulate the variability in demand in terms of overall demand, or in terms of usage and leakage independently. By disaggregating demand into usage and leakage we can refine the estimates of dry years and report them as an appropriate combination of probable figures for usage and leakage.

H.14 For more information on the sensitivity of usage and leakage to weather, please refer to sections 'Analysis of weather-dependent usage' below. Section 'Critical period peaking factors' (below) investigates the weighting that would be required to estimate long run average values based on a weighted combination of the 1 in 2 year and 1 in 10 year figures reported in our Annual Returns.

Analysis of weather-dependent usage

H.15 Section H.A described how scenarios driven from a number of historic weather scenarios can be used to estimate 1 in 2 year, 1 in 10 year and average figures for demand. The same process can be applied to the weather-dependent[3] usage and leakage. The analysis of usage can be used to estimate the variability in consumption. As revenue is specifically a function of usage, it is useful to understand how much of the overall variability in demand can be attributed to it. The analysis of leakage can be used to estimate the variability in demand that is independent of consumption.

Critical period peaking factors

H.16 The weather-dependent component of dry-year critical period is estimated using the same uplift mechanisms as described for the AA figures but using the curves generated from the summer critical-period values as shown in Figure H-3.

Commercial peak

H.17 The peak model only considers peak values due to domestic usage. Analysis was undertaken by RPS as part of a UKWIR project[4] which investigated the effects of climate change on non-household demand. The results of the analysis showed little evidence of commercial consumption being affected by weather. Therefore no peak factors are applied to uplift commercial consumption. Commercial consumption in peak periods is calculated as the difference between the peaked DI volume and the sum of the peaked domestic consumption.

Forecasts of future demand

H.18 Changes in demographics and domestic water use are built into our household demand forecasting model[5].

[3] Note: in this section and in section H2.2, only the weather-dependent components are considered. It is not required to consider the underlying 'base' components for this analysis.
[4] Impact of Climate Change on Demand UKWIR CL04B 2013
[5] Section 3 Demand Forecast

Peaking factors

H.19 Peaking factors are used to uplift or reduce out-turn DI in any year to the DYAA and DYCP planning scenarios. They are calculated using a model called Dry Year Uplift Tool which uses historic weather conditions and the current year's base demand to recreate how current demand would vary in different weather conditions. The model uses the peaking factors to uplift or reduce base year demand to the desired level of service, and then calculates uplift volumes that are applied to the base year demand (DI) figures. These uplifted volumes are then used within our demand forecasting models.