2027 DRAFT Drought Plan Appendix F Summary of the DEL Methodology with Worked Examples for London and SWOX

APPENDIX F DEL Methodology and Worked Examples

Introduction

Appendix F provides a practitioner-level description of the Drought Event Level (DEL) methodology for the London and SWOX WRZs, illustrated through application to three historical droughts (1976–2022). For each event, the DEL is compared with the measures actually implemented at the time to assess the effectiveness of the methodology.

1 DEL methodology

Overview

Our DEL assessment and associated methodologies have been developed in accordance with legislation and drought guidance. The key requirements that the methodology must enable are:

- The full sequencing of measures to be taken to avoid or minimise the need for Emergency Drought Orders (EDOs).
- Timely introduction of those measures to maximise demand savings and supply-side benefits and allow for their implementation.
- Proactive communication with customers on their participation.

The broad approach we take to assess our drought level is broken into three steps:

- Step 1 Data collation and modelling.
- Step 2 Overall Risk Indicator assessment
- Step 3 DEL assignment

A high level schematic diagram of the DEL assessment is provided in Figure 1, with further detail of each step provided in the following sections.

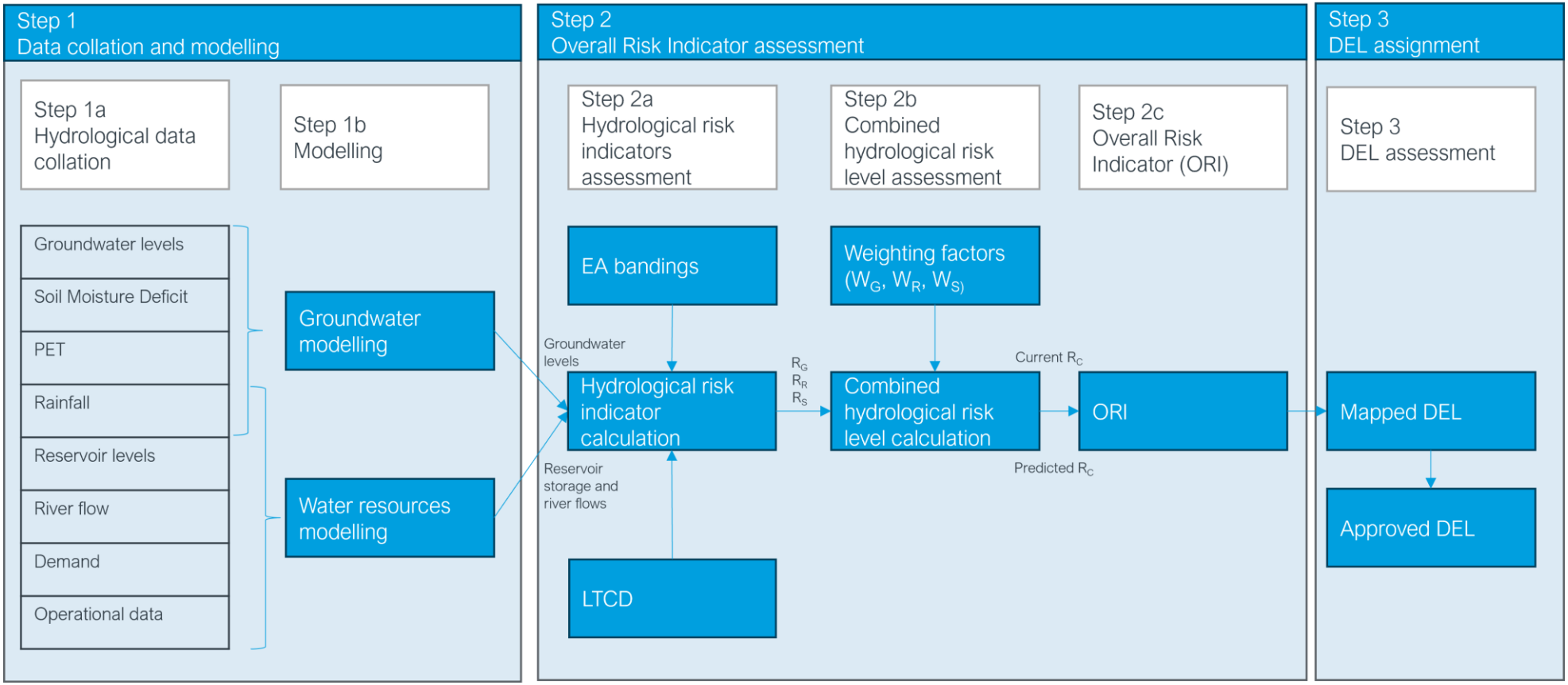

Figure 1 High level schematic diagram of the Drought Event Level methodology

Step 1 Data collation and water resources modelling

1.1.1 Step 1a Hydrological data collation

The Environment Agency provides groundwater levels, river flows, rainfall, and Soil Moisture Deficit (SMD) monthly. These provide the initial conditions for Step 1b.

A spatial overview of observation boreholes provided is shown in Figure 2. A summary of the key observation boreholes (OBHs) used is provided in Table 1, the risk assessment for five sites are factored in the ORI calculation, the remaining sites provide additional insight across the catchment.

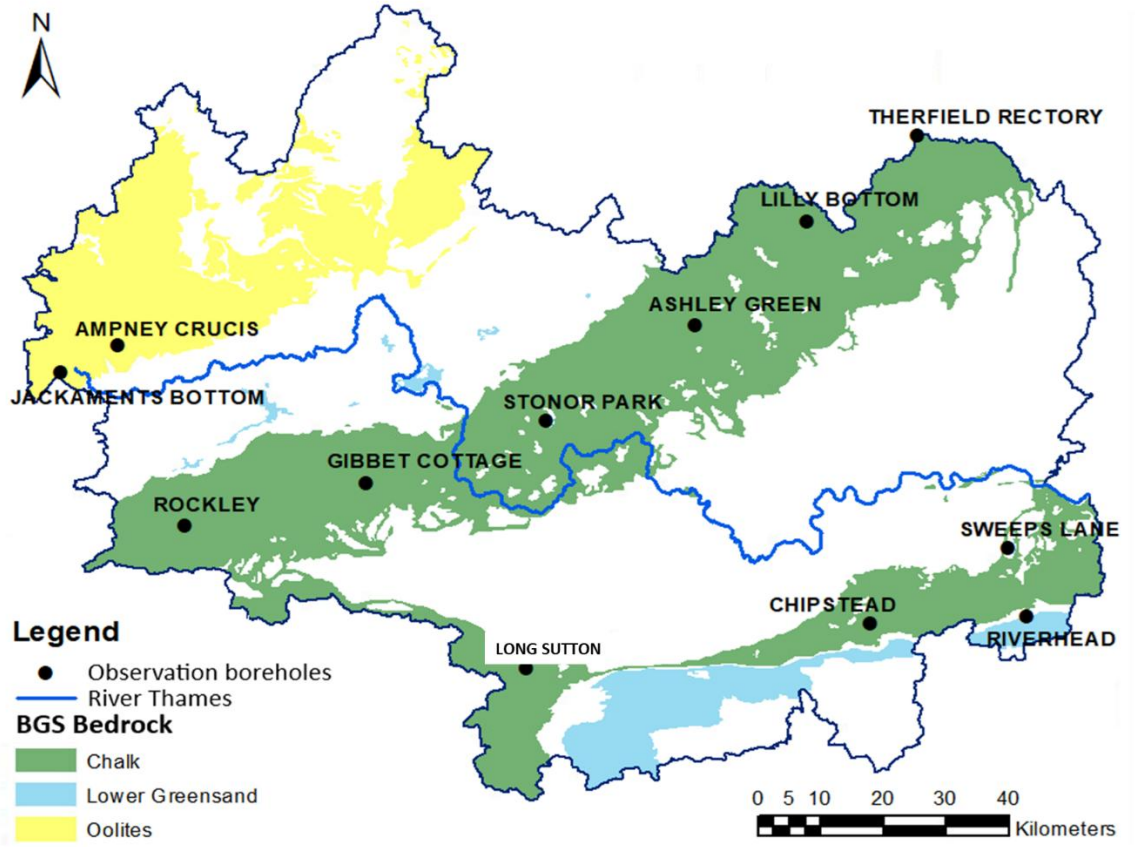

Figure 2 Location of groundwater observation borehole data provided by the EA

Table 1 EA observation boreholes and associated regional aquifers used in the DEL methodology

Observation Borehole	Regional Aquifer	Directly used in ORI calculation?
Ampney Crucis	Cotswold Limestone	Yes
Jackaments Bottom	Cotswold Limestone	No

Observation Borehole	Regional Aquifer	Directly used in ORI calculation?
Rockley	Chalk- Marlborough Downs; also surrogate for Cotswold Limestone	Yes
Gibbet Cottages	Chalk- Berkshire Downs	No
Stonor Park	Chalk- Chilterns West	Yes
Ashley Green	Chalk- Chilterns East	No
Lilley Bottom	Chalk- Chilterns East	Yes
Therfield Rectory*	Chalk- Chilterns East	No
Tile Barn Farm	Chalk- North Downs	No
Well House Inn (Chipstead)	Chalk- North Downs	Yes

1.1.2 Step 1b Water resources modelling

Hydrological data is used in our water resources model to predict river flows and reservoir storage, while the Environment Agency's Catchmod model produces groundwater predictions for key OBHs. We simulate a range of Long Term Average (LTA) scenarios.

Step 2 DEL assessment

1.1.3 Step 2a Hydrological risk indicators assessment

Groundwater level, river flow, and reservoir storage from Steps 1a and 1b are assessed for both current and predicted (future) risk. These risks are determined using EA percentile bands for groundwater and river flow, and Lower Thames Control Diagram (LTCD) bands for reservoir storage. Five risk levels (0 to 4) describe conditions from normal to extreme. The assessment tracks how risk escalates over time and links this to the appropriate Drought Event Level (DEL). When there is no drought concern, day-to-day operations classify the prevailing risk as R0.

The Environment Agency's percentile bands are used to assign groundwater (R_G) and river flow (R_R) risk levels from 0 to 4, as provided in Table 2. Reservoir storage (R_S) risk levels are based on the LTCD control curve bandings shown in Figure 3. Note that while the risk bandings which form a subset of the LTCD bands and curves are considered specifically for the ORI calculations, the full LTCD is also reviewed when considering the risks and water resources position as a whole.

Table 2 Groundwater level and river flow percentile and associated groundwater and river flow risk level

EA bands		Percentile of the band	Groundwater Risk Level (R_G)	River Flow Risk Level (R_R)
	Exceptionally High	> 95	R_G0	R_R0
	Notably High	> 87 to ≤ 95		
	Above Normal	> 72 to ≤ 87		
	Normal	> 28 to ≤ 72		
	Below Normal	> 13 to ≤ 28	R_G1	R_R1
	Notably Low	> 5 to ≤ 13	R_G2	R_R2
	Exceptionally Low	< 5	R_G3	R_R3
	Not on record		R_G4	R_R4

Table 3 LTCD control curve levels and associated reservoir storage risk level

Reservoir storage indicator (Rs)	LTCD control curve
0	> Level 1
1	≤ Level 1
2	≤ Level 2
3	≤ Level 3
4	≤ Level 4

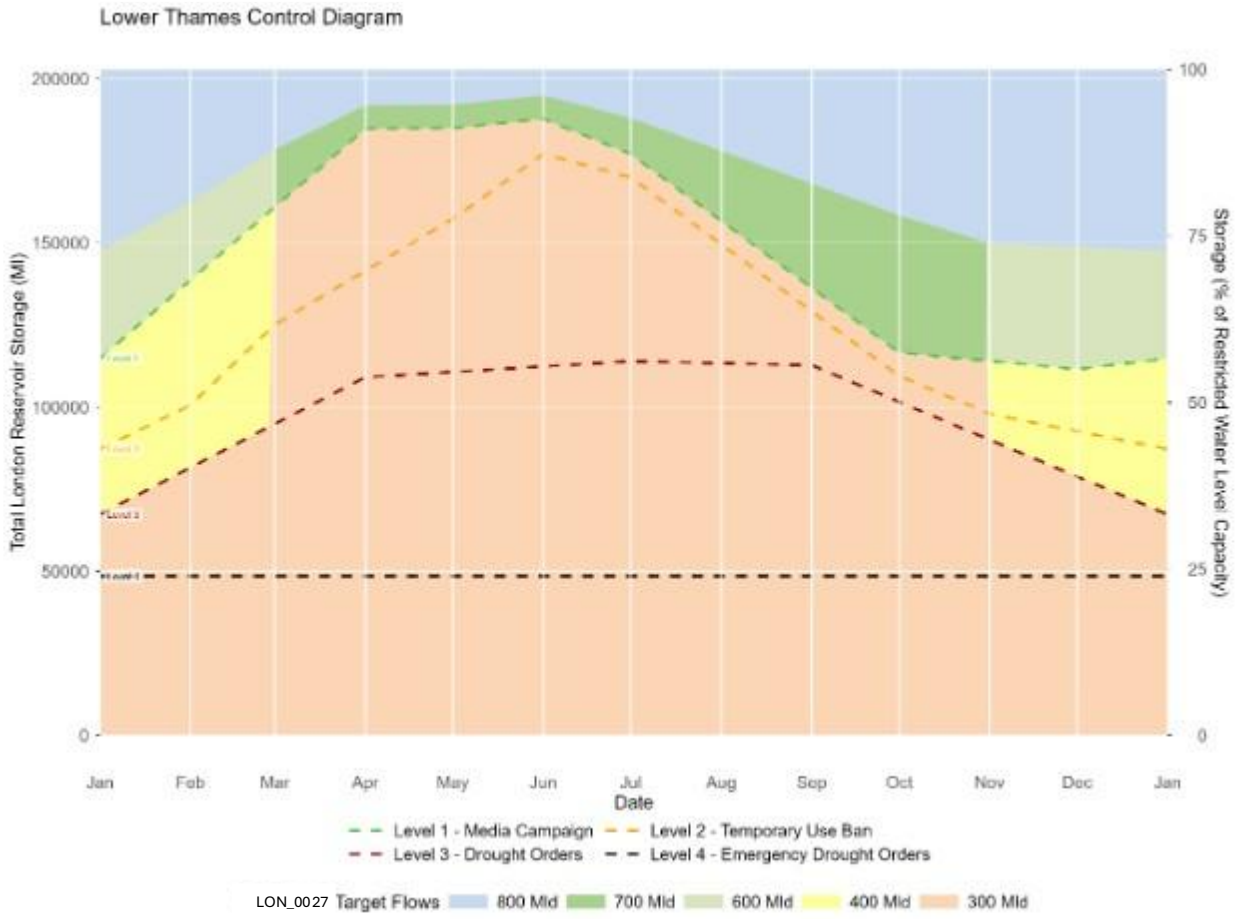

Figure 3 Lower Thames Control Diagram

The assessed prevailing and predicted risk levels are then placed into risk matrices. These can be used to monitor the drought position on a weekly or monthly basis, depending on the drought severity.

For groundwater, as there are multiple sites that contribute to the risk calculation, each risk value assigned to the site are weighted and summed to give one groundwater risk value for each zone (i.e. one value for London and one value for SWOX). The weightings for those sites are given in Table 4. Following the 2022 drought, these weightings have been reviewed by AtkinsRéalis and updated weighting for SWOX are currently being tested and will be updated for our revised draft Drought Plan.

Table 4 Weightings for groundwater site risk levels.

London		SWOX	
Chipstead	15%	Ampney Crucis	60%
Lilley Bottom	27%	Rockley	4%
Stonor Manor	58%	Stonor Manor	36%

1.1.4 Step 2b Combined hydrological risk level assessment

The Hydrologic Risk Levels for a chosen month are entered into the Drought Risk Assessment Matrix, this produces one value for the time period, the Combined Hydrological Risk Indicator, R_C.

Groundwater, river flow and reservoir storage each vary in importance through the year, so monthly weightings are applied to reflect their relative influence on drought risk. The full weighting profiles for London and SWOX are provided in Table 5

In London, groundwater receives the highest weighting because it drives baseflow and determines the longer-term drought outlook. Its weighting decreases from March, after which river flow and reservoir storage better reflect current conditions. River flow is less important in scenario assessment at the start of the year, when flows are typically sufficient to keep storage full. Reservoir storage has a lower weighting in January and February (when it is usually at 100%) before increasing later in the year as its relative importance grows.

The SWOX weightings follow the same principles as London, but with greater emphasis on river flow because SWOX_0006's abstraction licence makes reservoir levels more sensitive to low flow conditions than in the Lower Thames.

The combined hydrological risk indicator, R_C, is calculated by multiplying the hydrological indicators by their respective weightings, adding them, and rounding the result to the nearest integer. For the current assessment the weighting is used for the current month and for the predictive assessment the weighting is used for the future month for which the prediction is made.

Table 5 Weighting factors for London and SWOX

Month	London weighting factors			SWOX weighting factors		
	Groundwater (W_G)	River Flow (W_R)	Reservoir Storage (W_S)	Groundwater (W_G)	River Flow (W_R)	Reservoir Storage (W_S)
Jan	55%	20%	25%	60%	25%	15%
Feb	55%	20%	25%	60%	25%	15%
Mar	50%	20%	30%	55%	20%	25%
Apr	50%	20%	30%	50%	20%	30%
May	50%	20%	30%	50%	25%	25%
Jun	50%	20%	30%	50%	25%	25%
Jul	50%	20%	30%	40%	25%	35%
Aug	50%	20%	30%	35%	30%	35%
Sep	50%	20%	30%	35%	30%	35%
Oct	50%	20%	30%	40%	30%	30%
Nov	50%	20%	30%	45%	30%	25%
Dec	50%	20%	30%	55%	25%	20%

1.1.5 Step 2c Overall Risk Indicator (ORI) assessment

The risk to security of supply and the appropriate measures to be taken are determined by a simultaneous consideration of both the current and predicted situation. The current and predicted R_C are combined to provide the Overall Risk Indicator. For example, if the current R_C is R_C0 and the predicted R_C is R_C2, the ORI would be 0/2. Typically, the predicted R_C in six months' time is used.

Step 3 DEL assignment

The ORI is used to inform the appropriate drought measures and set the Drought Event Level (DEL), which combines the water-resources position with operational considerations such as supply demand balance and outages. DELs range from 0 to 4, with DEL0 equating to business as usual. A summary of the ORI, mapped DEL, potential drought measures and implied Level of Service is provided in Table 6. As the current risk increases, the assessment focuses on the most severe potential outcomes, meaning fewer predicted risk combinations remain but they reflect higher levels of escalation.

Most droughts begin with a current risk of R_C1 but can have predicted risks ranging from R_C1 to R_C4. For both SWOX and London, even high predicted risks (R_C3 or R_C4) can reduce if summer rainfall improves conditions. The methodology is therefore designed to adjust the DEL as the drought evolves. ORI 1/4 is not listed as it is deemed unlikely to occur. ORI 2/4 is listed to map to DEL3 *or* DEL4 as the disparity between a current risk 2 and projected risk 4 warrants for some discretion in the decision making for the drought at the time.

The triggers for lifting drought measures are essentially the equivalent of the triggers for escalation but in reverse. In the same way that the DEL assessment provides an assessment of the escalation of risk to security of supply, so do they provide an assessment of the diminution of risk to security of supply.

Therefore, for London and SWOX WRZs we will use the drought risk methodology to review the DEL levels, and we will lift measures when the risk has diminished sufficiently. We will also use the DEL measures to guide the lifting of drought measures in the other WRZs, with the position in London used to guide the other WRZs that are largely groundwater based.

Table 6 Overall Risk Indicator and mapped DEL

Overall Risk Indicator	Mapped DEL
ORI0/0	DEL0
ORI0/1	DEL1
ORI0/2	DEL2
ORI0/3	DEL3
ORI1/1	DEL1
ORI1/2	DEL2
ORI1/3	DEL3
ORI2/2	DEL2
ORI2/3	DEL3
ORI2/4	DEL3 or DEL4
ORI3/3	DEL 3
ORI3/4	DEL 4
ORI4/4	DEL 4

2 Application of DEL methodology to selected historical drought events

Introduction

The drought years 1976, 2012 and 2022 were chosen to demonstrate the London and SWOX methodology across a range of different droughts. Each example starts with a brief summary of the year's conditions, followed by application of the methodology using a selected base month to show the decision-making process. In practice, forecasts would be updated monthly, as a minimum.

2022 drought - London

2.1.1 Background

Chalk groundwater levels and flows at LON_0027 were below average following the 2021/22 recharge season. Continued dry weather through early summer led to low flows in the Thames, constrained abstraction, and resulted in reservoir storage decline. Exceptional July heat accelerated the decline, and London reservoir storage crossed LTCD Level 1 on 21 July, prompting major media campaigns and use of LON_0013. A drought was declared nationally in August by the Environment Agency. Thames Water implemented a company-wide Temporary Use Ban from 24th August to November 2022. Heavy rain over autumn gradually reduced soil moisture deficit enabling recovery of groundwater levels and river flows.

2.1.2 Step 1 Data collation and water resources modelling

The current (March to June) and predicted (July to December) groundwater levels, river flows, and reservoir storage are provided in .

2.1.3 Step 2 DEL assessment

The current (July 2022) and predicted (January 2023) risk indicators for groundwater level, river flow, and reservoir storage and relevant weightings are provided in Table 7. The predicted risk factor is calculated based on the simulated results from 60% LTA rainfall scenario in six months' time. The resulting ORI for July 2022 is 1/1.

Table 7 Calculation of combined risk indicator (R_C) for London 2022 worked example

	Current Jul-22		Predicted 6-month (60% LTA scenario) Jan-23	
	Risk indicator	Weighting	Risk indicator	Weighting
Groundwater Levels (R_G)	1	50%	1	55%
River Flows (R_R)	1	20%	3	20%
Reservoir Storage (R_S)	0	30%	0	25%
Combined Risk Indicator* (R_C)		1		1

2.1.4 Step 3 DEL assignment

An ORI of 1/1 maps to DEL1. Once this recommendation is approved, the final DEL is used to identify the required governance and measures. Final actions are refined based on the time of year and operational factors such as outages.

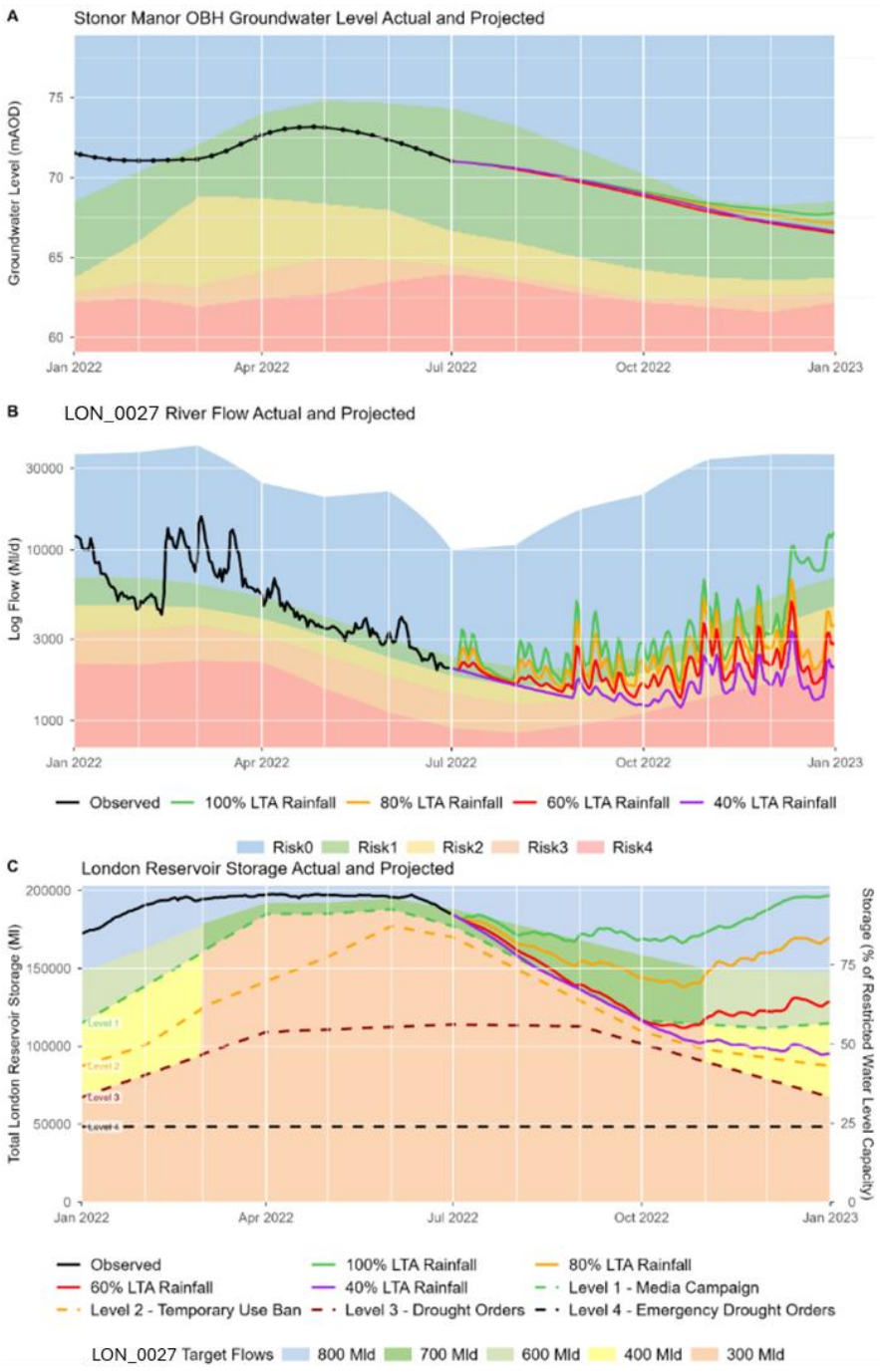

Figure 4 Current and predicted data for London (2022 worked example)

2.1.5 Summary of DEL methodology results

The DEL assessment would normally be updated monthly. To illustrate how the ORI changed through 2022, the ORI outcomes for each month in 2022 are shown in Table 8 for London. It shows London would not have exceeded an ORI of 2/2, mapping to DEL2, indicating a need for TUBs and possible use of the KEN_0006.

Table 8 ORI figures for the 2022 drought, London WRZ.

	Current combined risk indicator	Predicted combined risk indicator 3 months 60% LTA rainfall	Predicted combined risk indicator 6 months 60% LTA rainfall	ORI	Mapped DEL
Jul-22	1			1/1	DEL1
Aug-22	2			2/2	DEL2
Sep-22	2			2/2	DEL2
Oct-22	1	1		1/2	DEL2
Nov-22	1	1		1/2	DEL2
Dec-22	1	1		1/1	DEL1
Jan-23		1	1		
Feb-23		2	2		
Mar-23		1	2		
Apr-23			2		
May-23			2		
Jun-23			1		

2.1.6 Conclusion

The mapped DEL indicates a need for DEL2 measure such as TUBs from August onwards, in practice a TUB was implemented from August 2022.

2022 drought - SWOX

2.1.7 Background

Below average rainfall during the 2021/22 recharge season resulted in below average groundwater levels in the Cotswolds and slightly below average flows in the Thames at SWOX_0006 entering spring 2022. Continued dry weather through early summer led to low flows in the Thames and increased pressure on SWOX_0006 reservoir. By summer, significantly low flows and steep storage decline triggered applications for drought permits in SWOX. Only the SWOX_0006 permit was granted, though ultimately not used, as heavy rain in November removed the need.

2.1.8 Step 1 Data collation and water resources modelling

The current (March to June 2022) and predicted (July to December 2022) groundwater levels, river flows, and reservoir storage are provided in Figure 5.

2.1.9 Step 2 DEL assessment

The current (July 2022) and predicted (January 2023) risk indicators for groundwater level, river flow, and reservoir storage and relevant weightings are provided in Table 9. The resulting ORI for July 2022 is 1/3 in SWOX. The prediction window used for SWOX can be shorter (e.g. 4 months as used in the 2012 example), this is because the system responds quickly. However, in recent years we have used 6 months for consistency with London reporting and enabling a longer outlook. The fast response time of the SWOX system is taken into consideration when reviewing the results of the longer modelling timeframe.

Table 9 Weighted risk indicators for 2022, SWOX WRZ.

	Current Jul-22		Predicted 6-month (60% LTA scenario) Jan-23	
	Risk indicator	Weighting	Risk indicator	Weighting
Groundwater Levels (R_G)	1	50%	3	55%
River Flows (R_R)	1	20%	4	20%
Reservoir Storage (R_S)	0	30%	1	25%
Combined Risk Indicator* (R_C)		**1**		**3**

2.1.10 Step 3 DEL assignment

DEL 3 maps to an ORI of 1/3. Once this recommendation is approved by the executive representatives, the final DEL is used to identify the required governance and measures. Final actions are refined based on the time of year and operational factors such as outages.

2.1.11 Summary of DEL methodology results

The DEL assessment would normally be updated monthly. To illustrate how the ORI changed through 2022, the ORI outcomes for each month in 2022 are shown in Table 10 for SWOX. It

shows SWOX would have reached DEL3 in July, indicating the potential need for drought permits.

Table 10 ORI figures for the 2022 drought, SWOX WRZ.

	Current combined risk indicator	Predicted combined risk indicator 3 months 60% LTA rainfall	Predicted combined risk indicator 6 months 60% LTA rainfall	ORI	Mapped DEL
Jul-22	1			1/3	DEL3
Aug-22	2			2/3	DEL3
Sep-22	2			2/3	DEL3
Oct-22	2	2		2/2	DEL2
Nov-22	1	2		1/2	DEL2
Dec-22	0	2		0/1	DEL1
Jan-23		3	3		
Feb-23		2	3		
Mar-23		0	3		
Apr-23			2		
May-23			2		
Jun-23			1		

2.1.12 Conclusion

The ORI calculation indicates a move to DEL3 in SWOX at the beginning of July. In practise the move to DEL3 company-wide occurred in August. Drought permit applications were in preparation before this.

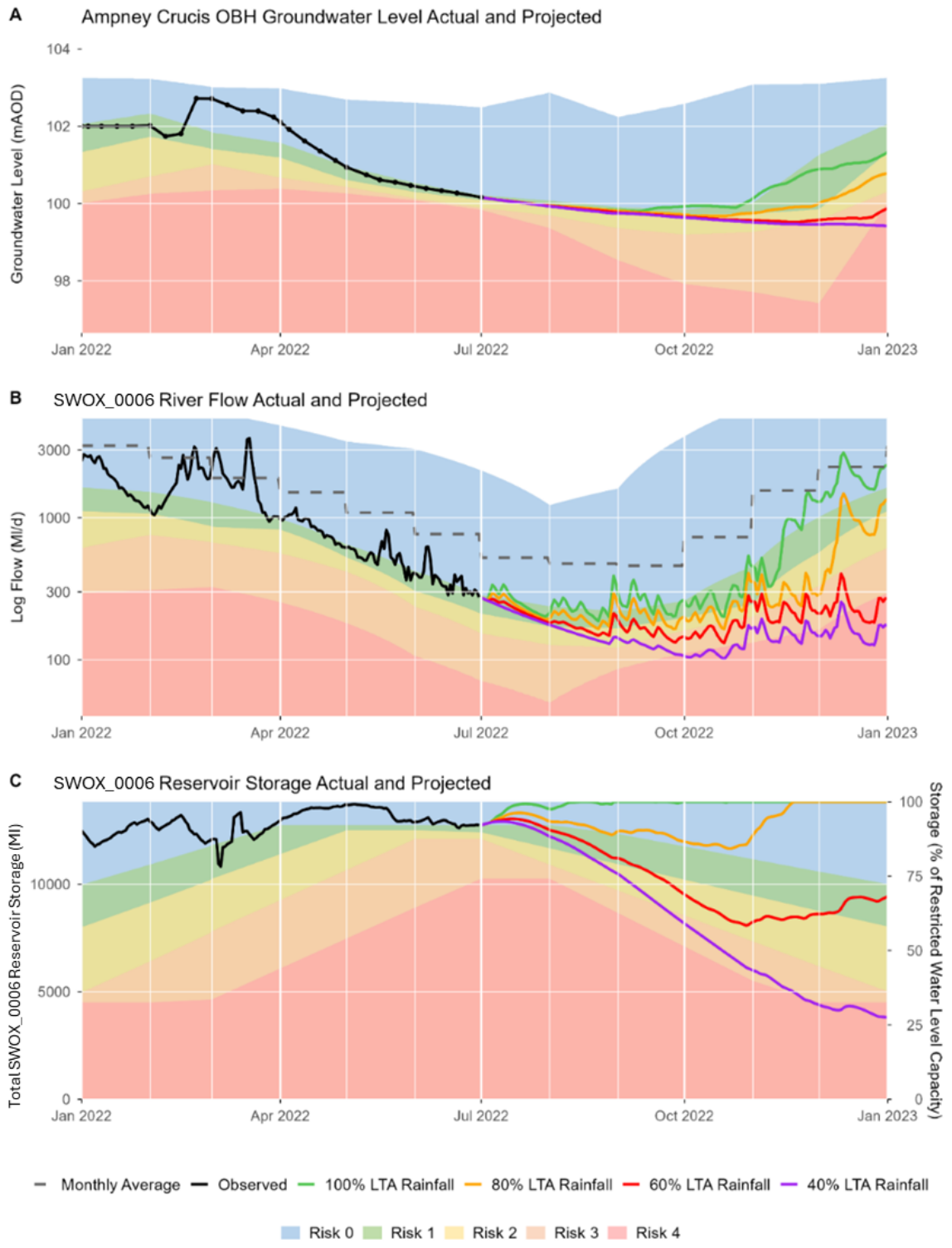

Figure 5 Current and predicted data for SWOX (2022 worked example)

2012 drought - London

2.1.13 Background

Low rainfall through 2011 raised drought concerns, particularly due to poor winter recharge. By early 2012, groundwater levels across the Thames catchment were exceptionally low, signalling the need for early restrictions. To protect storage, the LON_0027 Target flow (TTF) was reduced to below the LTCD guide levels with approval from the EA, and customers were urged to use water wisely. A company-wide Temporary Use Ban (TUB) was introduced on 3 April 2012, but unprecedented summer rainfall led to rapid groundwater recovery, allowing the ban to be lifted in June.

2.1.14 Step 1 Data collation and water resources modelling

The current (March) and predicted (March to September) groundwater levels, river flows, and reservoir storage are provided in Figure 6.

For groundwater levels, there are multiple sites included in the calculation (as noted in section 0 - DEL methodology), the figure includes the observation borehole that has the highest weighting in the calculation. For London this would typically be Stonor Manor. As the Stonor Manor OBH has missing data during the assessment period, Gibbet Cottages is used in this case as an appropriate alternative.

The 40% scenario in the groundwater level projection uses a rainfall from 1975-76, which results in some recovery in the autumn due to heavy rainfall at that time.

2.1.15 Step 2 DEL assessment

The current (March) and predicted (August) risk indicators for groundwater level, river flow, and reservoir storage and relevant weightings are provided in Table 11. The predicted risk factor is calculated based on the simulated results from 60% LTA rainfall scenario in six months' time.

The resultant Overall Risk Indicator (ORI) is 2/3.

Table 11 Calculation of combined risk indicator (R_C) for London 2012 worked example

	Current March 2012		Predicted (60% LTA scenario) August 2012	
	Risk indicator	Weighting	Risk indicator	Weighting
Groundwater Levels (R_G)	3	50%	4	50%
River Flow Levels (R_R)	3	20%	1	20%
Reservoir Storage (R_S)	0	30%	4	30%
Combined Risk Indicator* (R_C)	2		3	

** rounded to the nearest integer*

Step 3 DEL assignment

An ORI of 2/3 maps to DEL3. Once this recommendation is approved, the approved DEL is used to identify the required governance and measures. Final actions are refined based on the time of year and operational factors such as outages.

2.1.17 Summary of DEL methodology results

The DEL assessment would normally be updated monthly. To illustrate how DEL changed through 2012, the analysis was applied retrospectively. The current combined risk indicator never exceeds 2. The six month prediction briefly suggested a potential DEL4, meaning preparation, but not submission, of DD11 applications would have been appropriate. Results of the assessment are provided in Table 12.

Table 12 Summary of current and predicted combined risk indicator (R_C) for London 2012 worked example

	Current combined risk indicator	Predicted combined risk indicator 3 months 60% LTA rainfall	Predicted combined risk indicator 6 months 60% LTA rainfall	ORI	Mapped DEL
Mar-12	2			2/3	DEL3
Apr-12	2			2/4	DEL4
May-12	2			2/2	DEL2
Jun-12	1	3		1/2	DEL2
Jul-12	1	4		1/1	DEL1
Aug-12	0	2		0/2	DEL2
Sep-12		1	3		
Oct-12		1	4		
Nov-12		0	2		
Dec-12			2		
Jan-13			1		
Feb-13			2		

2.1.18 Conclusion

The retrospective DEL assignment indicates that drought permit applications would have been needed under DEL3 in spring 2012. In practice, a media campaign and TUB were introduced early in the year, in April 2012, in response to the significant risk of more severe drought. However following unusual early summer rainfall storage never fell to Level 1 on the LTCD, and the actions taken matched what the methodology recommended.

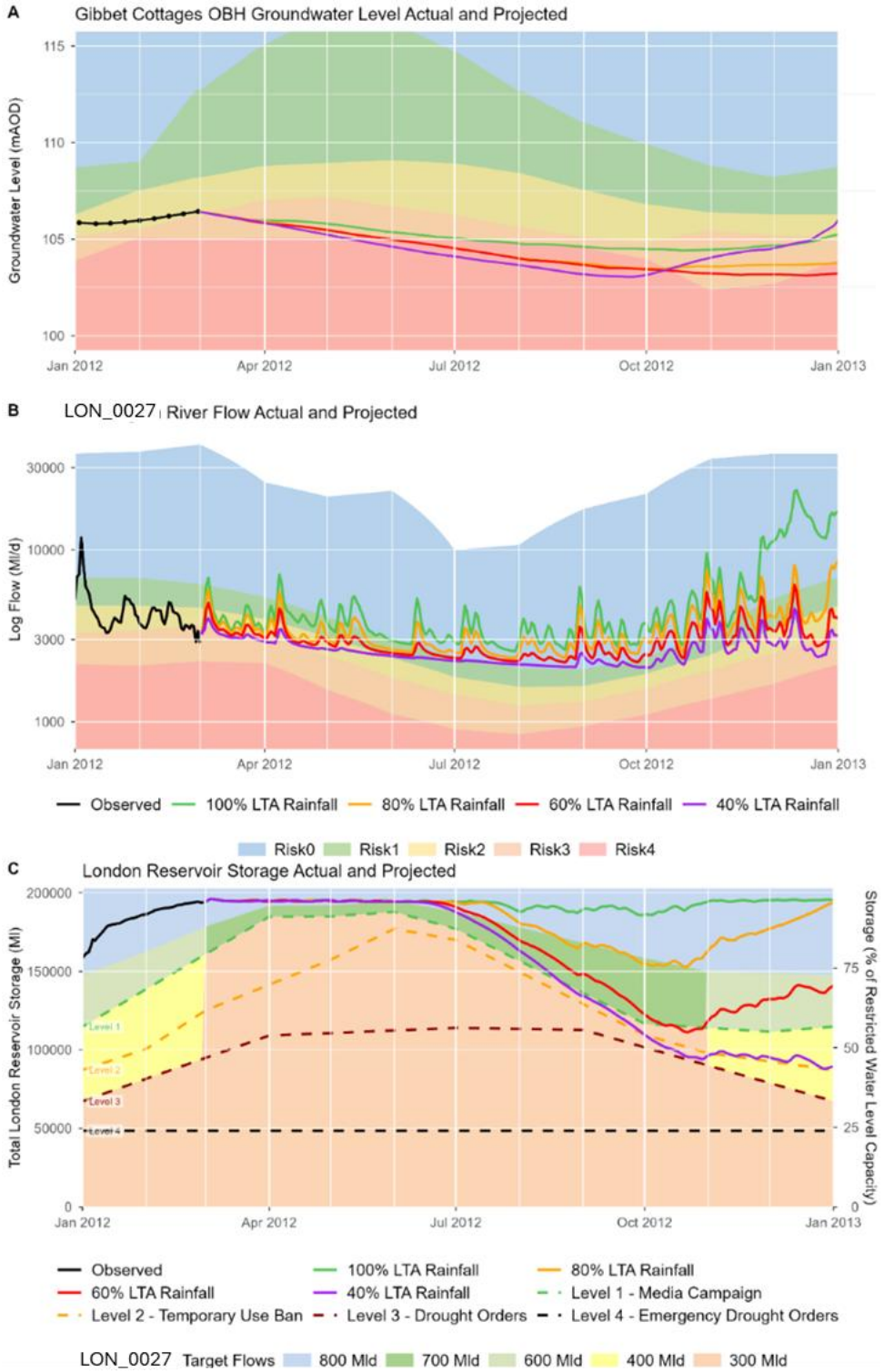

Figure 6 Current and predicted data for London (2012 worked example).

2012 drought – SWOX

2.1.19 Background

Aquifer recharge in the Cotswolds was limited from January to March 2012, leaving groundwater levels below average and signalling potential summer drought risk. With London and SWOX both under pressure, Thames Water launched an early year media campaign and introduced a company-wide TUB on 3 April. However, exceptionally high rainfall in April, June and July led to strong groundwater recovery, removing drought risk in SWOX and keeping SWOX_0006 full through the summer.

It should be noted that as London drives most company-wide drought actions, severe-drought measures are likely to be implemented across the whole area. This means SWOX may see demand-management measures earlier than its own DEL assessment would normally indicate.

2.1.20 Step 1 Data collation and water resources modelling

The current (January to March) and predicted (March to September) groundwater levels, river flows, and reservoir storage are provided in Figure 7. The 200 Ml/d trigger for preparing drought permits is predicted to be reached at the end of July, almost 20 weeks into the future.

The 40% scenario in the groundwater level projection uses a rainfall from 1975-76, which results in some recovery in the autumn due to heavy rainfall at that time.

2.1.21 Step 2 DEL assessment

The current (March) and predicted (August) risk indicators for groundwater level, river flow, and reservoir storage and relevant weightings are provided in Table 11. The predicted risk factor is calculated based on the simulated results from 60% LTA rainfall scenario in four months' time. The prediction window for SWOX can be shorter than London as the SWOX_0006 system responds much more quickly than London.

The resultant Overall Risk Indicator (ORI) is 2/2.

Table 13 Calculation of combined risk indicator (R_C) for SWOX 2012 worked example

	Current March 2012		Predicted (60% LTA scenario) June 2012	
	Risk indicator	Weighting	Risk indicator	Weighting
Groundwater Levels (R_G)	3	55%	3	50%
River Flow Levels (R_R)	2	20%	3	25%
Reservoir Storage (R_S)	0	25%	0	25%
Combined Risk Indicator*(R_C)	**2**		**2**	

** rounded to the nearest integer*

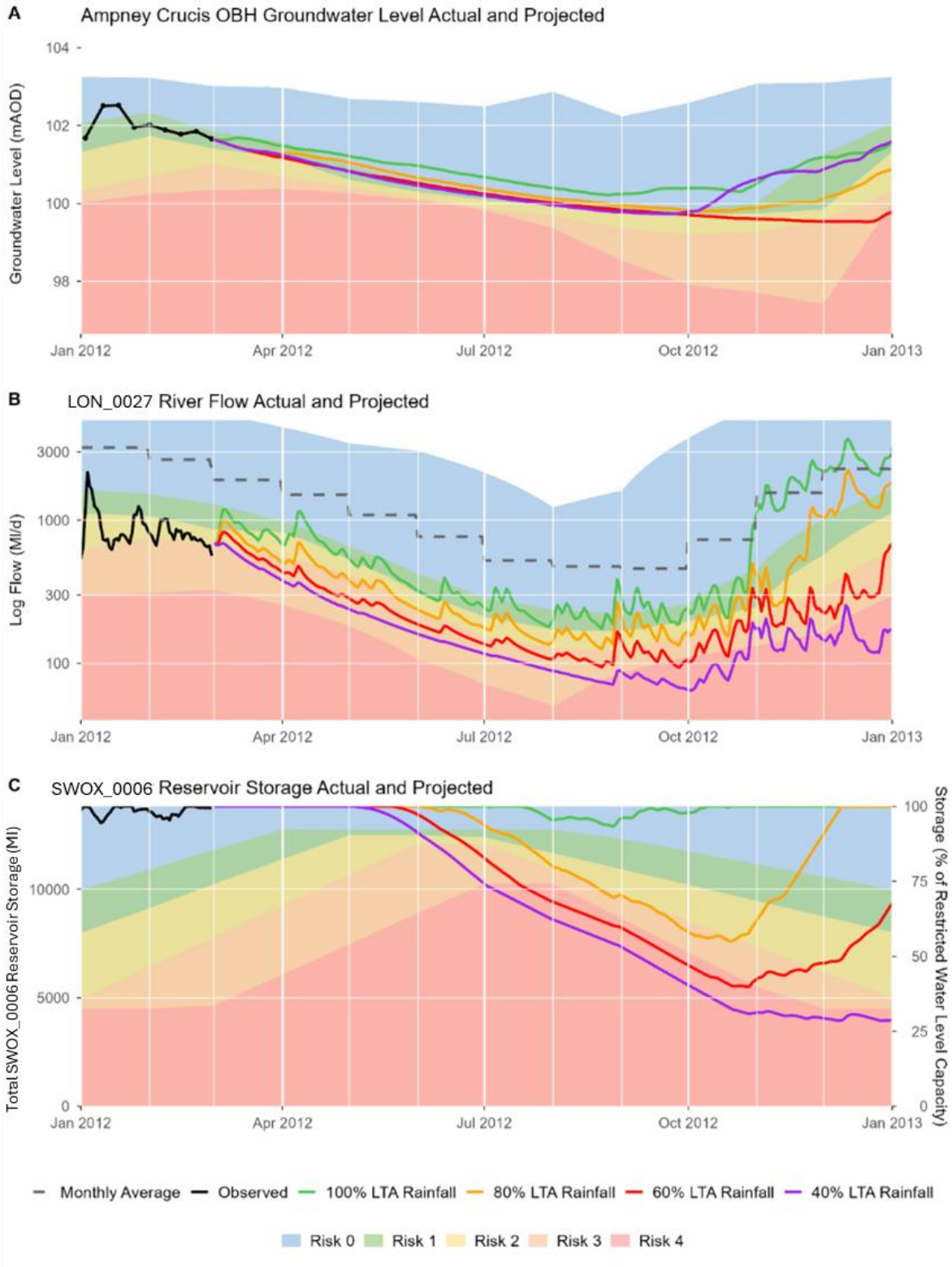

Figure 7 Current and predicted data for SWOX (2012 worked example)

2.1.22 Step 3 DEL assignment

DEL2 maps to an ORI of 2/2. Once this recommendation is approved, the final DEL is used to identify the required governance and measures Final actions are refined based on the time of year and operational factors such as outages.

2.1.23 Summary of DEL methodology results

The DEL assessment would normally be updated monthly, using observed data and projections per the method described above and in the 2022 example. Projections for this example were not available at the time of writing. The combined current risk for each month was retrospectively mapped to a DEL (Table 14). This provides an illustration of how DEL would move through the drought year, this is to be taken as an indication only, as it is based on simulated data without the 60% rainfall scenario which would normally be used in the Overall Risk Indicator to map to a DEL.

Table 14 Summary of current and predicted combined risk indicator (R_C) for SWOX 2012 worked example

Month	Groundwater	Reservoir Storage	Surface Water	Combined	Mapped DEL*
Mar 12	2	0	2	2	DEL2
Apr 12	1	0	0	1	DEL1
May 12	0	0	0	0	DEL0
Jun 12	0	0	0	0	DEL0
Jul 12	0	0	0	0	DEL0
Aug 12	0	0	0	0	DEL0
Sep 12	0	0	0	0	DEL0

*This is not a true mapped DEL using the full ORI method, this is an indication based on a retrospective assessment of observed data.

2.1.24 Conclusion

SWOX measures could follow the London DEL assessment, meaning an enhanced media campaign and a full TUB, as occurred in 2012.

The retrospective observed risk assessment in Table 14 shows DEL outcomes that are less severe. This is because of the exceptionally high rainfall in April and over the summer. Leading to improved groundwater recovery, removing drought risk in SWOX and keeping river flows healthier andSWOX_0006 reservoir full through the summer. Projections at the time would have shown more severe risk and prompted preparations for drought measures (such as the implemented TUB) without the foresight of the heavy rain.

1976 drought – London

2.1.25 Background

The autumn of 1975 was unusually dry and was followed by an exceptionally dry winter and spring. These conditions contributed to severely reduced groundwater recharge. River flows were some of the lowest on record in the Thames. The spring and early summer of 1976 continued to be very dry. This led to limited surface water flow, with river flows and groundwater levels becoming severely depressed in the summer.

A hosepipe ban was introduced in a phased pattern across the catchment at the time. Dates of hosepipe ban introductions (please note that Division names do not align with current WRZs):

- 17 July 1976 for Lambourn Division
- 19 July 1976 in Vales Division (Upper Thames area).
- 24 July 1976 extended to the whole region.

Measures to increase abstraction from the LON_0011 were required, including back-pumping over LON_0027 and LON_0025 weirs. It should be remembered that at this time the LTOA did not exist and the public water supply arrangements were very different to today. The pre-privatised legislative controls in force at the time were also very different. Drought Permits did not exist. Therefore, it is difficult to compare the actions taken in 1976 with those that would be taken under the present regulatory regime.

The hosepipe ban was lifted in all areas in the November of 1976 following the significant rainfall through autumn.

2.1.26 Step 1 Data collation and water resources modelling

Observed data was used to show which risk levels would have been triggered in 1976 (Figure 8). Due to data availability, Stonor Manor was the only site used to assess the groundwater risk. Reservoir storage and river flow conditions come from DO model outputs used in the 2024–25 Annual Review, which include Level 1 and 2 LTCD demand savings. River flows began the winter of 1975/76 at exceptionally low levels and continued falling until autumn rain. Groundwater levels at Stonor Manor started normal but dropped to exceptionally low by late summer. Groundwater levels recovered from January 1977. Reservoir storage started full but declined rapidly from April to early autumn.

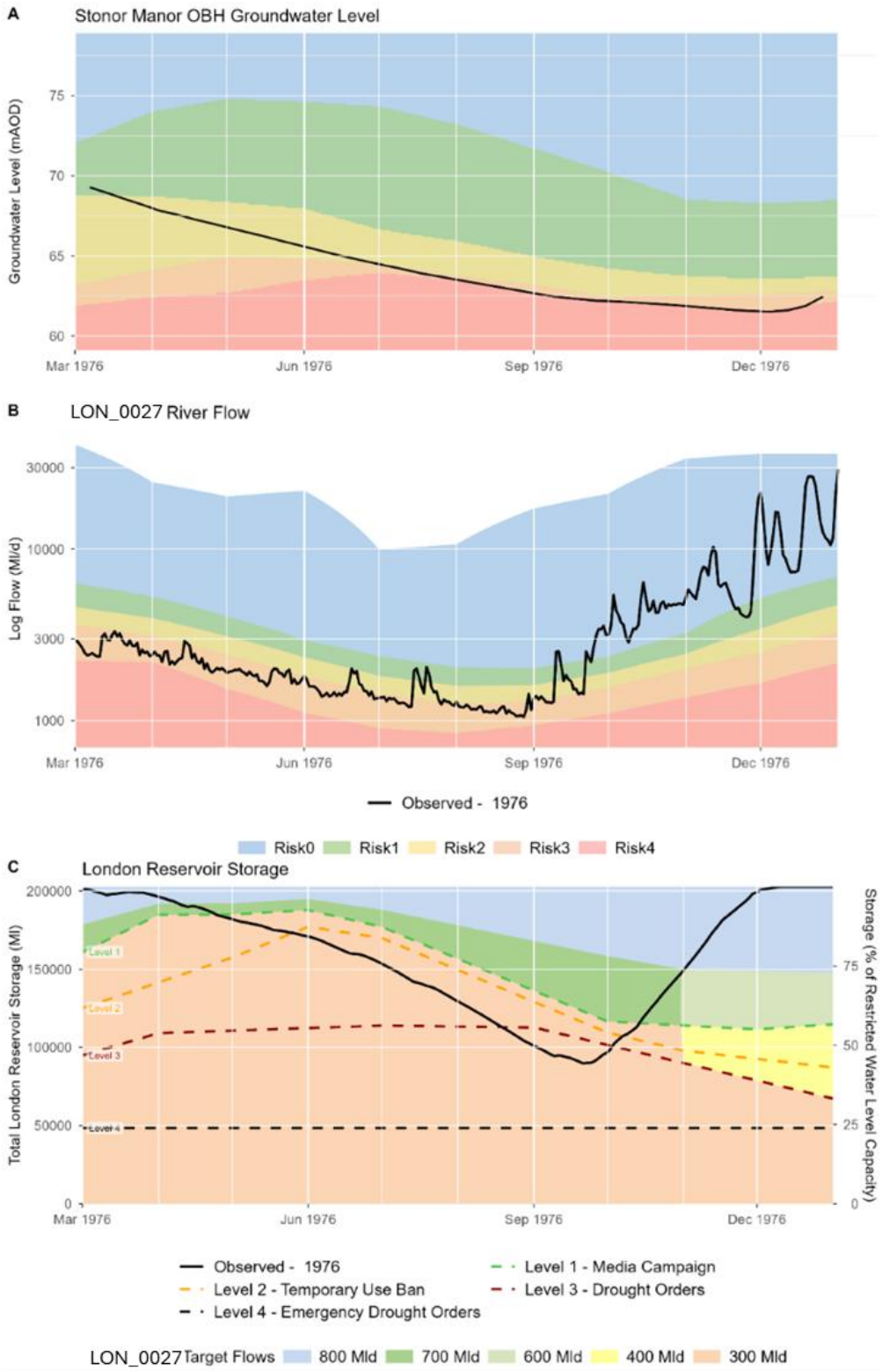

Figure 8 Simulated reservoir and storage data, and observed groundwater levels for London (1976 worked example)

2.1.27 Step 2 and 3 DEL assessment and assignment

The simulated and observed data for February to December 1976 was assessed determine a current risk level for each month. The combined current risk for each month was retrospectively mapped to a DEL (Table 15). This provides an illustration of how DEL would move through the drought year, this is to be taken as an indication only, as it is based on simulated data without the 60% rainfall scenario which would normally be used in the Overall Risk Indicator to map to a DEL.

Table 15 Risk indicators and combined risk for London assessment

Month	Groundwater	Reservoir Storage	Surface Water	Combined Risk	Mapped DEL*
Feb 76	0	0	3	1	DEL1
Mar 76	1	0	3	1	DEL1
Apr 76	2	0	3	2	DEL2
May 76	2	1	3	2	DEL2
Jun 76	2	2	3	2	DEL2
Jul 76	3	2	3	3	DEL3
Aug 76	4	2	3	3	DEL3
Sep 76	4	3	3	4	DEL4
Oct 76	4	3	1	3	DEL3
Nov 76	4	0	0	2	DEL2
Dec 76	4	0	0	2	DEL2

*This is not a true mapped DEL using the full ORI method, this is an indication based on a retrospective assessment of observed data.

2.1.28 Conclusion

The mapped DEL would have provided an early warning of drought risk with DEL1 in late winter. This would lead to implementing media campaigns, followed by a Temporary Use Ban (TUB) in spring. The TUB was actually introduced in July 1976. This indicates that the current methodology provides an improved means of addressing drought risk than existed in 1976 because of the ability to identify risk earlier through assessment of groundwater levels. This means that if a repeat of 1976 occurred measures such as TUBs would be introduced much earlier.

As the drought progresses, DEL3 would mean applying for and implementing Non-Essential Use Bans (NEUB) and drought permits over the summer. These measures did not exist at the time but would have helped with mitigating drought impacts and needing to implement DEL4 measures.

1976 drought – SWOX

2.1.29 Background

Following a dry summer in 1975 there was very little effective rainfall over the Upper Thames area during the winter of 1975/76 and so groundwater levels did not recover over the recharge period and were consequently very low at the start of the summer of 1976. The spring and early summer of 1976 continued to be very dry and hot which meant there was no effective surface runoff contribution to river flows at SWOX_0006 and so river flows became dangerously low in the summer.

A hosepipe ban was introduced in a phased pattern across the catchment at the time. Dates of hosepipe ban introductions (please note that Division names do not align with current WRZs):

- 17 July 1976 for Lambourn Division
- 19 July 1976 in Vales Division (Upper Thames area).
- 24 July 1976 extended to the whole region.

Measures to increase abstraction from the Upper Thames were required including diversion of flows from the River Cherwell to above Kings Weir and then back pumping into the SWOX_0006 reach of the River Thames. It should be remembered that at this time the public water supply arrangements were very different from those of today. For example, only SWOX_0006 Stage 1 reservoir was in operation during 1976 (equates to ~33% of the whole reservoir today) and the SWOX_0007 groundwater source did not exist.

The pre-privatised legislative controls in force at the time were also very different. Drought Permits did not exist. Therefore, it is difficult to compare the actions taken in 1976 with those that would be taken under the present regulatory regime.

The hosepipe ban was lifted in all areas in the November of 1976 following the significant rainfall through autumn.

2.1.30 Step 1 Data collation and water resources modelling

For this example, observed data has been used to roughly illustrate what risk levels we would have reached and would have been triggered in 1976. For groundwater in SWOX the site at Ampney Crucis was used alone due to data availability and it being the most influential in the risk assessment. Whilst for reservoir storage and river flows, model outputs from a Deployable Output (DO) run for Annual Review 2024-25 has been used.

The data from January to December 1976 are shown in Figure 9. The figure shows river flows starting the 1975-76 winter at exceptionally low levels, continuing to recede until rain in autumn / winter encouraged recovery. Groundwater levels at Ampney Crucis started at an exceptionally low level and continued to recede through summer, with recovery from October 1976 following heavy rain. Reservoir storage started full but from April onwards rapidly declined until early autumn.

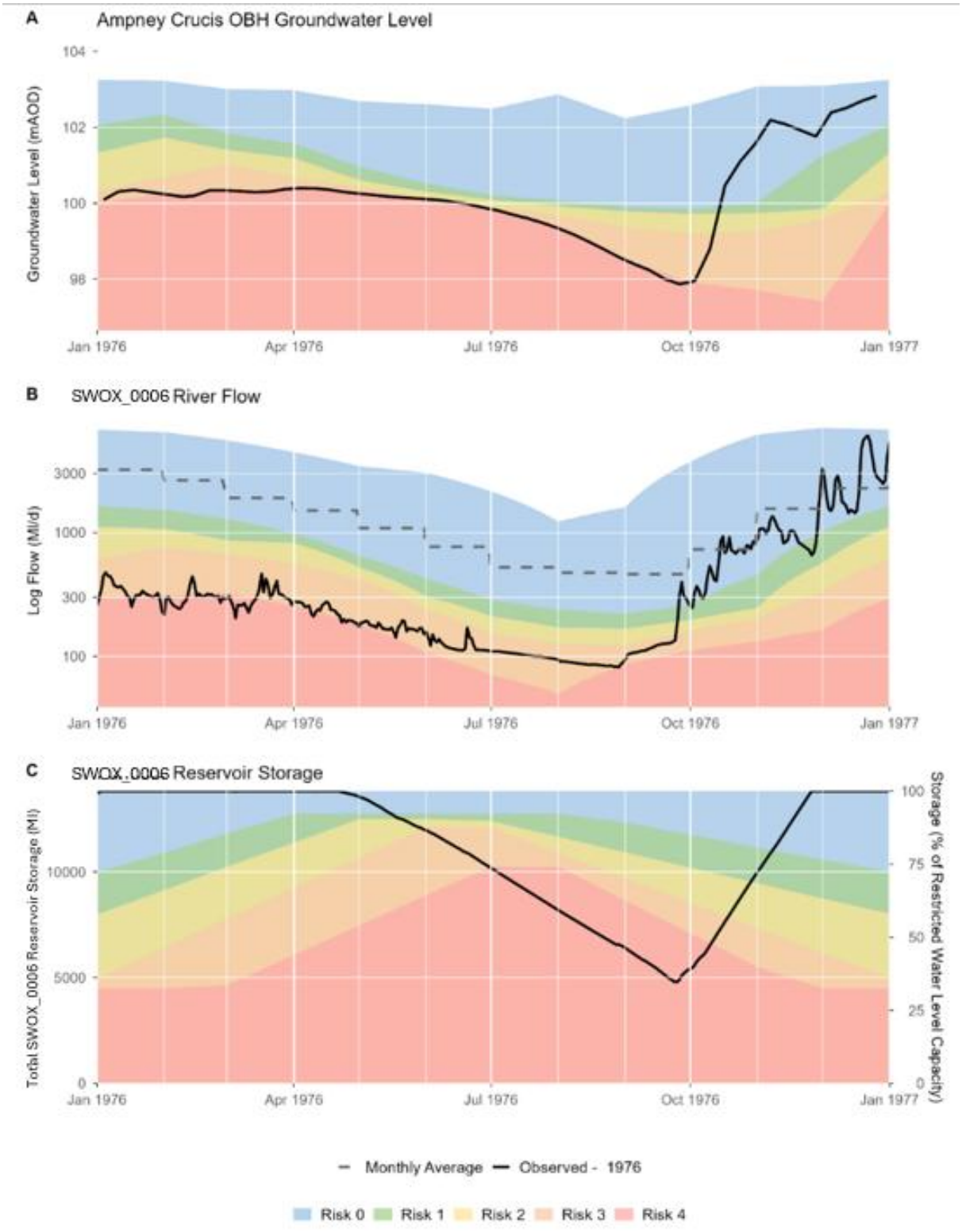

Figure 9 Simulated reservoir and storage data, and observed groundwater levels for SWOX (1976 worked example)

2.1.31 Step 2 and 3 DEL assessment and assignment

For this example, the simulated/observed data for February to December 1976 were assessed using the risk levels to determine a current risk level for each month. The combined current risk for each month was mapped to a DEL. The combined risk and mapped DEL are shown in Table 16.

Table 16 Risk indicators and combined risk for SWOX assessment

Month	Groundwater	Reservoir Storage	Surface Water	Combined	Mapped DEL*
Feb 76	4	0	4	3	DEL3
Mar 76	4	0	4	3	DEL3
Apr 76	4	0	3	3	DEL3
May 76	4	0	4	3	DEL3
Jun 76	4	3	3	4	DEL4
Jul 76	4	4	3	4	DEL4
Aug 76	4	4	3	4	DEL4
Sep 76	4	4	3	4	DEL4
Oct 76	4	4	1	3	DEL3
Nov 76	4	2	0	2	DEL2
Dec 76	4	0	0	2	DEL2

*This is not a true mapped DEL using the full ORI method, this is an indication based on a retrospective assessment of observed data.

2.1.32 Conclusion

Due to extremely low groundwater levels and surface water flows, the February DEL would have been DEL3. It is possible that the lower Drought Event Levels would have been introduced the previous autumn and winter. As noted for the London example, DEL3 measures such as NEUBs and Drought Permits did not exist at the time in reality but would likely have helped with mitigating drought impacts although the sustained severity may have meant that DEL4 measures would still have been required. Due to the heavier impact on the SWOX zone compared with London, measures may have been introduced in SWOX earlier than for the rest of the company.