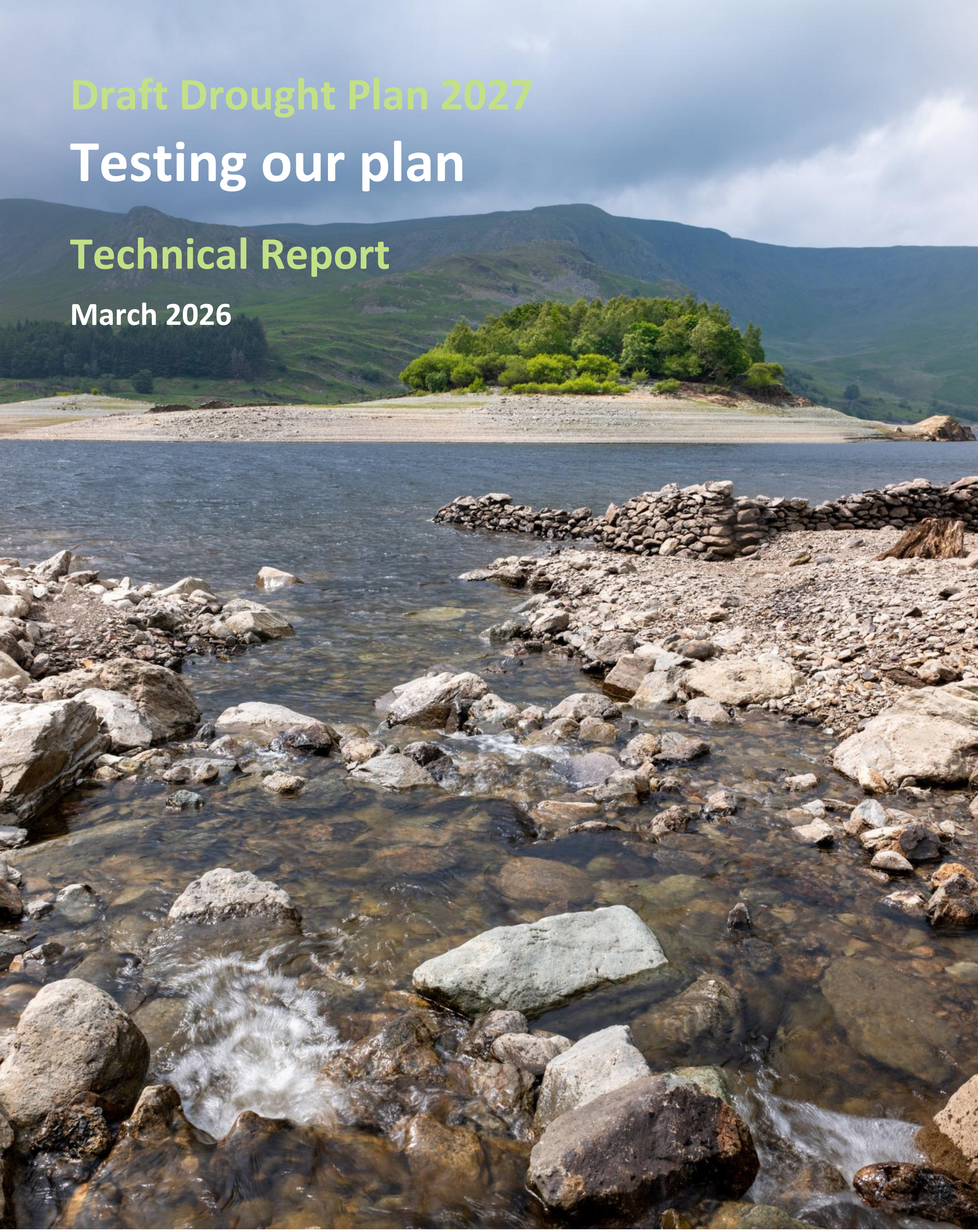
Draft Drought Plan 2027

Testing our plan

Technical Report

March 2026



United Utilities

Water for the North West

Contents

1. Introduction

Since our last drought plan we have undertaken a drought level optimisation project for our Strategic Resource Zone, as described in our Draft Drought Plan 2027 technical report, 'How we have developed the plan'. In our remaining resource zones, we have carried out a thorough review of the assumptions underpinning the drought levels set in our previous plan to demonstrate they remain effective. This report focuses on the next stage of the process: the scenario testing we have undertaken to validate our approach and ensure that our plan is robust to a range of future uncertainties. We applied a range of scenarios across droughts of varying severity to rigorously stress-test our drought actions and levels, demonstrating that the plan can deliver an effective response under challenging conditions.

2. Drought vulnerability

We completed the Drought Vulnerability Framework (DVF) assessment for our Drought Plan 2022, and because our water supply systems have not undergone significant changes the findings remain valid. The DVF, completed in accordance with Environment Agency guidance, evaluates drought risk by simulating system response to a range of droughts of varying durations and severities, characterised by rainfall deficits. Risk is quantified by calculating the number of days of supply-demand failure (implementation of emergency drought orders) for each scenario, with results plotted on a Drought Response Surface to illustrate vulnerability across return periods. The 2022 assessment showed Carlisle Resource Zone to be highly resilient, with no failures below emergency storage and only a handful of extreme short-duration events reaching emergency levels. The Strategic Resource Zone exhibited slightly higher vulnerability, with occasional failures only under severe, long-duration droughts. Given the stability of system configuration and the absence of new nationally adopted climate products or material changes to planning guidance, the existing DVF outputs continue to provide a robust basis for our Drought Plan 2027. The assessment provides quantitative risk mapping for each water resource zone, return-period analysis for drought measures, and integration of recent drought experience. It demonstrates that our supply system is robust against severe droughts, with only extreme, low-probability events triggering significant restrictions.

3. Drought characterisation

We also assessed drought vulnerability using a system-response approach, focusing on the estimated risk to customers and the environment under weather variability. We developed this for the 2022 Drought Plan and termed it as the drought characterisation exercise. This assessment was based on a synthetic dataset of stochastic droughts generated using a Weather Generator and comprising a 19,200-year record[1]. All events in this record were simulated to estimate the overall frequency of implementing customer restrictions and drought permits. For the most severe events, we examined the main causal factors to understand system behaviour under stress. This analysis was undertaken for the Strategic Resource Zone to identify failure events and inform scenario selection for robust drought plan testing. Sensitivity testing was also carried out to explore the influence of demand changes and leakage performance, ensuring that the scenarios reflect a wide range of plausible future conditions.

For each of the events that follow in this document there is a corresponding figure that illustrates the system response through the lens of simulated storage at drought level locations, for example Figure 2. Additionally for stochastic events we have also included the average rainfall and catchment inflows, for example Figure 10. This level of detail helps to breakdown the stochastic event and understand the narrative around the modelled system response. It also ensures that we have selected events that are effective in stressing our supply system and adequately test our drought plan.

[1] For WRMP24 we introduced a new, spatially coherent stochastic data series to enable us to assess the impacts of droughts more severe than those in our historical record. Our approach aligns with that adopted by the regional planning group, Water Resources West.

4. Drought levels scenario testing

The process undertaken to optimise our Strategic Resource Zone and develop drought levels at locations in this zone is detailed in our Draft Drought Plan 2027 technical report, 'How we have developed the plan'. This was a collaborative effort between our Water Resources and Integrated Planning teams alongside consultants, each bringing their expertise from operational insights to modelling capability. Optimising drought levels for the Strategic Resource Zone used a subset of our stochastic inflows, equating to 4,000 years of stochastic inflows. To fully stress-test the drought levels while accounting for future uncertainty in the drought plan horizon they have been tested over the full 19,200 year stochastic record in a variety of scenarios as outlined below. We also used the worst historical drought events on record to test our plan. This allows us a view of how the current supply system would respond if previous hydrological conditions were to reoccur, and in using stochastic hydrology we test our drought plan against droughts that are more severe and or have different characteristics to those in historic record.

In testing the plan significant consideration is given to the levels of service for drought restrictions (such as a temporary use ban) and adequate timing between drought levels for actions to be implemented and the benefits realised. When these criteria are met it demonstrates that our plan is robust across a host of potential different futures.

To ensure the drought plan is resilient across a range of plausible and extreme conditions, a suite of modelling scenarios was developed for the Strategic and Carlisle Resource Zones. These scenarios explore variations in demand and the application of drought actions to understand system performance under stressed conditions and to demonstrate the benefits of planned interventions. We selected these scenarios and associated drought events using relevant demand forecasts, climate-adjusted hydrological inputs, and both stochastic and historical drought sequences, ensuring that each scenario reflects plausible future hydrological stress and allowing us to isolate the effects of different drought actions across a robust range of conditions.

4.1 Scenarios

The scenarios and events selected are summarised below. For both the 2027 and 2031 timeslices used, corresponding climate change impacts were applied[2]. This helps to ensure that the scenario best reflects plausible future hydrological stress.

Scenario A – No Drought Actions
Represents normal operating conditions with no drought interventions. Demand reflects conditions at the start of the plan period (2027). This provides a reference point for comparison.

Scenario B – All Drought Actions
Conceptual scenario assuming full implementation of all supply and demand drought actions. Demand reflects conditions at the start of the plan period (2027). This serves as a benchmark for the maximum potential benefit of the drought plan.

Scenario C – Demand Actions Benefit
Demand-side drought measures (e.g., voluntary use restrictions, publicity campaigns, leakage control) are enabled, while supply-side interventions remain inactive. Demand reflects conditions at the start of the plan period (2027), allowing the contribution of demand management to be assessed in isolation.

Scenario D – High Demand
Tests system performance under elevated demand conditions, representing a plausible stress case where customer usage increases during a drought. Demand-side actions are enabled.

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[2] Climate change perturbations were applied using monthly change factors derived from the UKCP18 Regional Climate Model ensemble, with RCM_06 under RCP8.5 used to represent the Central ("median change") scenario, consistent with United Utilities WRMP24 modelling. Monthly factors originally produced for 2070 were scaled to represent earlier time slices using the same WRMP24 scaling approach.

Scenario E – 2031 Conditions
Applies projected demand levels for the end of the plan period (2031), with both supply and demand drought actions enabled. This scenario evaluates whether the plan remains robust under future conditions. Climate change impacts differ for this scenario (i.e. reflect 2031 rather than 2027), ensuring that the scenario reflects plausible future hydrological stress alongside projected changes in demand.

4.2 Events

Each scenario was tested using both stochastic and historical drought sequences, which are 19,200 years and up to 131 years long respectively. We share the modelled system response for each scenario in events of differing magnitude in the sections below. This combination of both stochastic and historical inflows ensures that the analysis captures both statistically rare events and real-world drought experience. The range of events included is listed below:

- Our worst historical drought event; 1995-1996;
- 1 in 200 year Emergency Drought Order single-season drought event;
- 1 in 200 year Emergency Drought Order multi-season drought event (for the Strategic Resource Zone only); and
- 1 in 500 year Emergency Drought Order event single-season drought event.

For these events we plotted the simulated storage at drought level locations and checked there is sufficient time between the drought levels for drought actions to take place.

4.3 Modelling approach

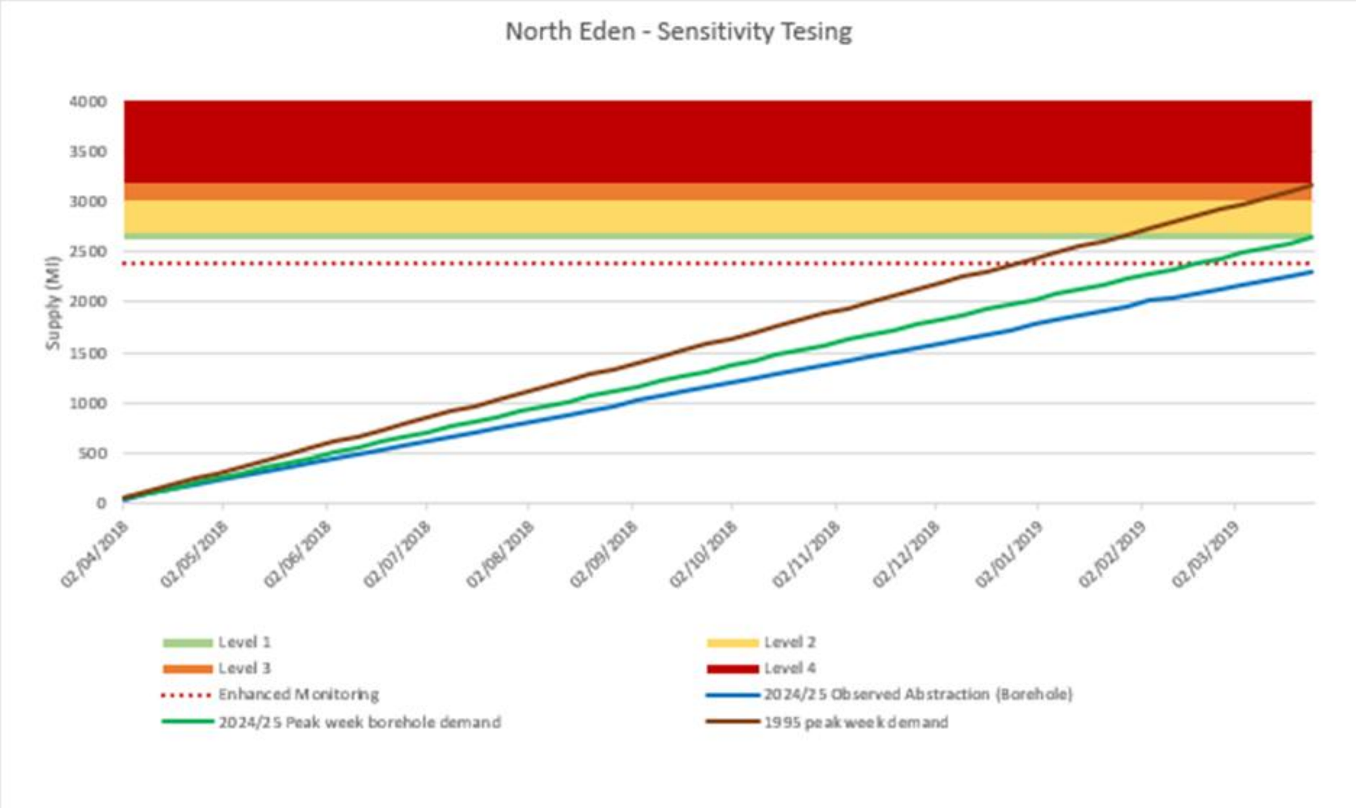
The water resources modelling approach applies the drought actions as described in section 2.4 of our Drought Plan 2027 main report, as well as the 'Demand actions' and 'Supply actions' technical reports. System failure during drought is assessed using a combination of reservoir storage and the model's ability to meet demand across the network. A failure is deemed to occur when simulated reservoir storage reaches dead water and a demand centre experiences a deficit that can't be met via alternative supply routes. In this situation, customer supply could only be maintained through the rationing of water, representing the need for an Emergency Drought Order. The model makes assumptions about when actions would be implemented, however in reality, every drought event is different. The timing, severity, and combination of actions would be tailored to the evolving situation, informed by operational judgment, environmental considerations, and regulatory engagement. While the types of actions; such as voluntary use restrictions, pressure management, temporary use ban, and drought permits, are consistent, the sequence and timing of their implementation would vary between events. For example, in practice, we might introduce voluntary use restrictions early to encourage savings, delay pressure reduction until later stages, or apply for selected drought permits only if forecasts indicate prolonged stress. These decisions depend on real-time data, customer behaviour, and environmental risk, none of which the model can replicate.

In section 5 we discuss adaptive pathways and extreme drought measures. These are part of a flexible, decision-making framework to be considered as a drought escalates, rather than predetermined actions to be modelled in advance. As the drought event develops, we would assess the need to activate an adaptive pathway for implementing extreme drought measures. These measures, which represent the next stage of drought management during an exceptional event, are discussed in detail in Section 5 of this document. However, because the adaptive approach is inherently contingent and designed to respond to real-time conditions, these measures have not been included in our scenario modelling. This ensures compliance with the guidance, which prioritises flexibility and proportionality over prescriptive modelling of highly uncertain, extreme interventions.

The scenario testing results presented in the following sections focus on the Strategic and Carlisle Resource Zones. As outlined section 2 our North Eden and Barepot zones do not exhibit drought vulnerability. Nonetheless, to illustrate this conclusion more clearly, we applied highly unrealistic stress conditions in North Eden—

specifically, we modelled demand as if the highest weekly usage occurred continuously throughout the whole year (see Figure 1). This helped reinforce the robustness of the zone under extreme assumptions.

Figure 1: Scenario testing applied to the North Eden Resource Zone to illustrate its resilience to extreme demand conditions. The green and brown traces represent artificially elevated demand levels, set to match the annual peak week across all weeks of the year.



4.4 Strategic Resource Zone

4.4.1 1995-96 historical event (two-season)

Rationale

For many sources in the Strategic Resource Zone, and the zone as a whole, the 1995-96 drought represents the most severe historical event. The 1995-96 drought provides a robust benchmark for assessing individual source vulnerability, the effectiveness of the conjunctive nature of our Strategic Resource Zone, and the resilience of the system under severe and historically observed conditions.

Event description

This scenario represents a repeat of the severe drought experienced across our region during 1995-96. The event spanned two seasons and affected the entire area. Historical records show that drought permits and orders were first applied for in early August 1995, implemented from September through December, and in many cases extended into 1996. Additional measures were introduced between late January and July 1996.

Rainfall deficits were extreme. At Holden Wood rain gauge, six-month rainfall to September 1995 was only 306 mm, around 49% of the long-term average, making it the driest April to September period on record in a 106-year series. Regional rainfall for the 15 months to June 1996 was 906 mm, approximately 53% of the long-term average, also ranking as the driest in a 108-year dataset. These conditions drove significant operational challenges and regulatory interventions, forming a benchmark for severe drought planning.

Results

Figure 2: Haweswater simulated storage alongside new drought levels, salient drought actions and timing between levels

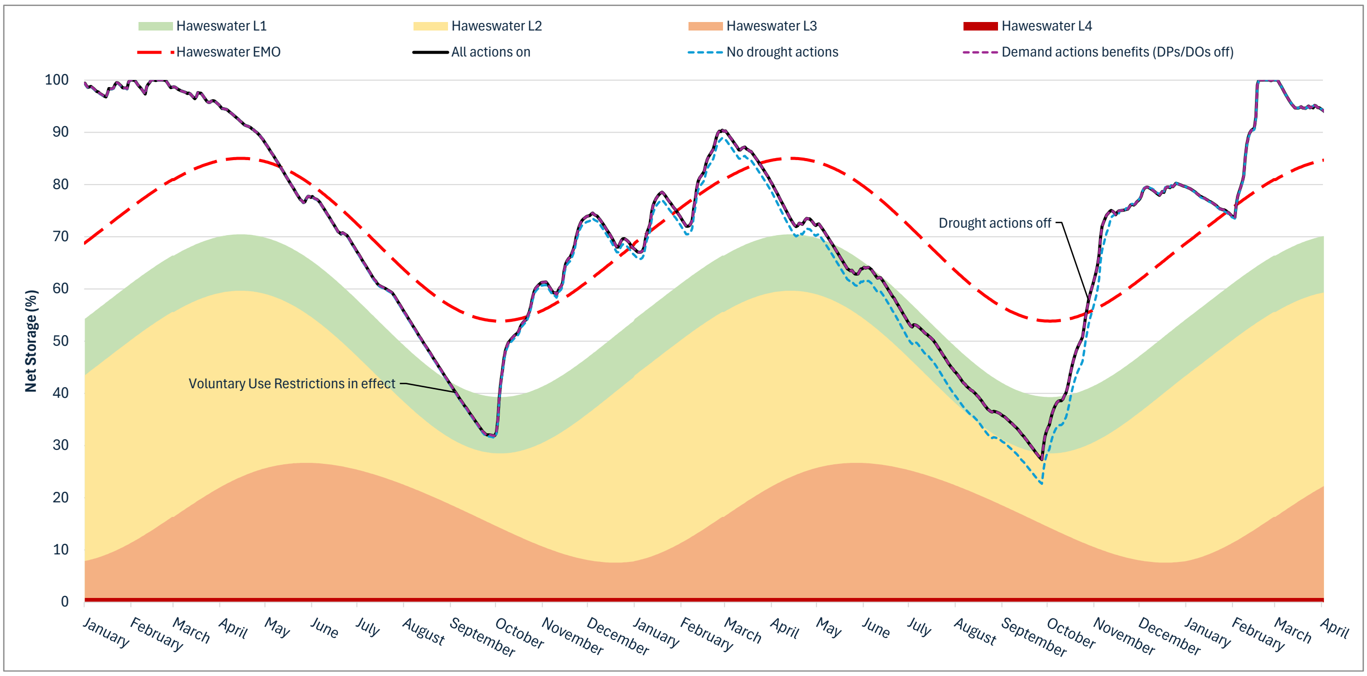


Figure 3: Dee simulated storage alongside new drought levels, salient drought actions and timing between levels

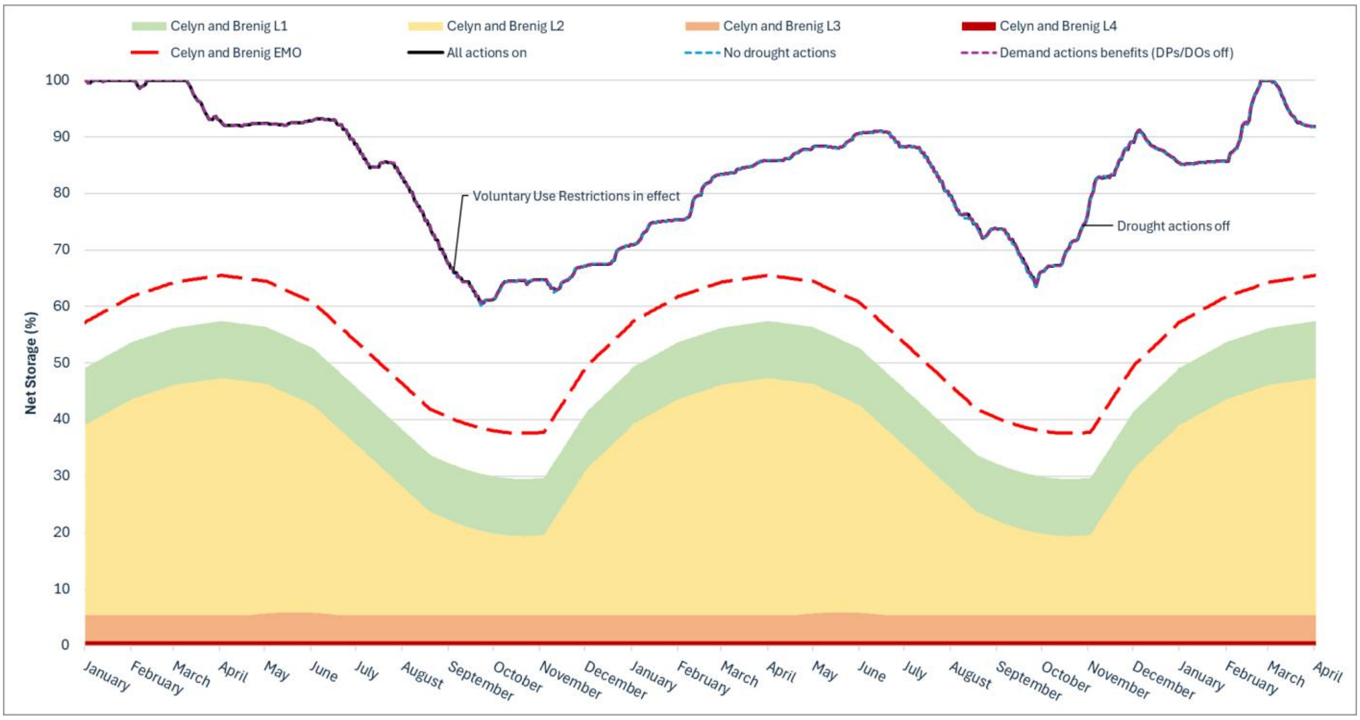


Figure 4: Pennines simulated storage alongside new drought levels, salient drought actions and timing between levels

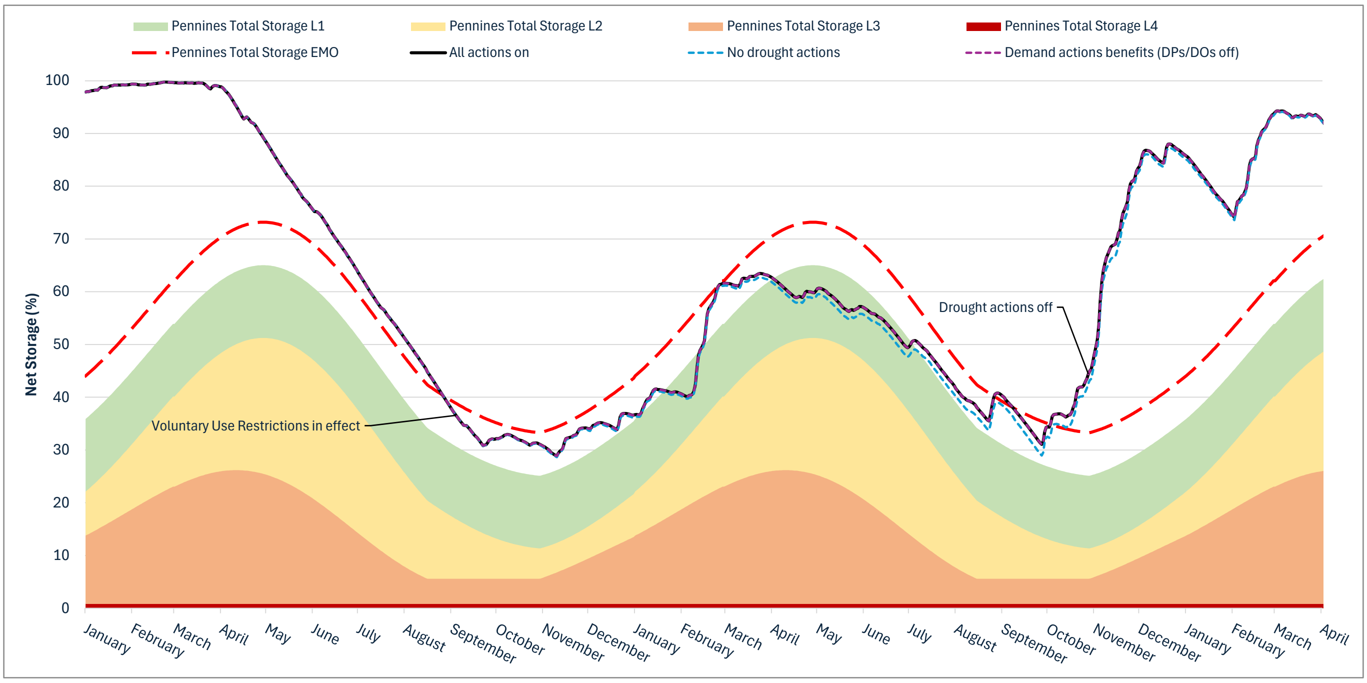
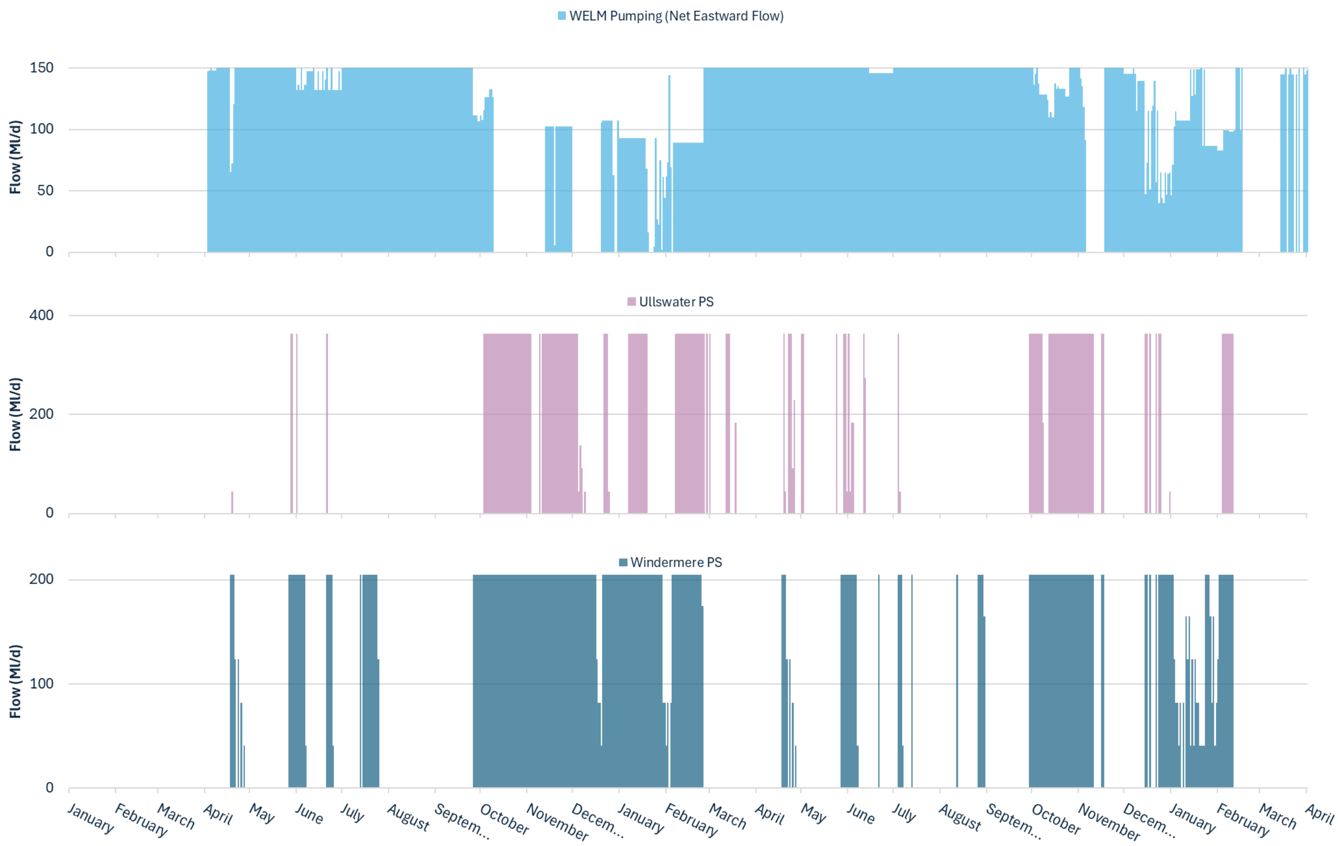


Figure 5: Simulated operational actions showing strategic pumping across the Strategic Resource Zone



Discussion

Our water resources modelling indicates that under a repeat of 1995/96 climatic conditions, Haweswater storage declines to a minimum of 32% during the first year of the event, reaching an overall minimum of 27% in September 1996. During this scenario, storage at both Haweswater and Pennines drought level locations falls into level 1, while storage at the Dee remains above the Enhanced Monitoring and Operations (EMO) threshold.

System resilience during this event is maintained through operation of the West East Link Main (WELM), transferring surplus water from the west to the eastern resource zone. Additional support is provided by pumping from Ullswater and Windermere, subject to hands-off flow conditions, primarily during autumn and winter.

These results indicate that, aside from implementing voluntary use restrictions, no further drought actions are required under a repeat of 1995/96 conditions on the current supply system. In the ‘no drought actions’ scenario, simulated Haweswater storage declines an additional 5%, reaching a minimum of 22%, demonstrating the benefit of voluntary restrictions.

4.4.2 1 in 200 year stochastic event (one-season)

Rationale

The selection of a drought event with a return period of 1 in 200 years aligns with the resilience standard set out in our WRMP24 until 2039. This corresponds to our current minimum level of service, where the implementation of emergency drought orders is expected no more frequently than once in 200 years on average.

From 2039 onwards, following planned leakage reduction and demand management measures, this minimum level of service will improve further, with emergency drought orders anticipated only under events with a return period of 1 in 500 years. While outside the timescales for our Drought Plan 2027, this progression reflects our long-term strategy to enhance system resilience and customer service standards.

Event description

- This drought scenario represents a stochastic, single season drought with a 1 in 200 year return period, based on the system response across the Strategic Resource Zone.
- Haweswater modelled storage falls below level 1 in May, triggering voluntary use restrictions and reaching a minimum of 13.8% in October.
- The Pennines exhibit a similar response, crossing level 1 in May and reaching minimum storage (14.1%) in October.
- Rainfall remains below the stochastic long-term average (S-LTA) from February to August, with Cumbria and the Pennines experiencing the most severe deficits compared to Wales.
- All reservoir sources begin progressive drawdown from February, continuing until rainfall returned to S-LTA levels in September and October.
- Welsh catchments, although consistently below S-LTA, receive more rainfall than Cumbrian and Pennine sources. However, recovery here is slower, with Dee storage not returning above S-LTA until January of the following year.

Results

Figure 6: Haweswater simulated storage alongside new drought levels, salient drought actions and timing between levels

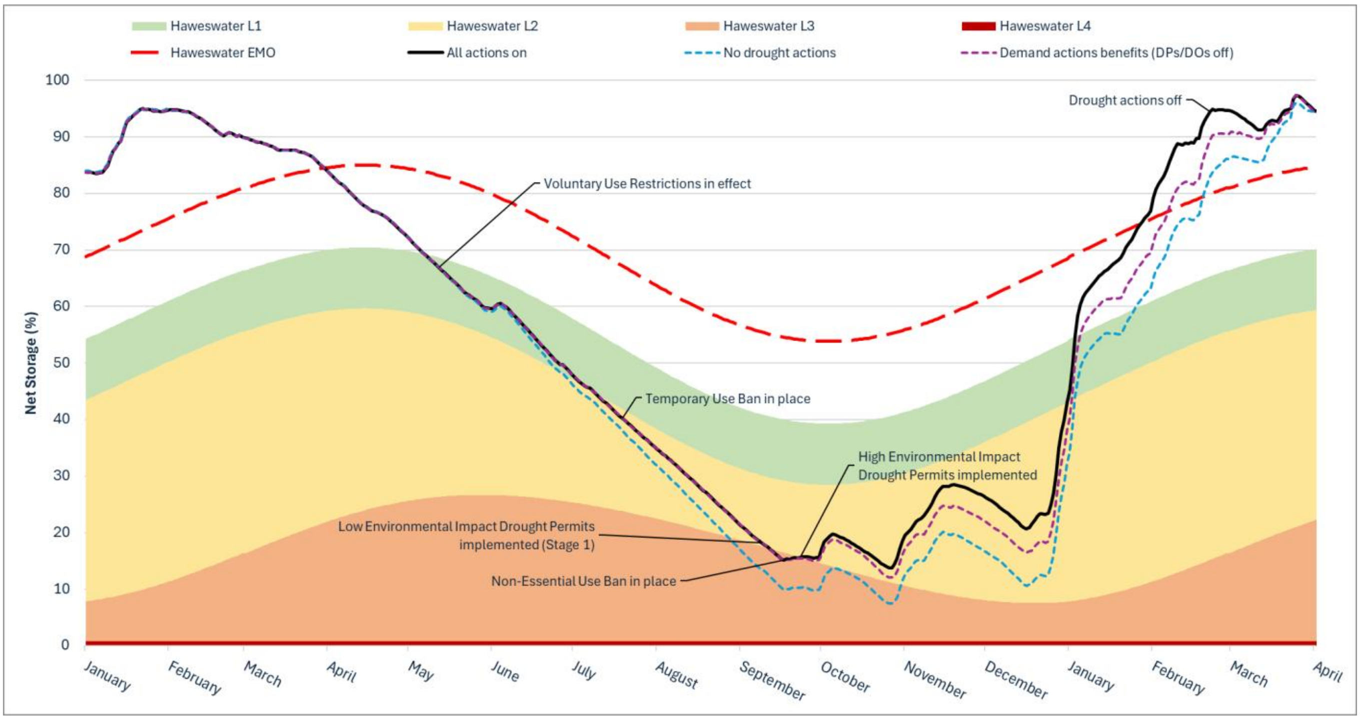


Figure 7: Dee simulated storage alongside new drought levels, salient drought actions and timing between levels

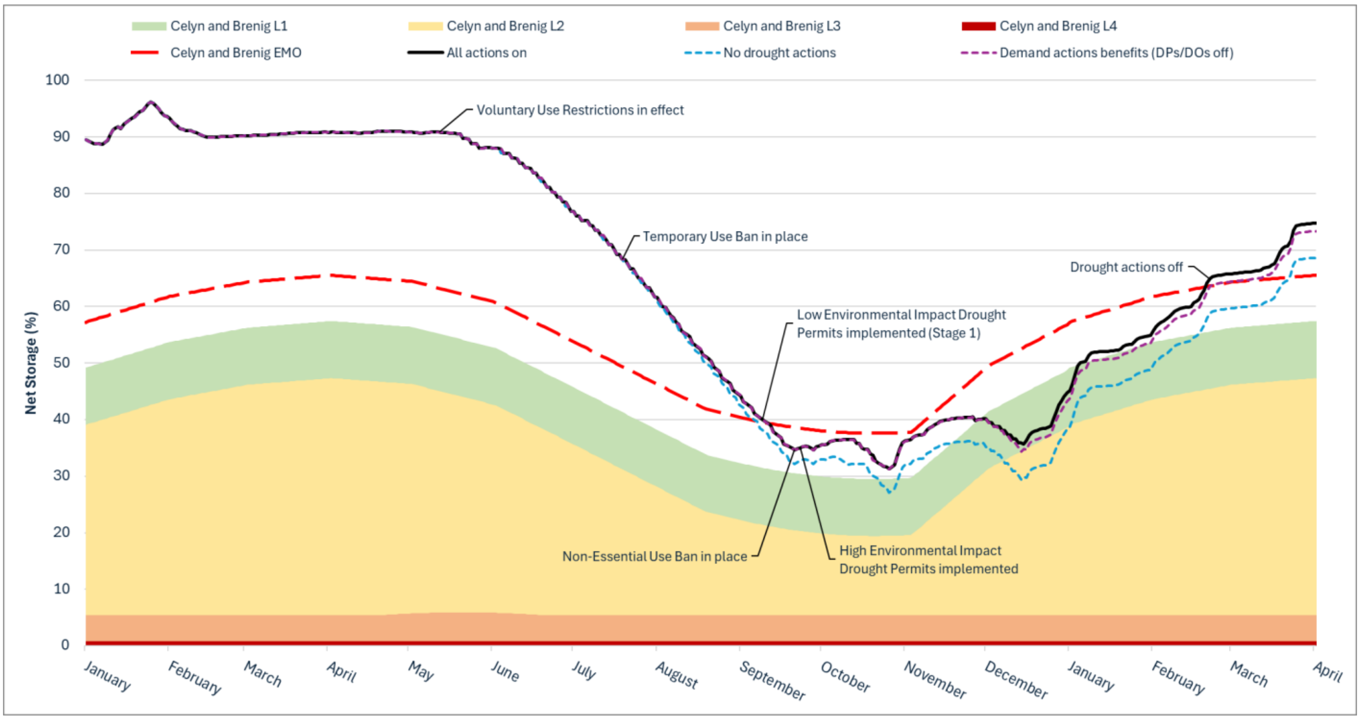


Figure 8: Pennines simulated storage alongside new drought levels, salient drought actions and timing between levels

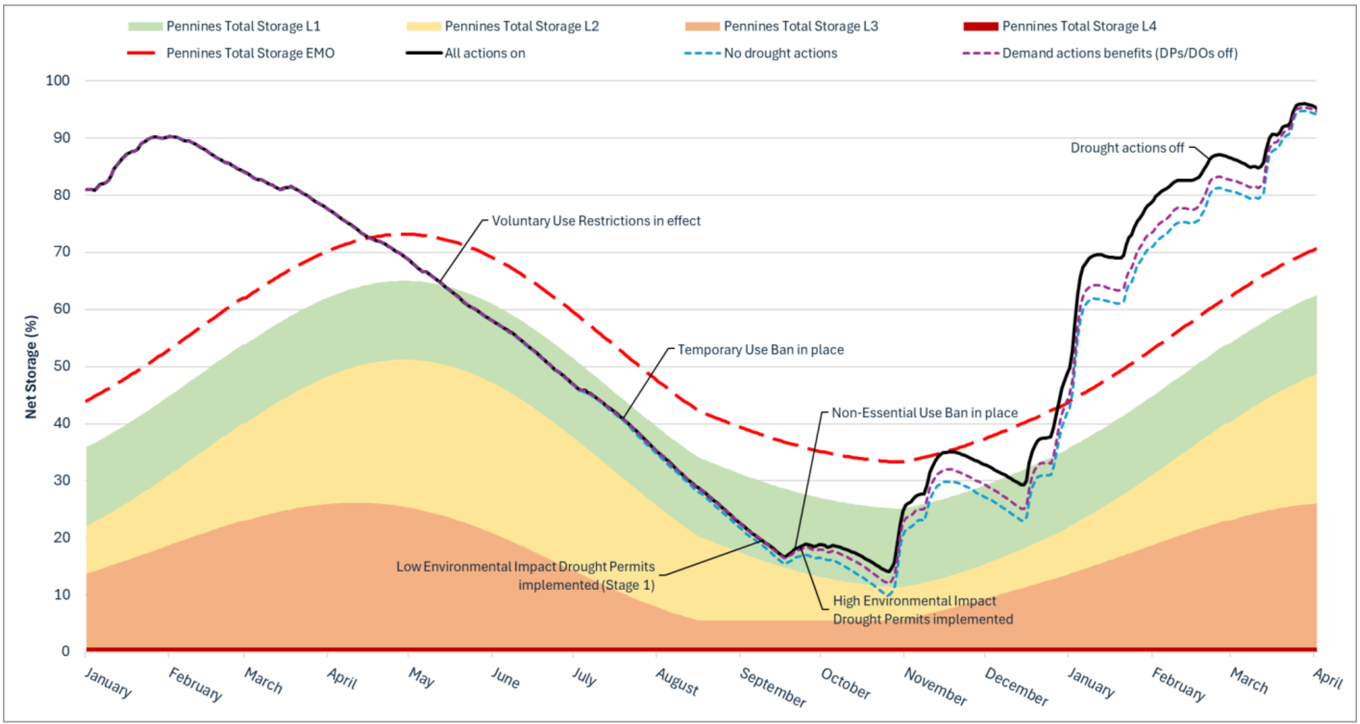


Figure 9: Simulated operational actions showing strategic pumping across the Strategic Resource Zone

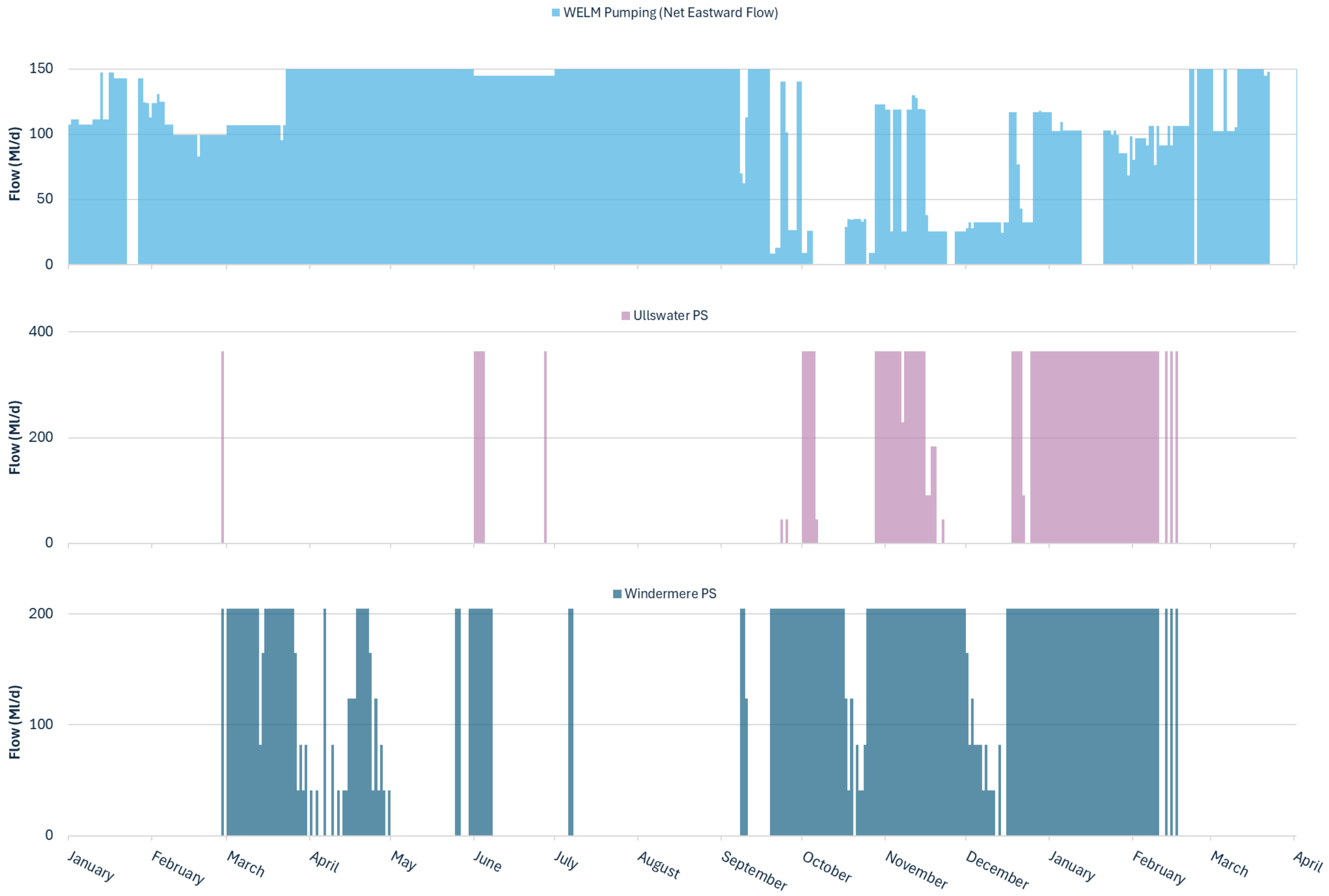
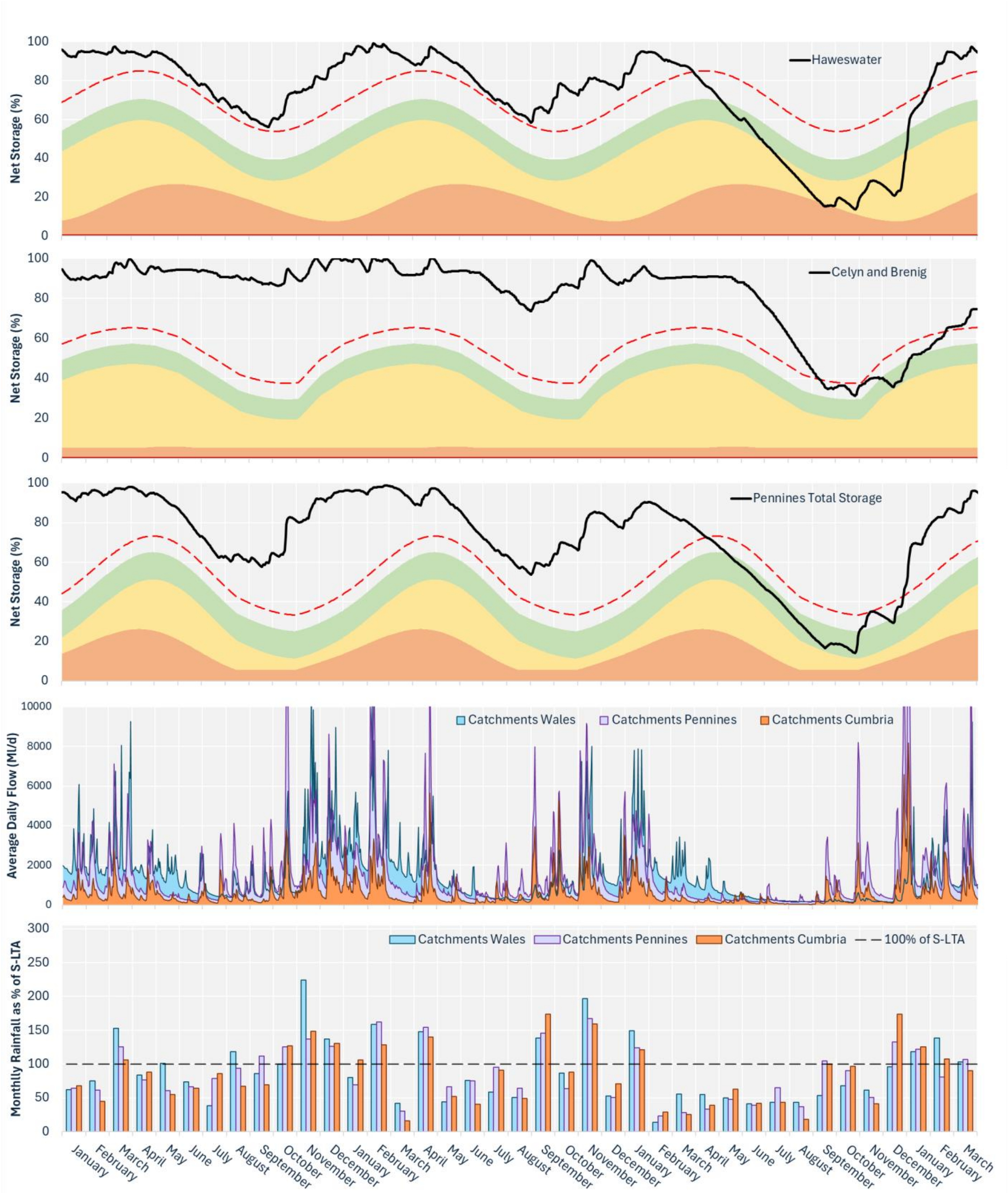


Figure 10: Drought characterisation of a 1 in 200 year single season stochastic event showing storage (net) across drought level locations as well as rainfall and flow aggregated into Cumbria, Wales, and Pennines catchments



Discussion

Figure 10 presents a detailed breakdown of a simulated stochastic drought event from our drought characterisation exercise, illustrating modelled reservoir storage, average daily flows, and monthly rainfall across designated drought level locations. The severity of this event corresponds to a calculated return period of 1 in 200 years; indicating a 0.5% annual probability of occurrence. It's important to note that this does not imply such an event will occur once every 200 years, but rather that each year carries a 1 in 200 chance of occurrence. This aligns with our current level of service for initiating emergency drought orders, in accordance with WRMP24.

Simulation results confirm system resilience under these conditions, though they indicate the likely need for a temporary use ban, non-essential use ban, and the implementation of drought permits and orders. Haweswater storage dips below level 1 in May, closely followed by the Pennines. While Haweswater initiates drought response actions, the Pennines exhibit a parallel storage decline, mirrored in the rainfall data for the event.

Operationally, the WELM plays an important role in system support, drawing on western resources where rainfall remains below the S-LTA, yet exceeds levels observed in the Cumbrian and Pennine catchments. This highlights the zone's operational flexibility to redistribute resources based on availability.

Pumping from Ullswater and Windermere, dependent on river conditions, is actively deployed and proves instrumental in recovery efforts. The effectiveness of our drought interventions is evident when comparing scenarios: both 'No drought actions' and 'Demand actions only' result in lower storage levels and delayed recovery.

In this high-severity, single-season event, our revised drought levels provide adequate lead time to implement response measures and realise their benefits. They also offer the adaptability needed to make informed, condition-responsive decisions throughout the event lifecycle.

4.4.3 1 in 200 year stochastic event (two-season)

Rationale

From historical droughts we know that two-season droughts are plausible, and with a largely surface water based supply system a prolonged dry period can potentially have significant impacts on reservoir refill over the winter period. By scenario testing an extended drought event with a 1 in 200 year return period (or 0.5% chance of occurrence in any given year) we stress tested our drought plan and drought levels for robustness while aligning to the national planning standards of resilience.

Event description

- This drought scenario represents a stochastic, two-season drought with a 1 in 200 year return period, based on the system response across the Strategic Resource Zone.
- During the winter leading into this event, rainfall across the region is above the S-LTA, however March to August has sustained deficits with rainfall often less than 50% of the S-LTA (notably March at ~30%, June at ~40%, July at ~25%, and August at ~20%). These consecutive dry months drive steep declines in storage across Haweswater and the Pennines, pushing both into level 1 by late summer and triggering VUR. The Dee has a slower response, crossing level 1 in January of the second year of the event.
- Above average rainfall in Cumbria, at 126% of S-LTA, sees reservoir stocks partially recover, however a return to below average S-LTA across the region through November and December prevents any meaningful recovery before winter.
- The second year of the event remains dry with rainfall consistently below average (35-70% of S-LTA). The prolonged deficit sustains low inflows, pushing Haweswater and Pennines into level 2 by early January, with a temporary use ban being implemented shortly after, and maintaining hydrological stress through spring. Throughout the event Dee storage only crosses level 1 early in the second year of the event, reflecting cumulative catchment stress rather than immediate response.
- Despite above average rainfall in Cumbria in July (110% S-LTA), this doesn't prevent reservoirs reaching their lowest point in early autumn (Haweswater ~14%, Pennines ~13%), with Haweswater storage prompting the

implementation of a non-essential use ban in September. Rainfall in August and September remains below average, and October and November finally deliver sustained above-average rainfall (≈110–185% S-LTA), driving recovery across all sites.

Results

Figure 11: Haweswater simulated storage alongside new drought levels and salient drought actions

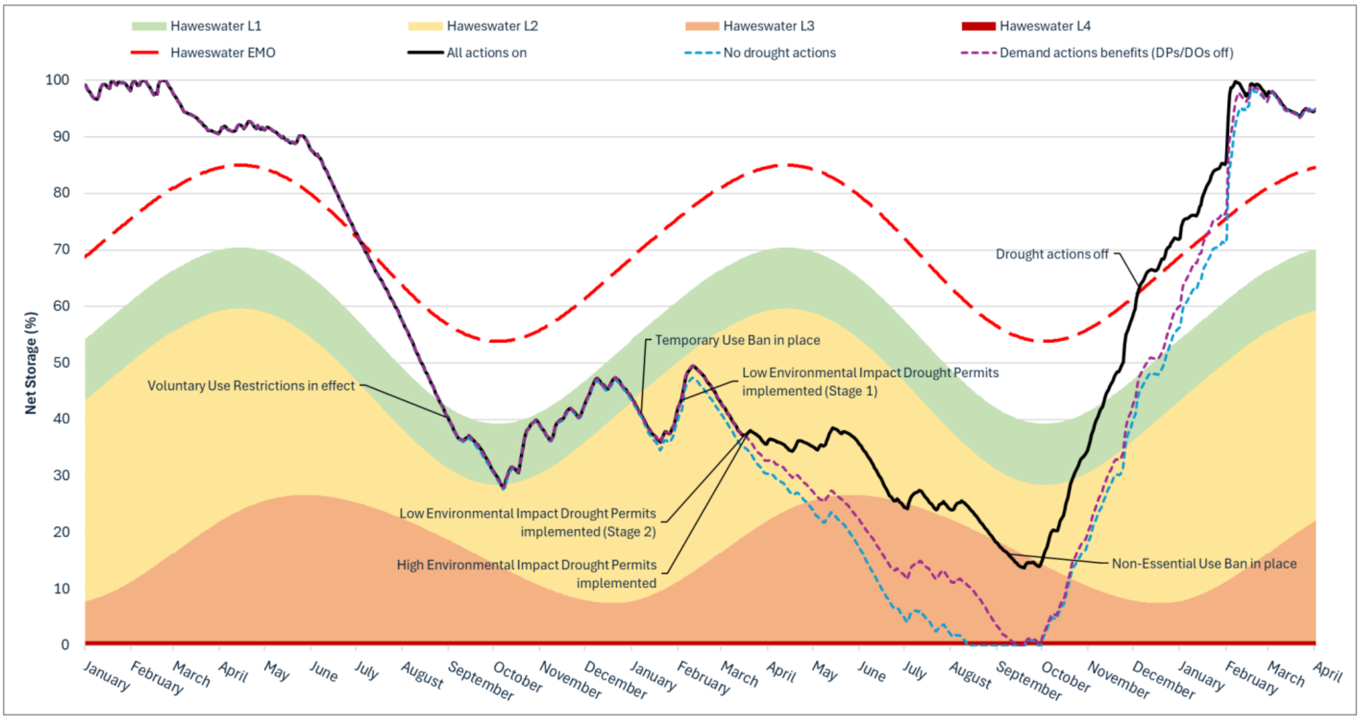


Figure 12: Dee simulated storage alongside new drought levels and salient drought actions

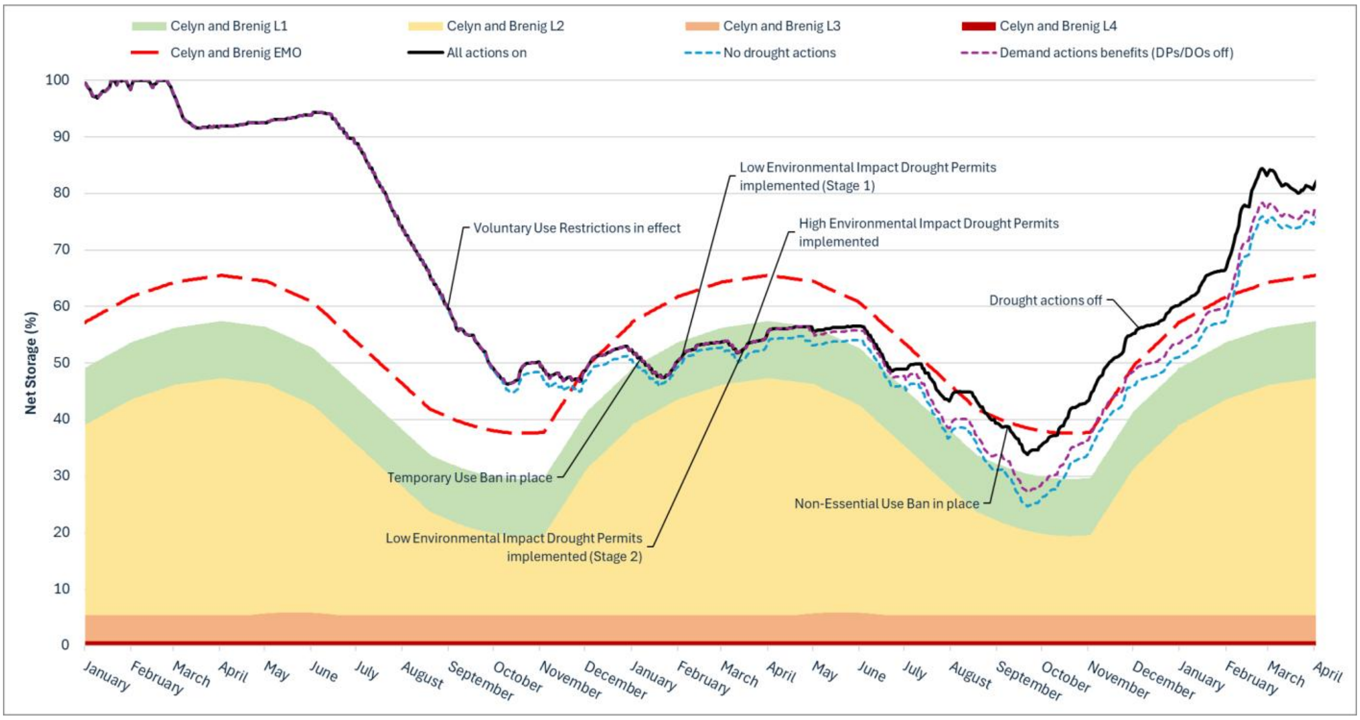


Figure 13: Pennines simulated storage alongside new drought levels and salient drought actions

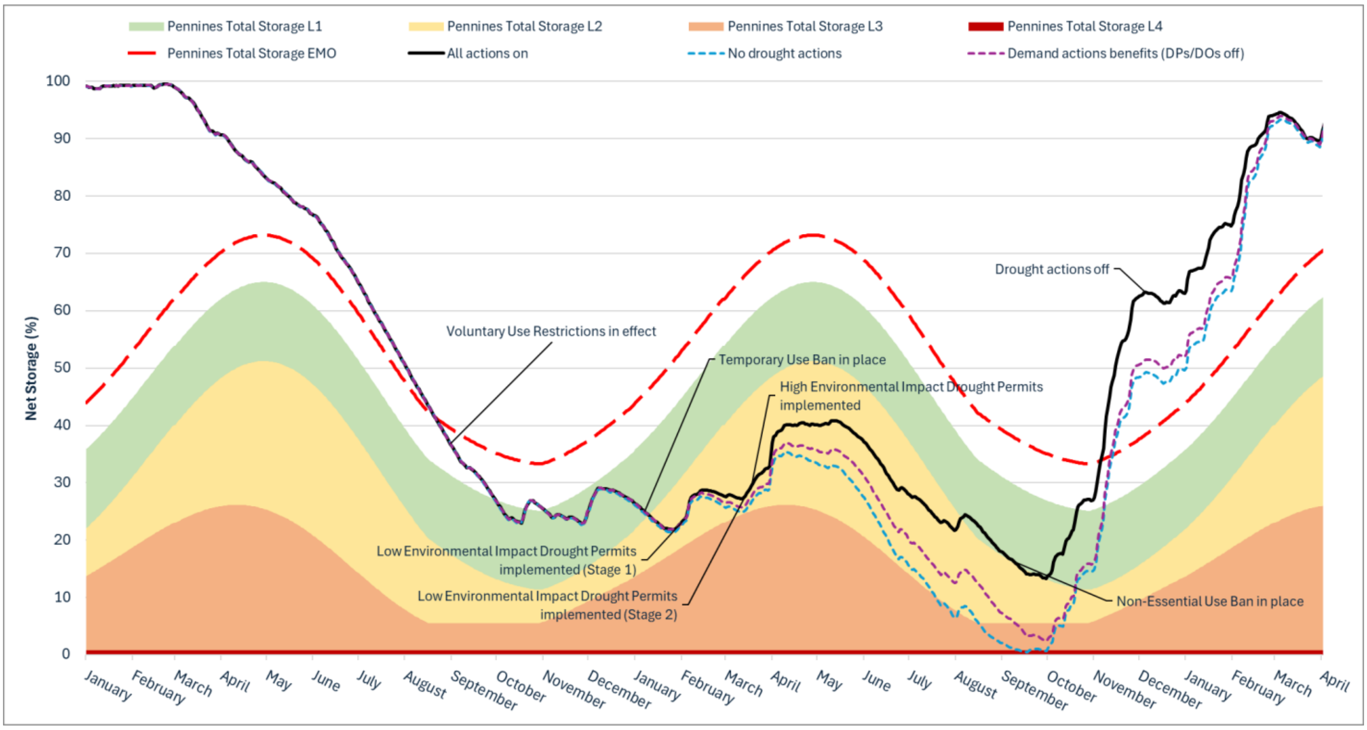


Figure 14: Simulated operational actions showing strategic pumping across the Strategic Resource Zone

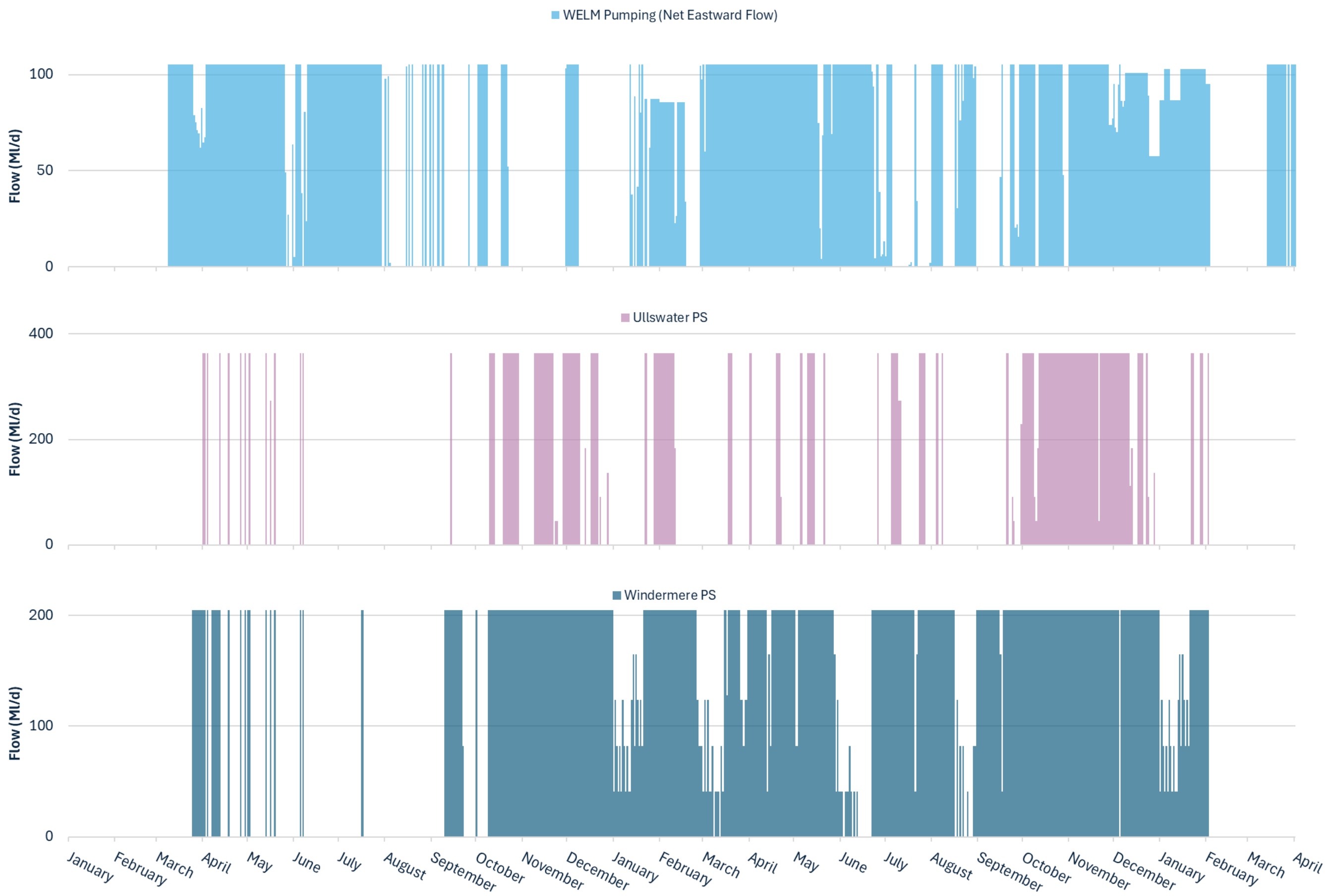
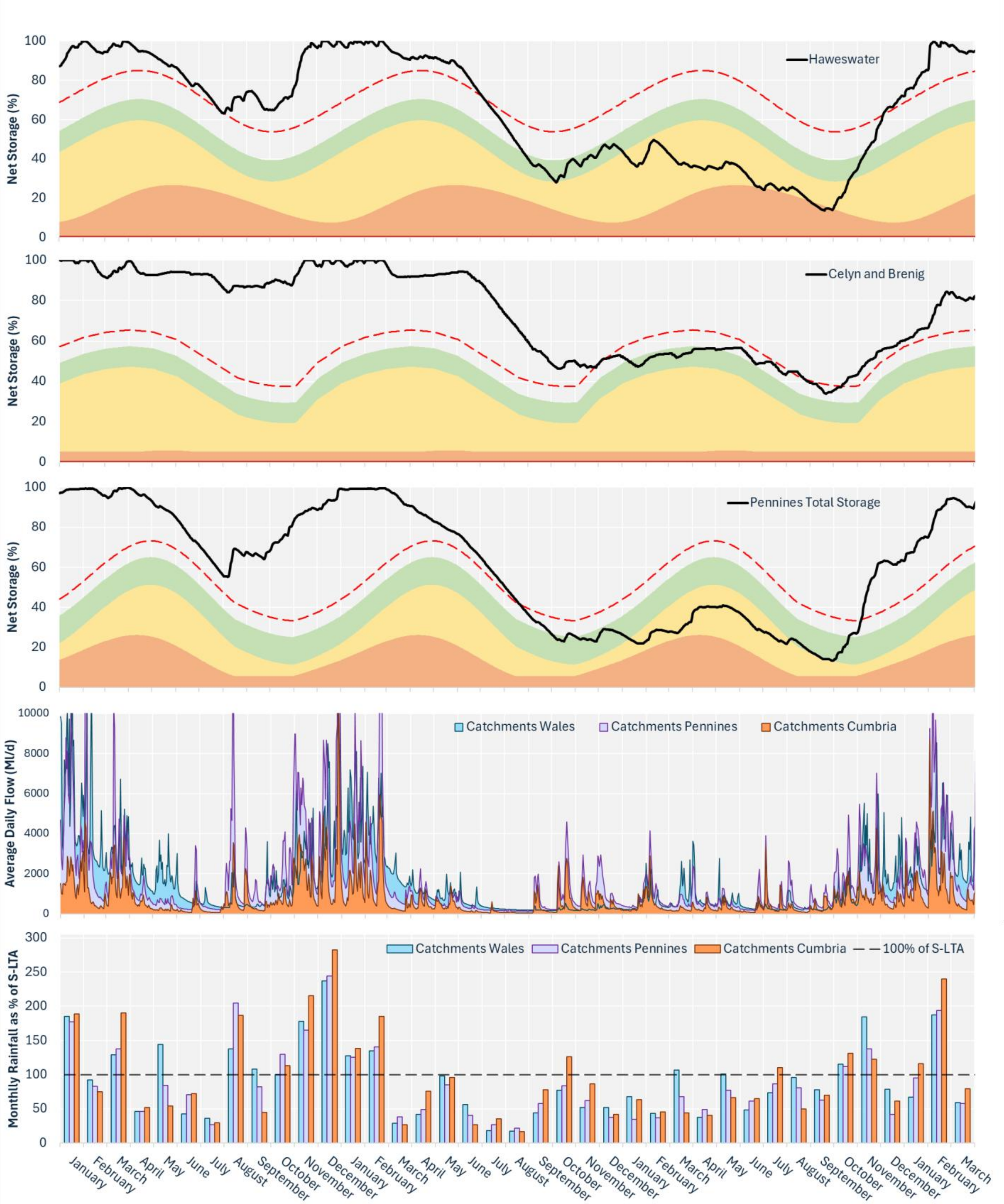


Figure 15: Drought characterisation of a 1 in 200 year two-season stochastic event showing storage (net) across drought level locations as well as rainfall and flow aggregated into Cumbria, Wales, and Pennines catchments



Discussion

Figure 15 presents a detailed breakdown of a simulated stochastic drought event from our drought characterisation exercise, illustrating modelled reservoir storage, average daily flows, and monthly rainfall across designated drought level locations. This is a double-season event with a 1 in 200 year return period aligning to our level of service (as noted with more detail in section 4.4.2).

Simulation results confirm system resilience under these conditions, though they indicate the likely need for a temporary use ban, non-essential use ban, and the implementation of drought permits and orders, actions prompted by Haweswater drought levels. The drought actions included in our drought plan and their impacts are clearly demonstrated in this scenario; from mid-March there is a divergence of modelled storage depending on whether drought actions are implemented or not. As shown in Figure 11, without any drought actions (dashed blue trend) or only demand restrictions (dashed purple trend) then modelled storage at Haweswater would drop into levels 3 and 4, triggering the implementation of a non-essential use ban in May and an emergency drought order in late summer of the second year of the event.

As with the previous 1 in 200 year event, the WELM is instrumental in supporting water supply across the region, with pumping from Ullswater and Windermere offsetting the drawdown of Haweswater when river availability allows.

In terms of severity, Haweswater and Pennines experience the deepest storage deficits, both dropping below 14%, while the Dee remains comparatively healthy. It's clear that the same drought event has stressed the drought level locations differently. Haweswater and Pennines deteriorate rapidly from late summer of year one into early January of year two, whereas the Dee lags by nearly a year. The Dee recovers first, Pennines next, and Haweswater last; underscoring the different resilience and refill dynamics across the system.

4.4.4 1 in 500 year stochastic event (one-season)

Rationale

We are expected to meet a 1 in 200 year level of resilience as our 'baseline'. The selection of a drought event with a return period of 1 in 500 years goes beyond this level of resilience by stress testing the drought plan in a more severe event. It also aligns with the expected resilience standard from the year 2039 onwards, as set out in WRMP24. While outside the timescales for our Drought Plan 2027, this progression reflects our long-term strategy to enhance system resilience and customer service standards.

Event description

- This scenario represents a stochastic drought with an indicative 1 in 500 year return period, derived from system response across the Strategic Resource Zone. The event is characterised by extreme early-season rainfall deficits, rapid escalation of drought levels, and a delayed recovery despite episodic high rainfall.
- Modelled storage at all drought level locations is above respective Enhanced Monitoring and Operations (EMO) curves, but for the Pennines it is low at ~55% in February, and Haweswater storage starts the year at 85%.
- Rainfall across the region is below average for the first six months of the year, except for slightly above average rainfall in Welsh catchments in January (102% of S-LTA). The minimum rainfall of the event is just 7.2% of the S-LTA in Cumbrian catchments in February.
- These conditions drive steep declines in simulated reservoir storage, the Pennines levels prompt our drought response as they cross level 1 in March, triggering VURs. This is followed by Haweswater storage crossing level 2 at the beginning of April prompting a temporary use ban and subsequent drought permits through May and June.
- Cumulative deficits in rainfall persist as Haweswater enters level 3 in early July, briefly recovering late July before deteriorating again. A non-essential use ban is implemented in early August as storage continues to decline.
- By late September reservoir storages reach their minimum of 5.9% and 8.1% at Haweswater and the Pennines respectively. Modelled storage at the Dee exhibits a slower trajectory, crossing level 1 briefly in September. Without drought actions, modelling indicates it would cross level 2 in September, with extended recovery lag due to cumulative stress.
- A spell of above average rainfall in October kickstarts drought recovery, followed exceptional totals in November (260%–294% of S-LTA) across all catchments, driving rapid replenishment. The Pennines storage

recovers to 90% by early December. Haweswater climbs to ~80% by year-end, reaching full recovery by February the following year.

Results

Figure 16: Haweswater simulated storage alongside new drought levels and salient drought actions

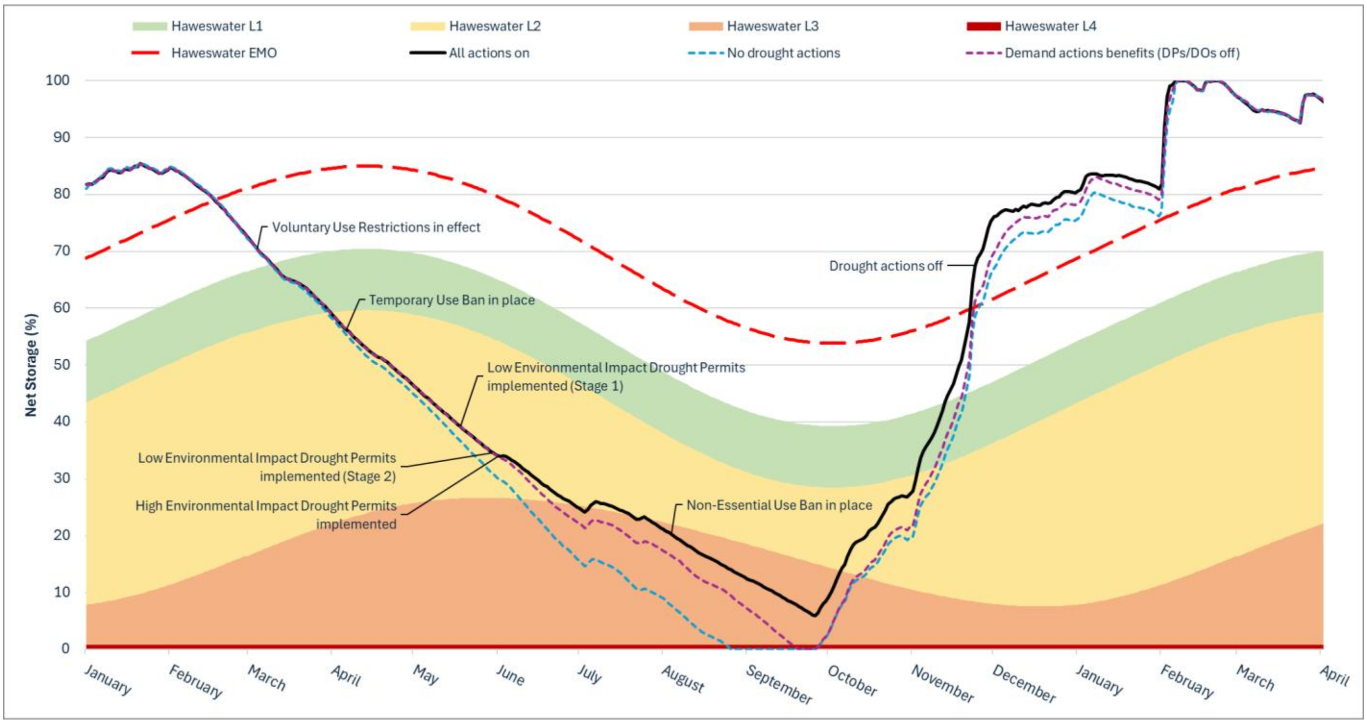


Figure 17: Dee simulated storage alongside new drought levels and salient drought actions

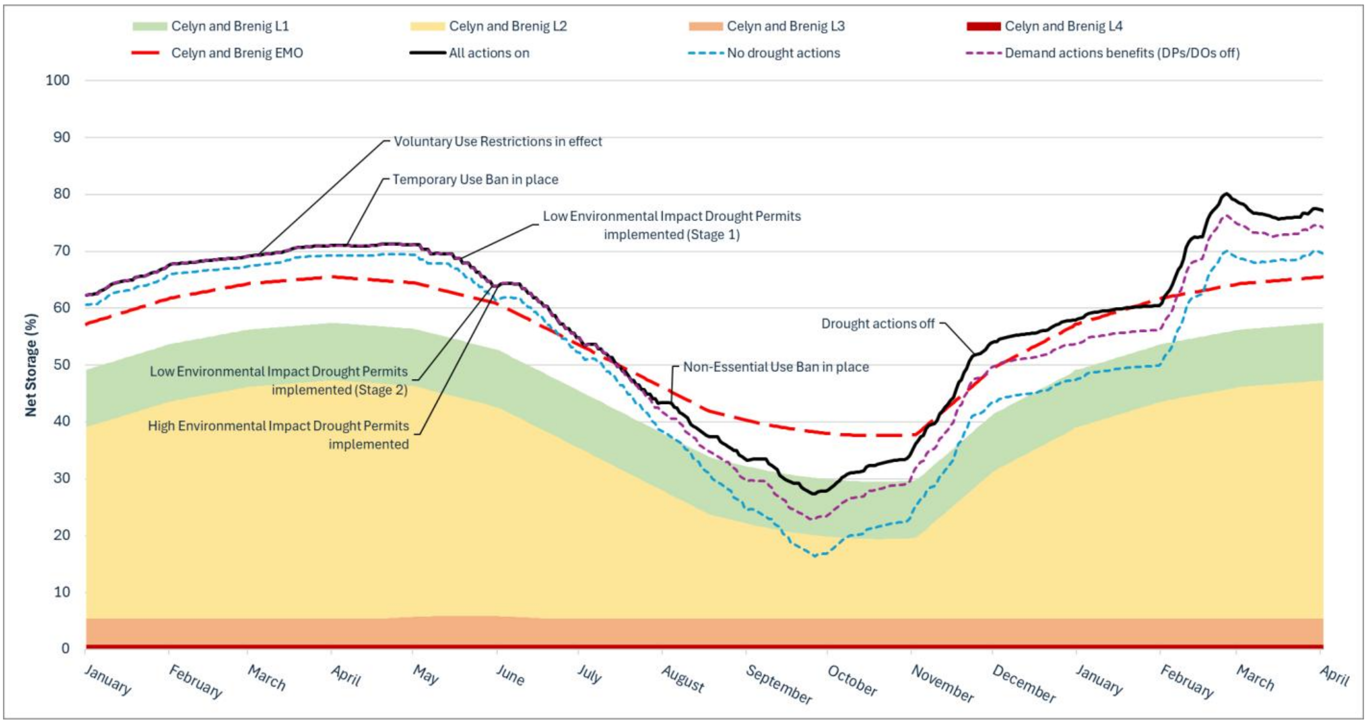


Figure 18: Pennines simulated storage alongside new drought levels and salient drought actions

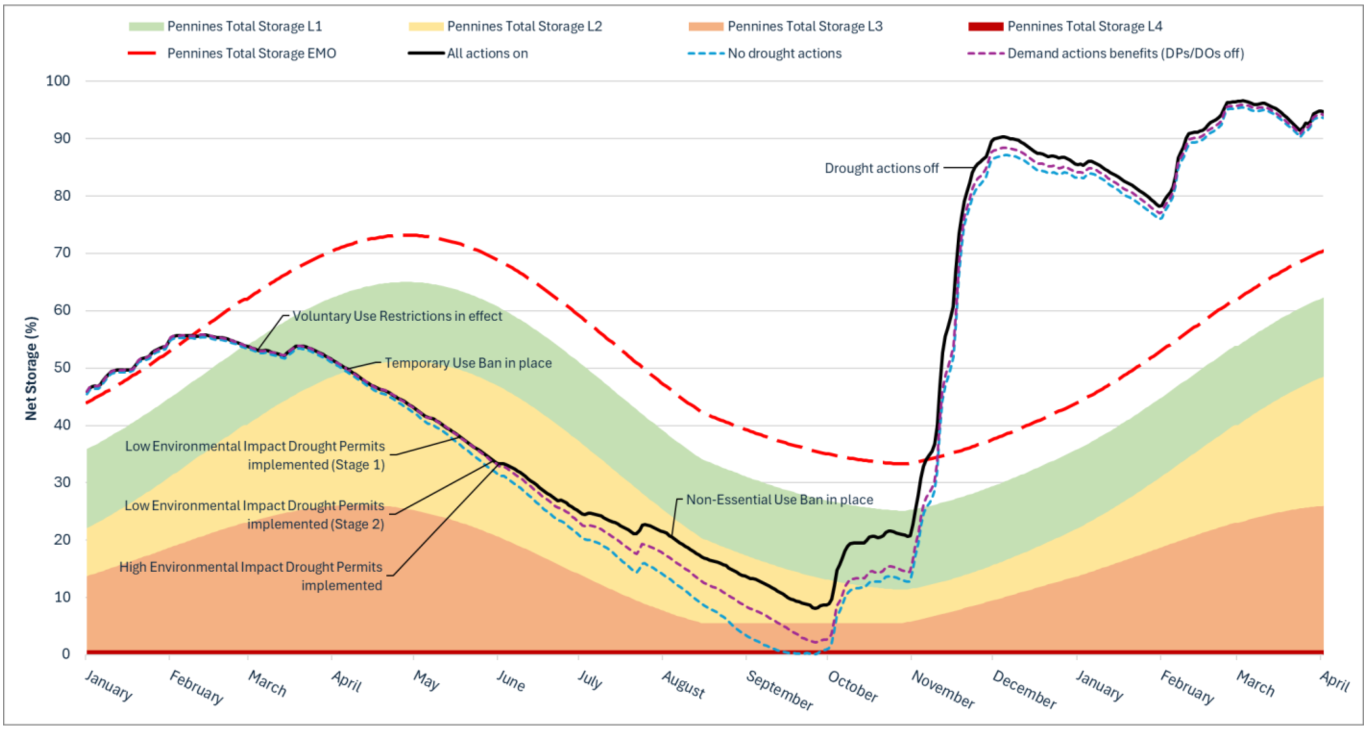


Figure 19: Simulated operational actions showing strategic pumping across the Strategic Resource Zone

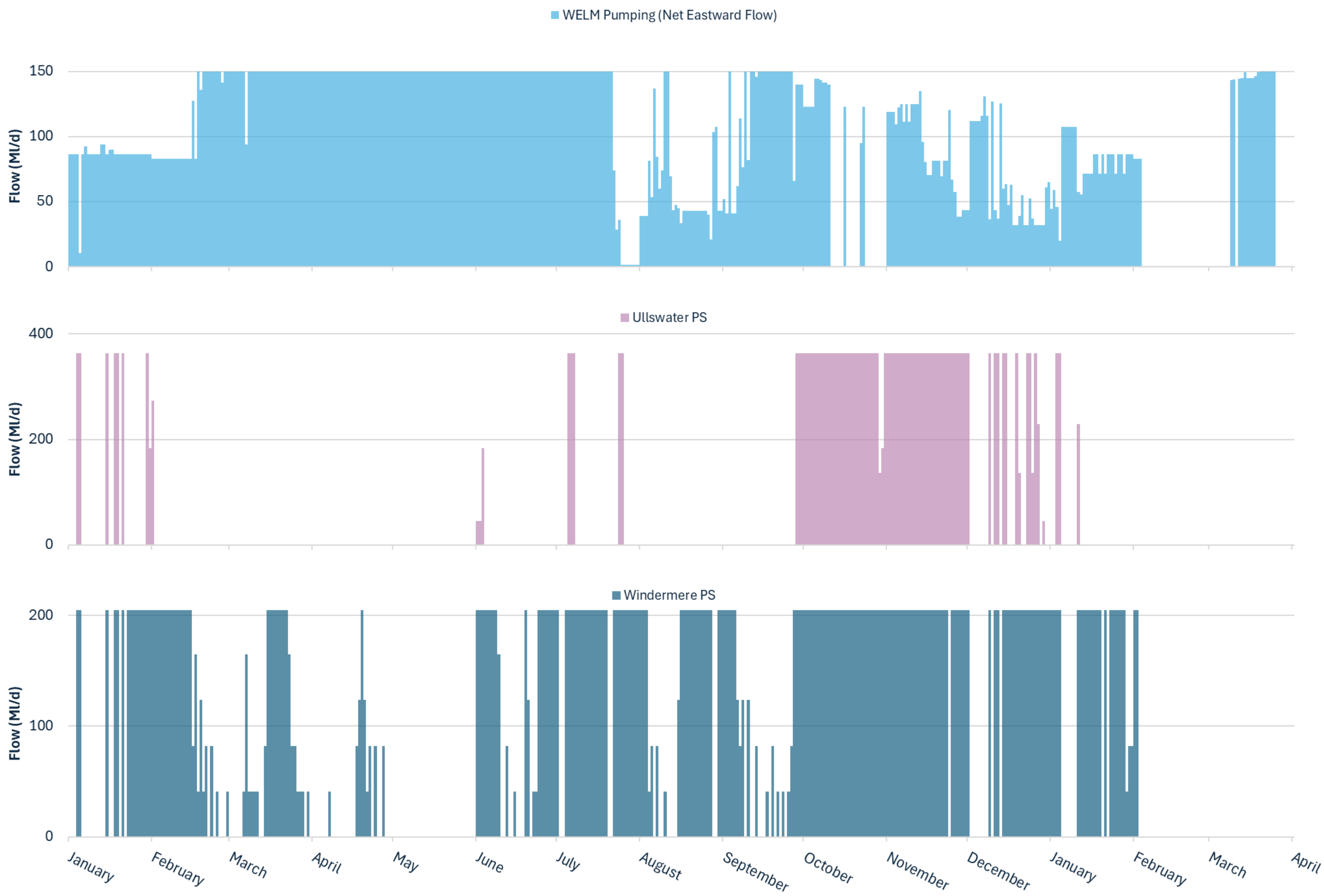
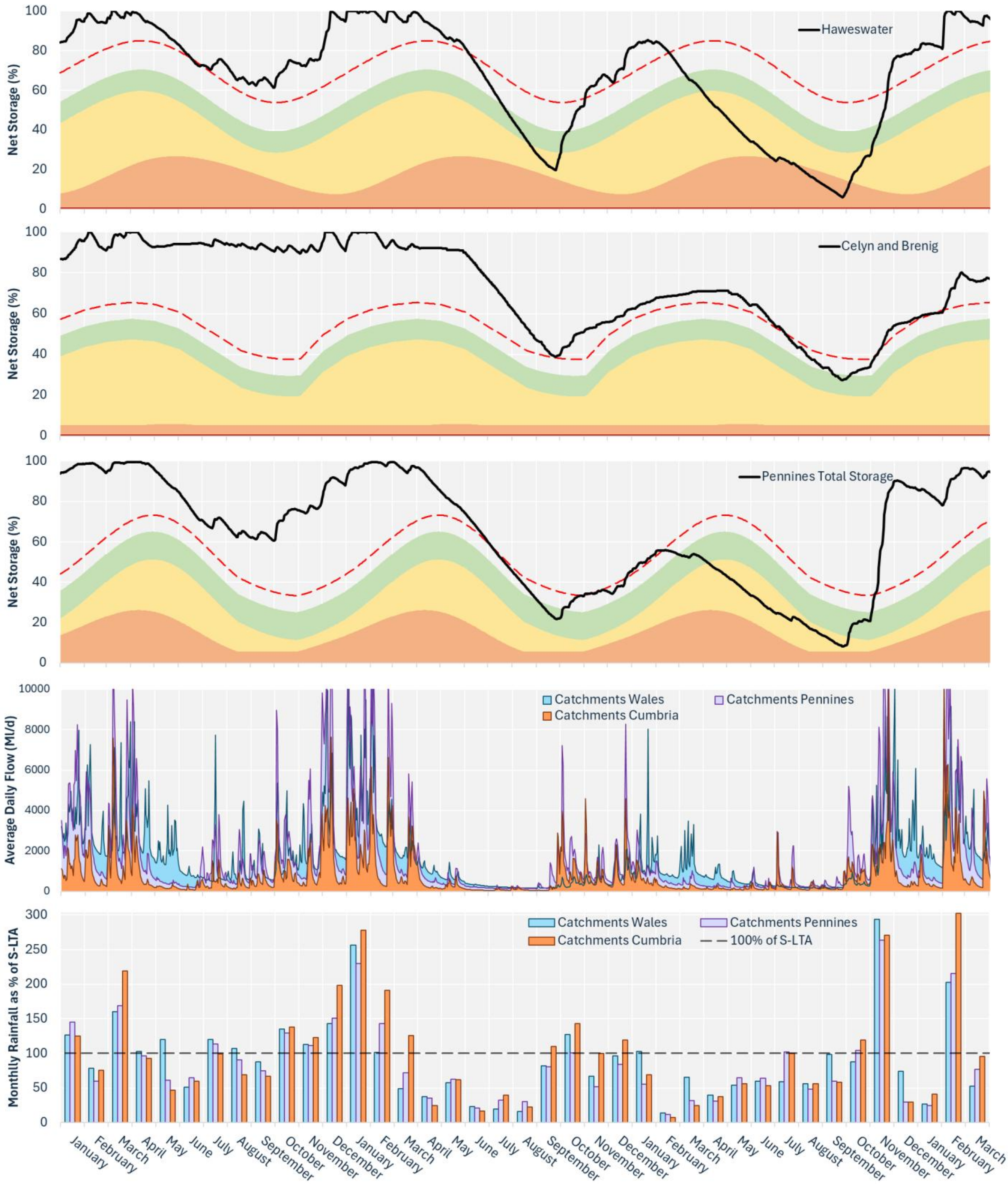


Figure 20: Drought characterisation of a 1 in 500 year single season stochastic event showing storage (net) across drought level locations as well as rainfall and flow aggregated into Cumbria, Wales, and Pennines catchments



Discussion

Figure 20 presents a detailed breakdown of a simulated stochastic drought event from our drought characterisation exercise, illustrating modelled reservoir storage, average daily flows, and monthly rainfall across designated drought level locations. The severity of this event corresponds to a calculated return period of 1 in 500 years, indicating a 0.2% annual probability of occurrence.

Simulation results confirm system resilience under these conditions, though they indicate the likely need for a temporary use ban, non-essential use ban, and the implementation of drought permits and orders. The event demonstrates how extreme early-season deficits (February to April) can impact the system, driving rapid escalation to level 2 and level 3 triggers within months. Despite this, the timings set out for our drought actions are maintained and are demonstrated to be effective; without them level 4 would be reached at both Haweswater and Pennines drought levels.

Short-lived wet spells in July are insufficient to cause storage recovery, which depends on exceptional late-autumn rainfall.

In this high severity event, the Pennines levels initiate our drought response, with Haweswater prompting the implementation of a temporary use ban. This underscores the need for early intervention and flexible application of drought actions relative to our various drought levels to mitigate severe drawdown.

4.4.5 High demand scenario

Rationale

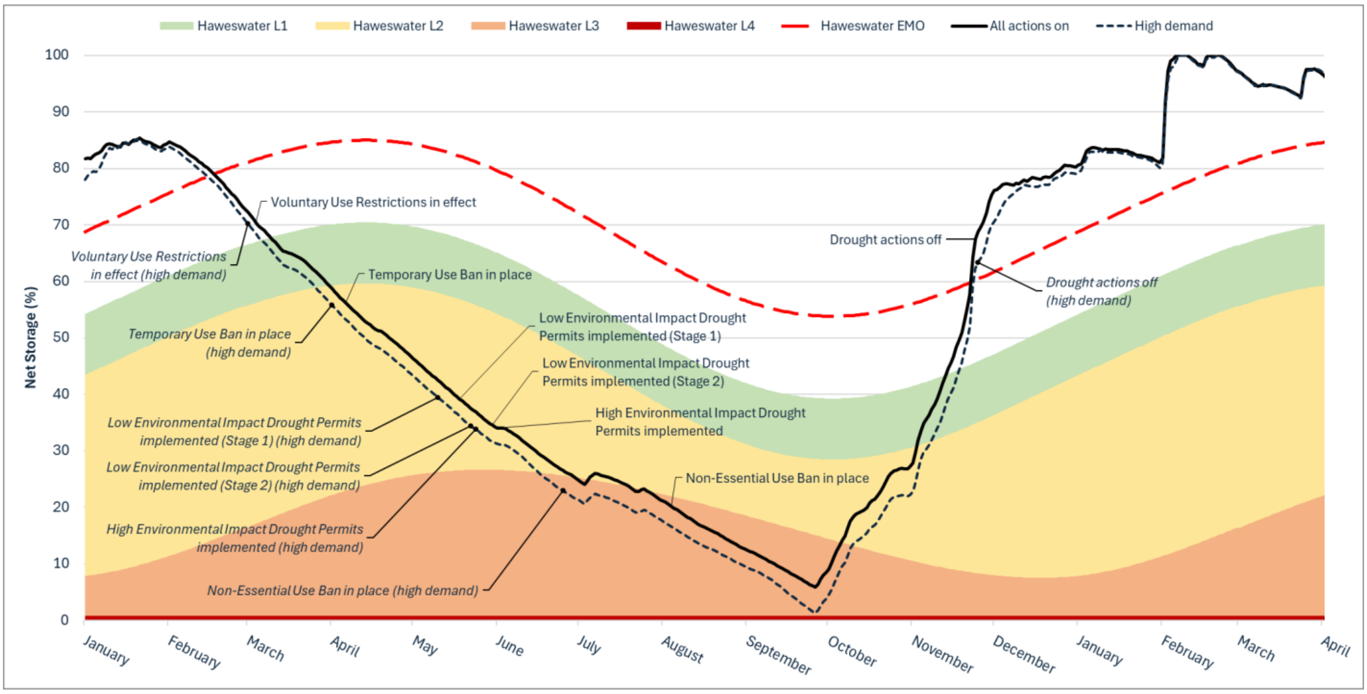
This is the same stochastic drought event with a 1 in 500 year return period that is included in section 4.4.4, modelled under a high demand scenario. Its inclusion ensures the drought plan is tested under combined stress from reduced supply and heightened consumption, which often coincides during severe droughts. Assessing this scenario helps confirm that triggers and mitigation measures are robust under worst-case demand conditions and aligns with regulatory guidance to consider extreme but credible events.

Event description

This event is described in detail in the previous section (4.4.4), with Figure 20 showing the event rainfall and flow aggregated into Cumbria, Wales, and Pennines catchments.

Results

Figure 21: Haweswater simulated storage alongside new drought levels and salient drought actions



Included in the graph above are the actions triggered in the high demand scenario, shown in italics, as well as the baseline 'All actions on' scenario. This demonstrates the difference in the timing of drought actions for the high demand scenario relative to the baseline scenario.

Figure 22: Dee simulated storage alongside new drought levels and salient drought actions

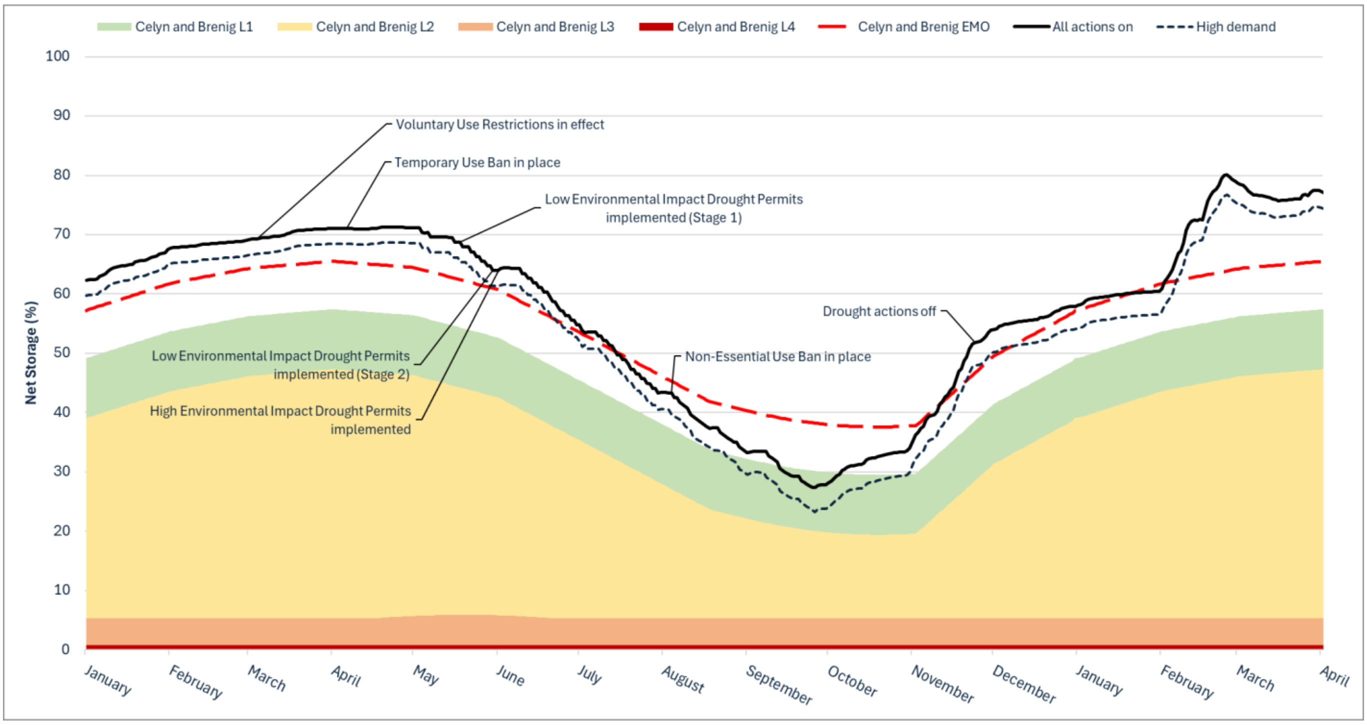
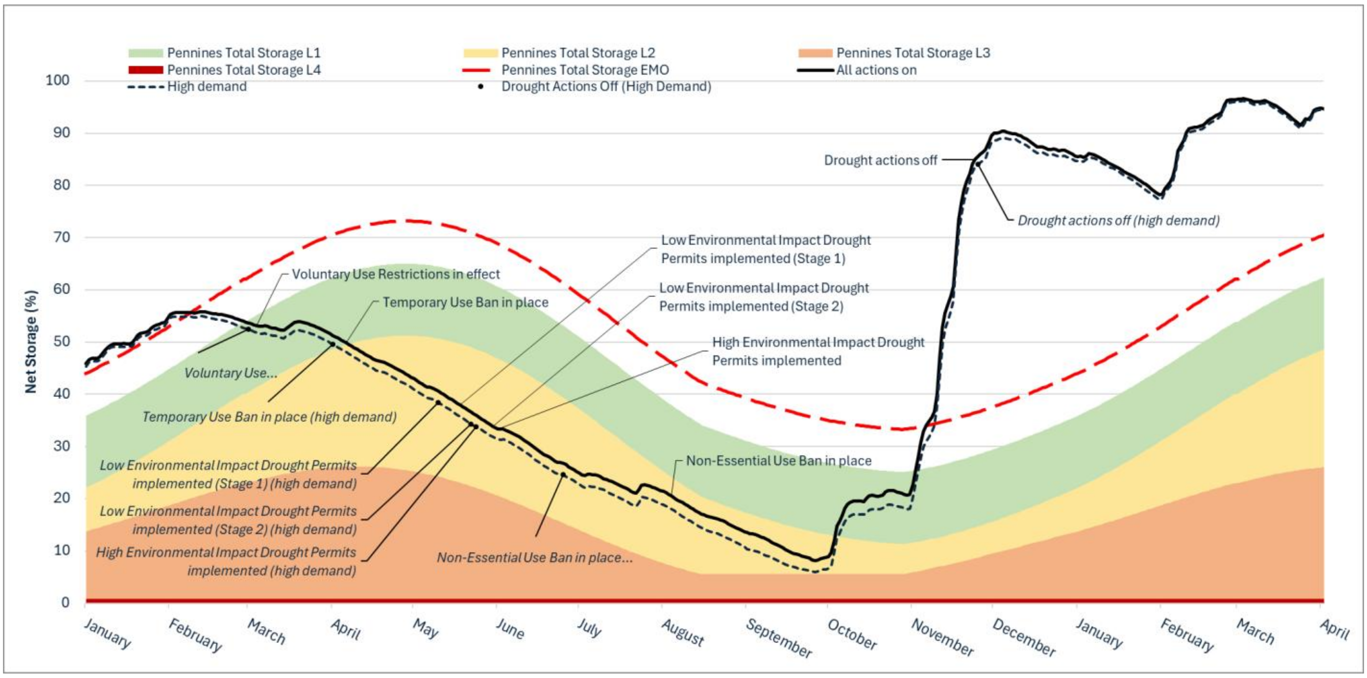


Figure 23: Pennines simulated storage alongside new drought levels and salient drought actions



Included in the graph above are the actions triggered in the high demand scenario, shown in italics, as well as the baseline 'All actions on' scenario. This demonstrates the difference in the timing of drought actions for the high demand scenario relative to the baseline scenario.

Discussion

For drought characterisation of this event refer to Figure 20, which illustrates the same event as shown in section 4.4.4. The impact of operating the system at elevated demand conditions is shown in the drought level storage graphs in Figure 21, Figure 22 and Figure 23. As expected, simulated system storage is consistently lower in the high demand scenario (dashed trend) compared to the general drought plan modelling demand. At Haweswater, minimum simulated storage is 4.6% lower than in the baseline demand scenario, reaching a critical minimum of 1.3%.

Similar to the baseline scenario discussed in Section 4.4.4, Pennine storage levels trigger drought response actions under high demand. All required timings between drought levels are maintained. There is a slight acceleration to initial drought actions under the high demand scenario, however it is notable that Haweswater enters level 3 significantly earlier, and the total duration of the non-essential use ban extends by 41 days, with implementation towards the end of June compared to August in the baseline scenario (see section 4.4.4).

The results presented here exclude interventions and potential benefits associated with activating an adaptive pathway for extreme drought measures. This next stage of drought activity during an extreme event is addressed in detail in section 5. In accordance with the Environment Agency's latest drought plan guidance, these measures have not been incorporated into prescriptive scenario modelling due to their inherently uncertain nature, and the aim to respond dynamically to real-time conditions rather than pre-defined assumptions.

4.4.6 End of drought plan period (2031) scenario

Rationale

This scenario reflects conditions at the end of the drought plan period and uses WRMP24 forecast components for 2031, including demand, outage allowance, and target headroom. Its inclusion ensures resilience is assessed against credible future conditions, accounting for projected changes in demand, operational risks, and uncertainty in supply-demand balance. Testing this scenario confirms that drought levels and actions remain effective throughout the plan horizon and demonstrates compliance with regulatory guidance to consider long-term risks and adaptive pathways.

Event description

This is the same 1 in 500 year drought event as described in detail in the earlier section (4.4.4) and used in the high demand scenario (Section 4.4.5). Figure 20 shows the event rainfall and flow aggregated into Cumbria, Wales, and Pennines catchments.

Results

Figure 24: Haweswater simulated storage alongside new drought levels and salient drought actions

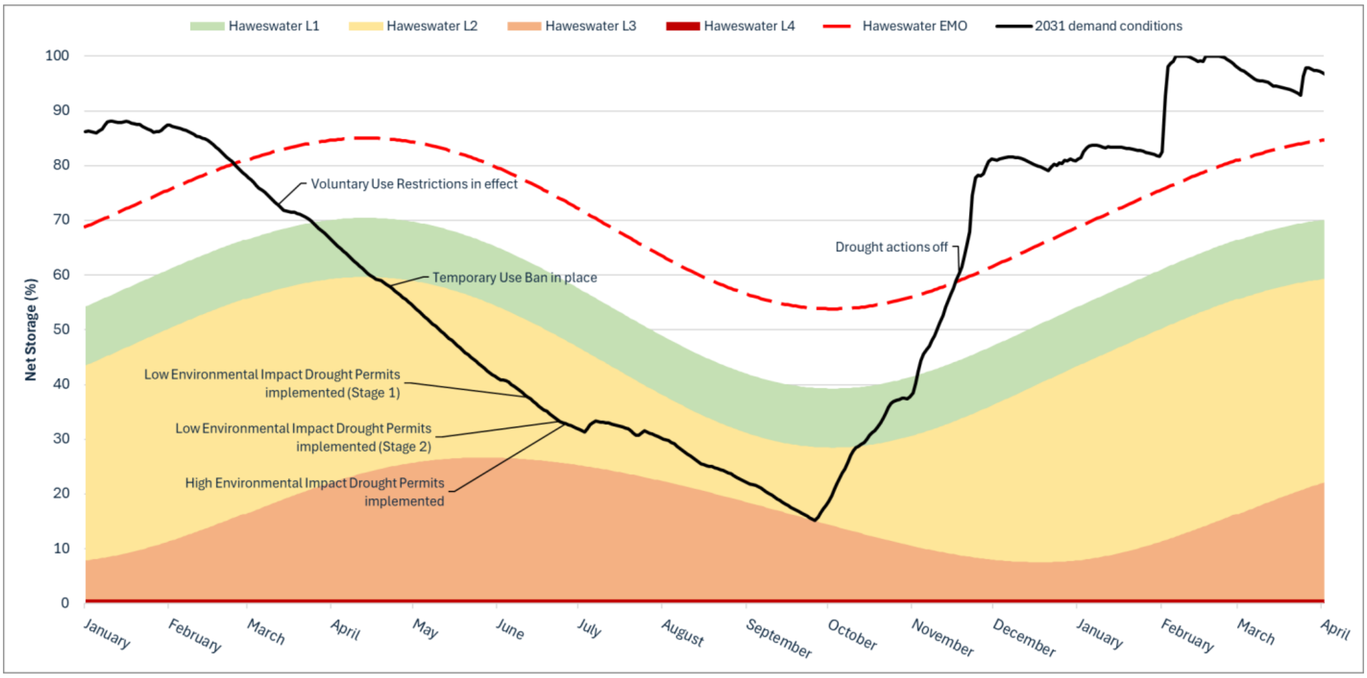


Figure 25: Dee simulated storage alongside new drought levels and salient drought actions

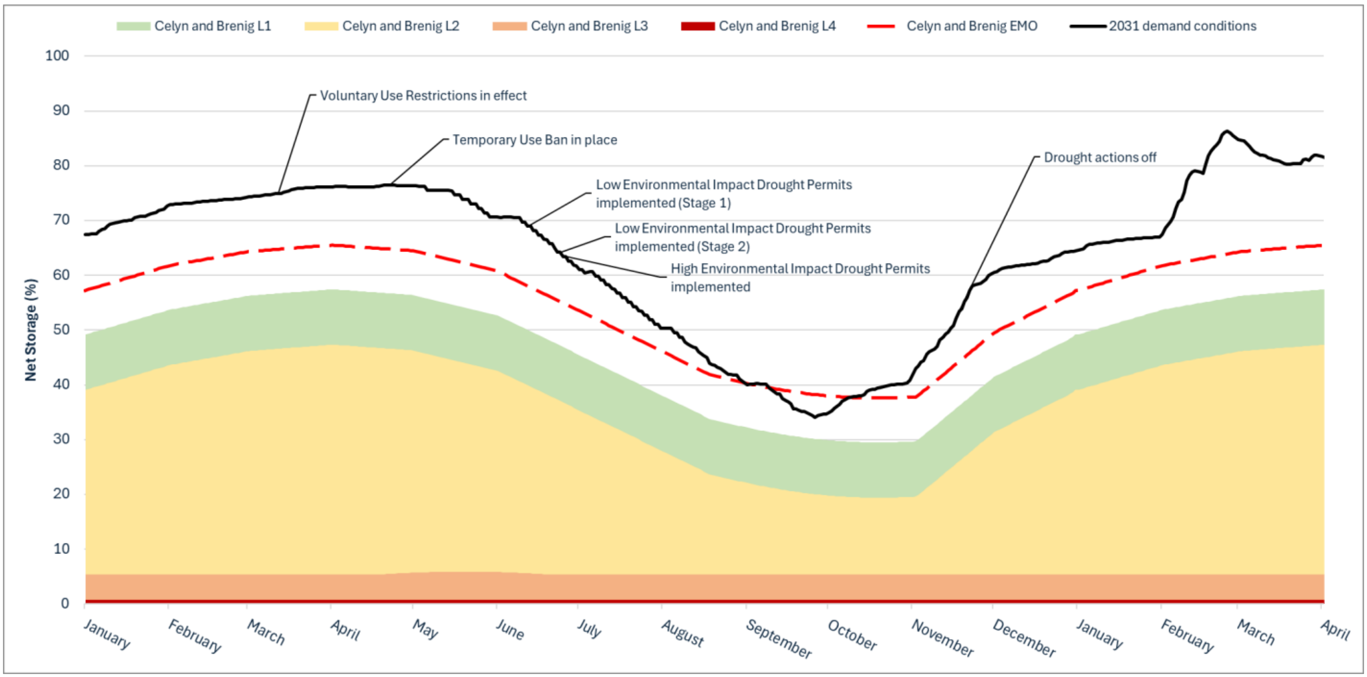
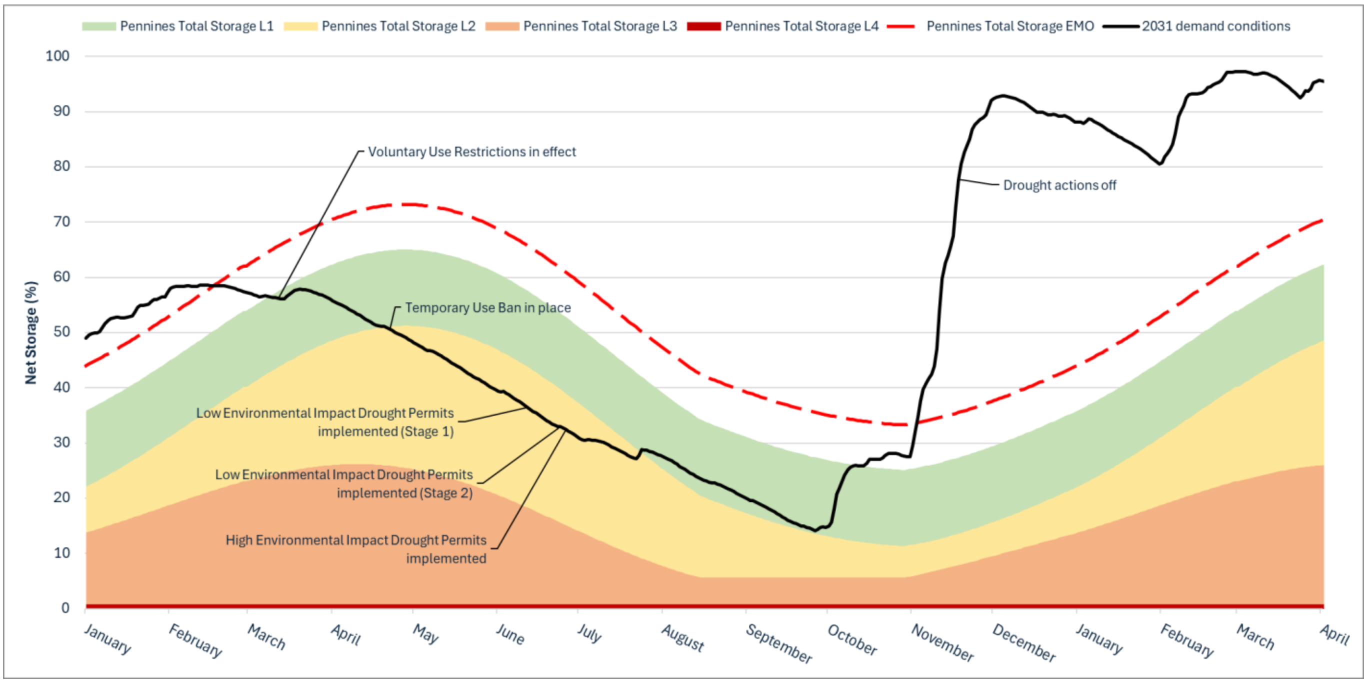


Figure 26: Pennines simulated storage alongside new drought levels and salient drought actions



Discussion

For drought characterisation of this event refer to Figure 20; this illustrates the same event as shown in section 4.4.4. Similar to the baseline scenario discussed in Section 4.4.4, Pennine storage levels trigger drought response actions under 2031 conditions. All required timings between drought levels are maintained; however, due to lower levels of forecast demand this simulated system response is less severe and does not cross into level 3 as in shown in the earlier example of this 1 in 500 year event. Haweswater minimum storage reaches 15.2% compared to 5.9% in the baseline 1 in 500 year event.

In this scenario temporary use bans and drought permits and orders are implemented, triggered by Haweswater, however a non-essential use ban would not be required as in the baseline and high demand scenarios. Climate change has been accounted for by adjusting the model inflows to reflect a 2031 position; despite this and with a lower overall demand due to the demand management actions selected as part of WRMP24, the system responds to this event more favourably than in the baseline or high demand scenarios. This demonstrates that with our new drought plan the system is able to cope under future conditions even during severe drought events.

4.5 Carlisle Resource Zone

As this resource zone is less complex relative to the Strategic Resource Zone; all modelled scenarios are presented on the same graph. The modelling shows that the Carlisle system is highly resilient to drought. Drought actions for this zone comprise demand management actions and restrictions; there are no drought permits or orders; the only supply-side option is the use of dead water at Castle Carrock. Simulation of the model does not trigger the implementation of drought actions; therefore, there is no distinction between scenarios for no drought actions, all drought actions, and demand actions benefit only. For this reason, it has been possible to display the high demand scenario on the same graph as the all drought actions results; unlike the Strategic Resource Zone where this scenario is presented in a separate section (section 4.4.5).

4.5.1 1976 historical event

Rationale

This scenario represents the most severe historical drought event on record for the Carlisle Resource Zone, based on the minimum storage level reached in Castle Carrock Reservoir.

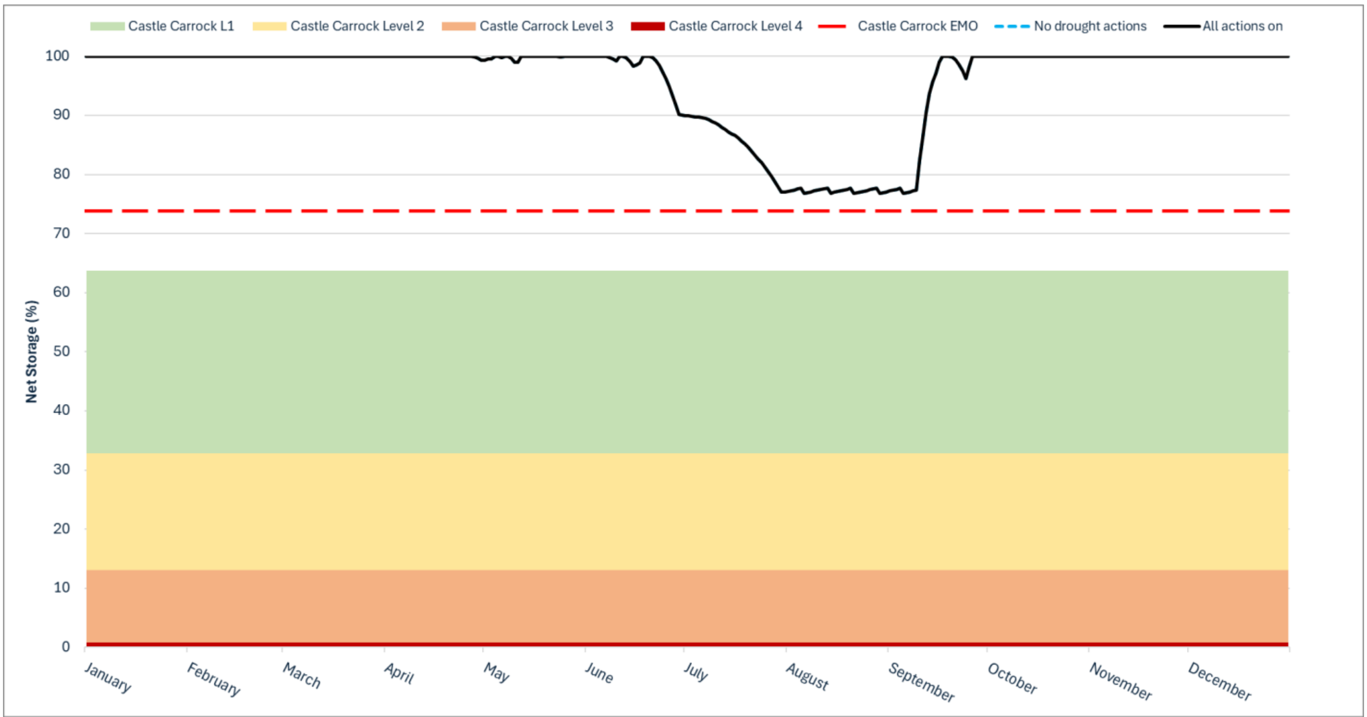
Event description

The scenario assumes a repeat of the climatic and hydrological conditions experienced in 1976, which remains a benchmark drought for the region. Key characteristics include:

- A single-season drought event.
- No drought orders or permits were historically applied for in the Carlisle Resource Zone during 1976.
- Rainfall at Burnbanks rain gauge (Haweswater) for the three-month period to August 1976 was 126 mm, approximately 43% of the long-term average for June to August.
- Ranked against an 86-year series (1932–2018) of June to August rainfall totals, this period was the third driest on record.

Results

Figure 27: Castle Carrock simulated storage alongside new drought levels and salient drought actions



Discussion

Modelling indicates that a repeat of the 1976 climatic conditions would result in a minimum storage of approximately 77% at Castle Carrock Reservoir, demonstrating a high level of resilience within the Carlisle Resource Zone under simulated operation. The main drawdown occurs when storage falls below 90% around late June 1976 across all scenarios. Eden pumps operate from late July through to early September, supporting recovery, with storage returning to full by mid-September 1976.

Sensitivity testing shows that a significant increase in zonal demand (a 17% increase to 35 Ml/d) would be required to reduce minimum storage below 50% (net storage), highlighting the robustness of the system even under elevated demand conditions.

As no drought actions are implemented during this modelled scenario the only trend visible is the 'All drought actions' scenario.

4.5.2 1 in 200 year stochastic event (one-season)

Rationale

Drought scenario modelling indicates that the Carlisle Resource Zone is highly resilient to drought; however, in the rare event that a severe drought occurs, modelling suggests it would likely be a short, single-season event. This scenario represents a stochastic drought with an estimated 1 in 200 year return period. This corresponds to our current minimum level of service, where the implementation of emergency drought orders is expected no more frequently than once in 200 years on average.

From 2039 onwards, following planned leakage reduction and demand management measures, this minimum level of service will improve further, with emergency drought orders anticipated only under events with a return period of 1 in 500 years. While outside of the timescales for our Drought Plan 2027, this progression reflects our long-term strategy to enhance system resilience and customer service standards.

Event description

- This drought scenario represents a stochastic, single season drought with an estimated 1 in 200 year return period, based on the system response within the Carlisle Resource Zone.
- The event is characterised by rainfall remaining below the S-LTA from March to October, with notably low rainfall in April impacting on the simulated storage at Castle Carrock.
- Under modelled conditions a minimum storage level of approximately 63% is reached at Castle Carrock reservoir, regardless of whether demand management actions are active. Storage only briefly touches level 1 in November and does not remain below this threshold, meaning a temporary use ban would not be triggered.
- In the high demand scenario, minimum storage reduces by a further 4%, reaching around 59% net storage at Castle Carrock. While the high demand scenario crosses into drought level 1 this is for insufficient time to trigger the implementation of a temporary use ban before reservoir storage begins to recover.
- Eden pumping operates for an extended period between June and November across all scenarios, supporting system resilience and recovery.
- A return to above S-LTA rainfall in November prompts the refill of reservoir storage, which recovers above EMO in mid-November and returns to 100% in December.

Results

Figure 28: Castle Carrock simulated storage alongside new drought levels and salient drought actions

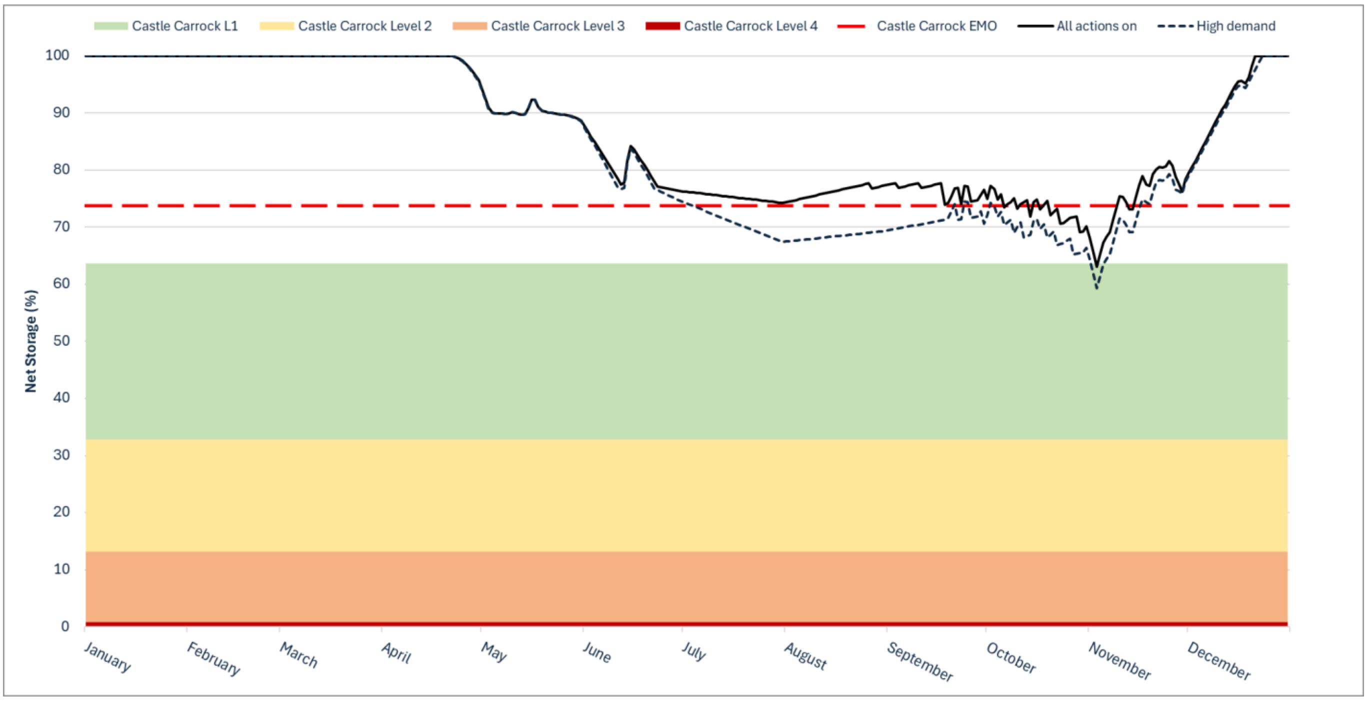
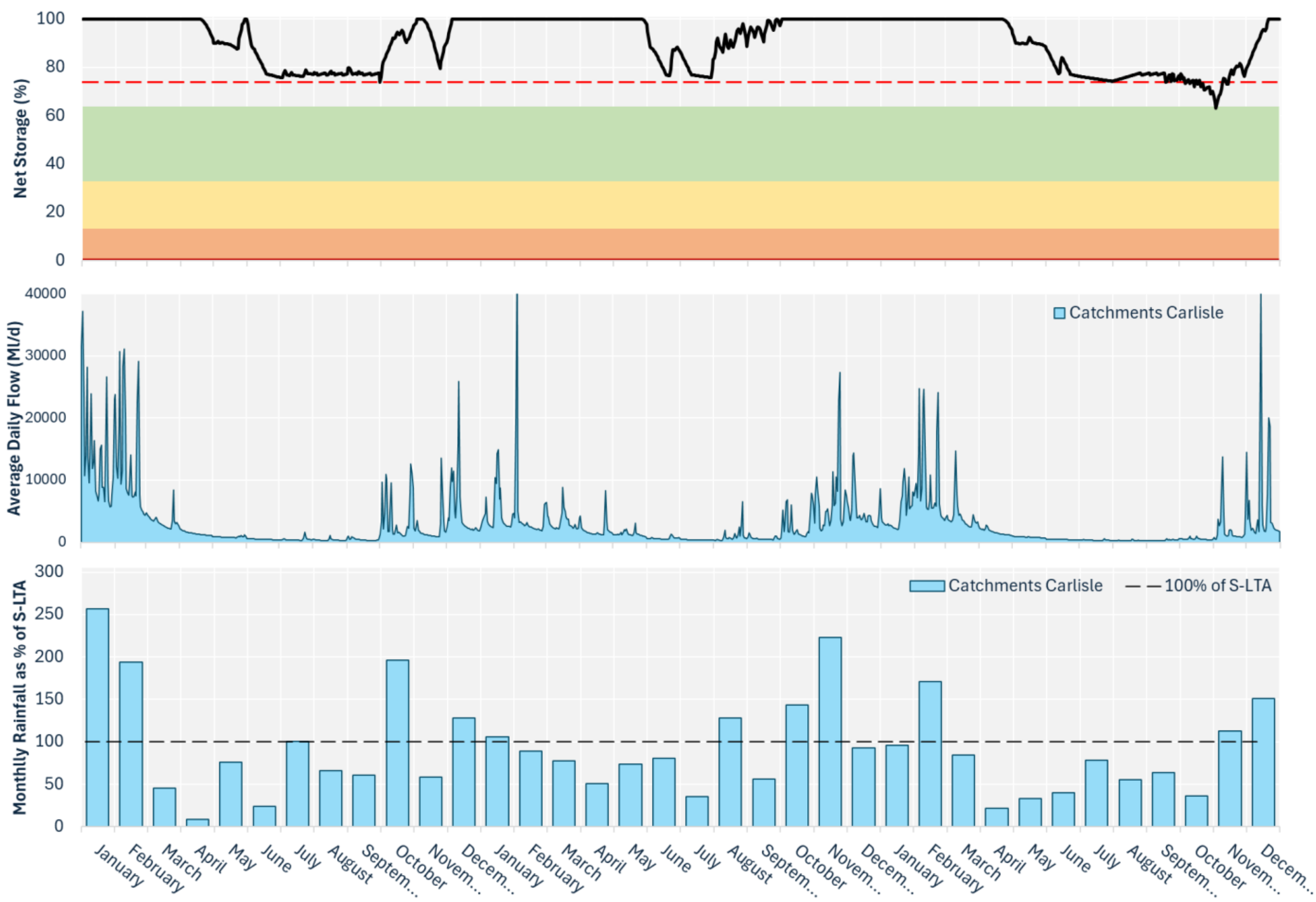


Figure 29: Drought characterisation of a 1 in 200 year single season stochastic event showing Castle Carrock storage (net) as well as rainfall and flow in the Carlisle catchments



Discussion

Figure 29 presents a detailed breakdown of a simulated stochastic drought event from our drought characterisation exercise, illustrating modelled reservoir storage, average daily flows, and monthly rainfall. The modelling again shows that Carlisle Resource Zone is very resilient to drought and insensitive to changes in demand as shown in the high demand scenario. Storage levels are drawn down to 63% and only slightly further reduce under the high demand scenario to 59%. The Eden pumps are active slightly later than in the 1 in 500 year event scenarios, with pump operation starting in June and remaining active until November when storage is recovering. Further discussion of the 1 in 500 year event used for scenario testing is included in section 4.5.3.

4.5.3 1 in 500 year stochastic event (one-season)

Rationale

The selection of a drought event with a return period of 1 in 500 years aligns with the resilience standard from the year 2039 onwards, as set out in our WRMP24. While outside the timescales for our Drought Plan 2027, this progression reflects our long-term strategy to enhance system resilience and customer service standards.

Event description

- This scenario represents a stochastic drought with an indicative 1 in 500 year return period, derived from system response across the Carlisle Resource Zone. The event is characterised by extreme early-season rainfall deficits, rapid escalation of drought triggers, and a delayed recovery despite episodic high rainfall.
- Castle Carrock starts the year at 100% net storage and maintains this through February despite below S-LTA rainfall. From April to October rainfall across the resource zone is below the S-LTA, with spells of near or above S-LTA in June and August.
- These conditions drive simulated reservoir storage to decline in April; then hold steady throughout the summer. Under the high demand scenario, storage dips below EMO at times during the summer months.
- Rainfall falls significantly below S-LTA again in September and October; reaching 47.7% and 12.6% of S-LTA respectively. In all scenarios this causes further decline of reservoir storage to level 1 in November. Storage levels are drawn down to 58% and only slightly further reduced under the high demand scenario to 52%. While level 1 is crossed in November, a temporary use ban is unlikely to be triggered because of the time of year.
- Eden pumping is active for a substantial period between May and November across all scenarios, supporting system resilience and recovery.

Results

Figure 30: Castle Carrock simulated storage alongside new drought levels and salient drought actions

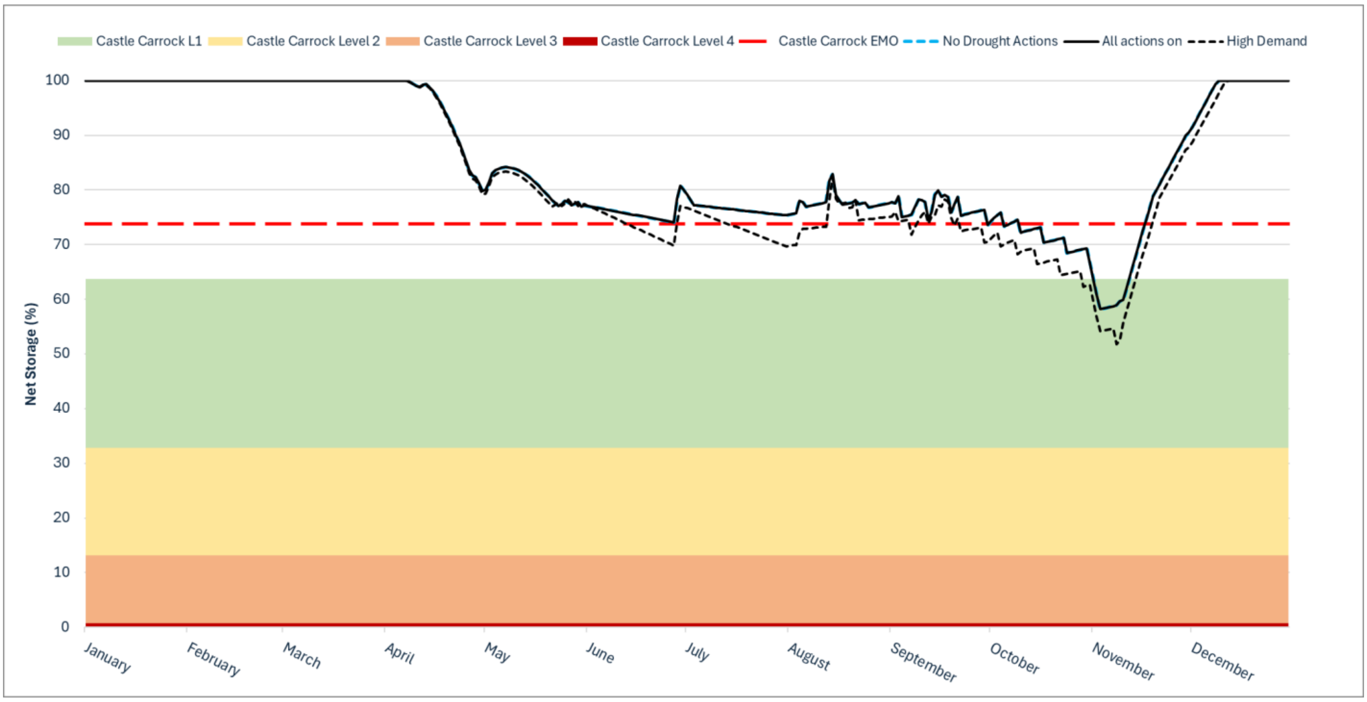
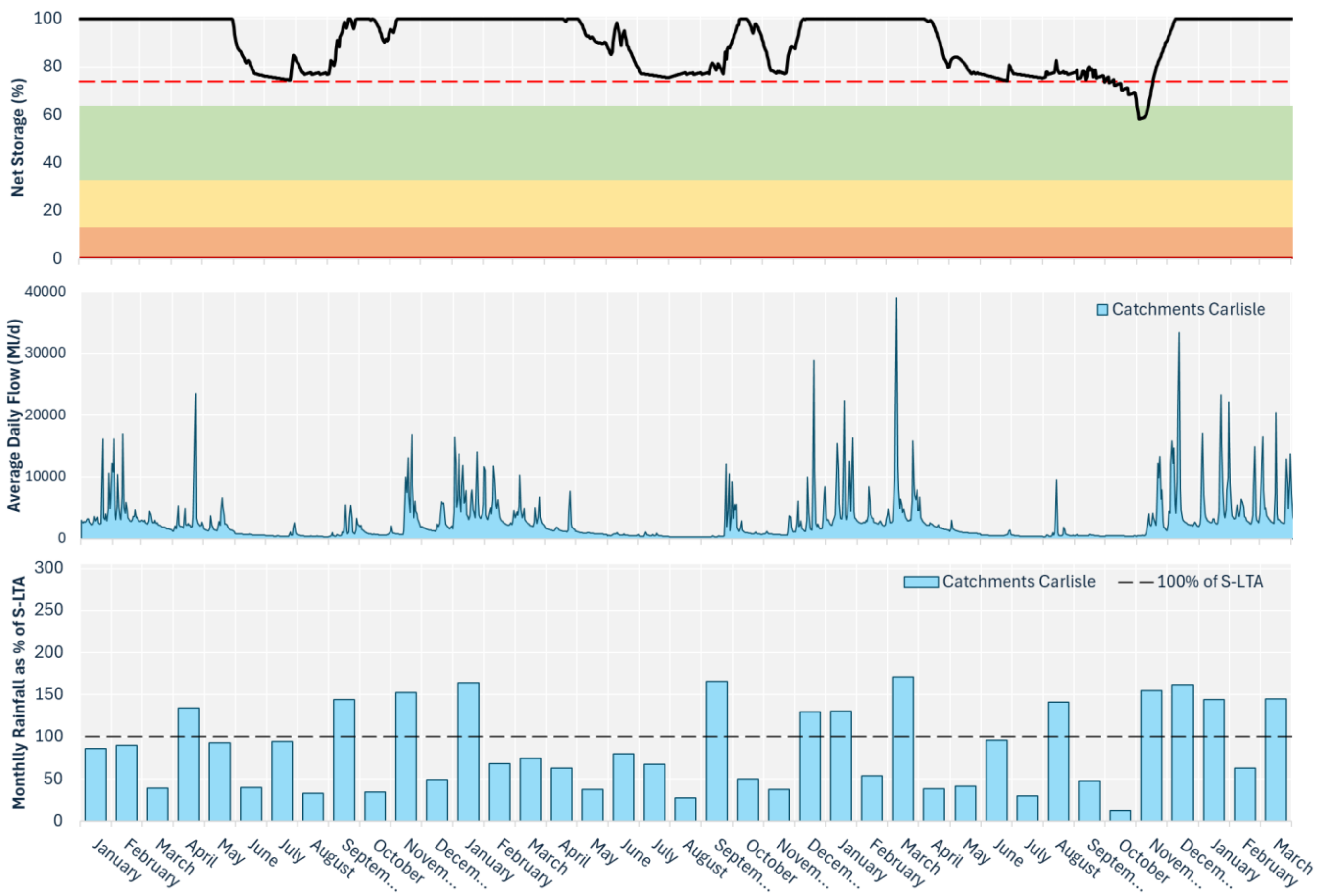


Figure 31: Drought characterisation of a 1 in 500 year single season stochastic event showing Castle Carrock storage (net) as well as rainfall and flow in the Carlisle catchments



Discussion

Figure 29 presents a detailed breakdown of a simulated stochastic drought event from our drought characterisation exercise, illustrating modelled reservoir storage, average daily flows, and monthly rainfall. Modelling indicates that the Carlisle Resource Zone remains highly resilient even under this extreme 1 in 500 year event. Storage levels decline steadily from April and reach a minimum of 58% under baseline conditions; the high demand scenario reduces this slightly further to 52%. While level 1 is crossed in November, the timing means a temporary use ban would be unlikely to be implemented.

Eden pumping operates for an extended period between May and November, supporting system performance and recovery despite prolonged rainfall deficits. The system demonstrates limited sensitivity to demand variations and maintains robust operation throughout the event. This confirms that Carlisle can cope with exceptionally severe drought conditions, reinforcing its resilience under rare and extreme scenarios.

4.5.4 End of drought plan period scenario

Rationale

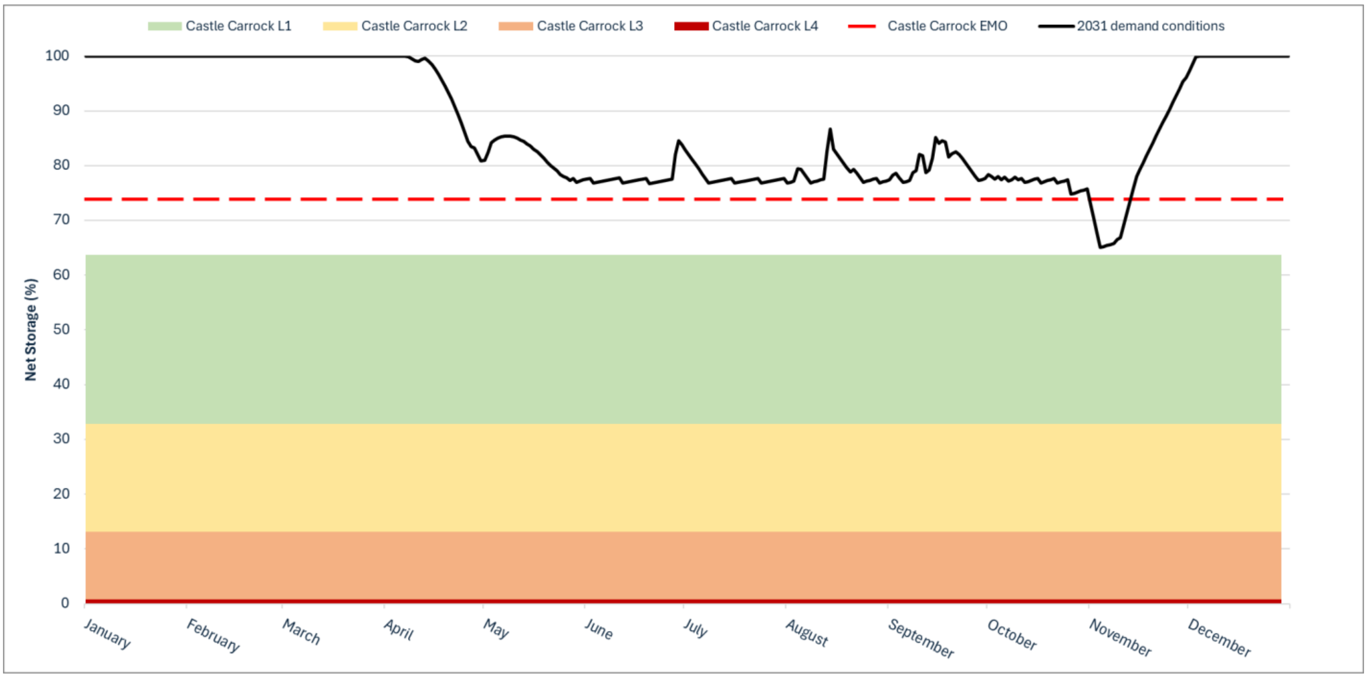
This scenario reflects conditions at the end of the drought plan period and uses WRMP24 forecast components for 2031, including distribution input, outage allowance, and target headroom. Its inclusion ensures resilience is assessed against credible future conditions, accounting for projected changes in demand, operational risks, and uncertainty in supply-demand balance. Testing this scenario confirms that drought triggers and actions remain effective throughout the plan horizon and demonstrates compliance with regulatory guidance to consider long-term risks and adaptive pathways.

Event description

This is the same 1 in 500 year drought event as described in detail in the earlier section (4.5.3). Figure 31 shows the event reservoir storage (net) as well as rainfall and flow in the Carlisle catchments.

Results

Figure 32: Castle Carrock simulated storage alongside new drought levels and salient drought actions



Discussion

For drought characterisation of this event refer to Figure 31; this illustrates the same event as shown in section 4.5.3 and overall the drought response in this scenario is very similar to the 1 in 500 year event shown earlier. Castle Carrock reaches a minimum storage of 65%, compared to 58% in the baseline scenario.

Climate change has been accounted for by adjusting the model inflows to reflect a 2031 position; despite this and with a lower overall demand due to the demand management actions selected as part of WRMP24, the system responds to this event more favourably than in the baseline or high demand scenarios. This demonstrates that with our new Drought Plan the system is able to cope under future conditions even during severe drought events.

5. Adaptive pathways

Drought plans are inherently adaptive, with progressively more severe measures implemented as conditions worsen. For this plan we have introduced adaptive pathways to help manage a severe drought. They are focused on our extreme drought measures as they are more uncertain and specific to conditions. This will help plan for the risk of extreme drought measures not being available on time or not delivering the required reduction in demand or increase in water supply. Due to the inherent uncertainty in both weather patterns and how drought conditions evolve, a single, fixed plan for managing drought is insufficient. Instead, we will adopt a flexible, adaptive approach for extreme drought measures.

Extreme drought measures, also termed level 3b extreme actions in the Environment Agency's water company drought plan guideline, are a range of extreme drought actions that we can use to delay or avoid level 4 restrictions. They are grouped into three tiers of actions (Tier 1-3), based on their risk, complexity, cost and resource requirements (see 'Extreme drought measures' technical report). Adaptive pathways for extreme drought measures are based on a tiered approach, involving activating extreme drought measures in different sequences or combinations depending on how drought conditions develop. The adaptive pathways are designed to balance the risks of acting too early, such as disproportionate costs, against the consequences of delaying a response, allowing for timely escalation only when necessary. Our adaptive planning framework is built around three key phases - preparation, mobilisation, and implementation based on the estimated lead-in times required for each action. This phased approach ensures that interventions are initiated at the optimal time to maximise the potential benefits. It also helps identify specific actions that require significant preparatory work ahead of implementation, for example drought orders.

This tiered system and phased approach allows us to respond proportionately to changing levels of risk, moving quickly, when necessary, while avoiding premature or unnecessary interventions. By keeping multiple options under consideration, we can progress several in parallel where appropriate. For example, we may need to prepare Tier 2 actions while simultaneously mobilising and implementing Tier 1 actions. This maintains operational readiness and ensures we remain agile and capable of responding effectively as the situation evolves.

5.1 Triggers for adaptive pathways

Several factors influence when extreme drought measures may need to be triggered, including:

- Tier 1 actions either unfeasible or showing small benefits when implemented
- Reservoir storage levels
- Rainfall and temperature forecasts
- Demand patterns
- Predicted number of days before drought level 4
- Environmental impact assessments
- Regulatory requirements and permits
- Public and stakeholder engagement

As a drought intensifies, we will initiate our Tier 1 (T1) actions as the first step. These measures offer relatively lower cost, lower risk interventions that are expected to deliver early benefits. Weather, demand, and the performance of early actions can vary; therefore, the adaptive pathways provide flexibility to move between response routes based on real-time conditions. We will monitor key drought indicators, such as reservoir storage, rainfall and temperature forecasts, demand trends, and projected days to reach drought level 4 to determine when to trigger the appropriate tiered actions.

If early actions deliver limited benefit or become unfeasible, the plan will shift to implementing Tier 2 (T2) measures that may involve relatively higher costs or operational challenges but provide essential resilience. Should drought conditions continue to deteriorate, or the expected benefits not materialise, we will then consider Tier 3 (T3) actions which are typically the most complex, resource-intensive, or carry greater environmental and social trade-offs. These actions are only implemented when justified by the increasing likelihood of reaching drought level 4.

Continuous monitoring of weather, hydrology, groundwater levels, and customer demand informs dynamic adjustments to the sequencing, timing, and scope of deployed measures, ensuring efficient use of resources and minimising environmental and social impacts.

Forecasts of rainfall and temperature underpin several of these factors. The 30-day water resources outlook, informed by meteorological and hydrological models, is a key input for drought monitoring. Extended rainfall deficits, declining reservoir storage, and reduced river flows increase the likelihood of activating complex supply-side interventions. For example, when forecasts indicate continued dry conditions with limited rainfall recovery, measures such as inter-catchment transfers or drought orders become more justifiable. Conversely, if forecasts show improving rainfall and wetter conditions, a cautious, staged mobilisation approach helps avoid unnecessary expenditure and operational and environmental risks.

Regular review points, aligned with operational monitoring and updated hydrological data, will assess whether alternative pathways should be triggered. If an option is unviable, lower-priority actions can be fast-tracked using these triggers. Daily monitoring of drought indices (e.g., Standardised Precipitation Index, soil moisture deficits), reservoir levels, river flows, and groundwater status will support these decisions, enabling interventions to be progressed, paused, or withdrawn based on the evolving situation.

We will work closely with the Environment Agency and other regulatory bodies throughout the process to ensure that all necessary permits, pre-authorisations, and thresholds for interventions (such as drought orders) are agreed in advance, enabling faster implementation when required.

It is important to note that level 3 extreme actions are designed to reduce the need for level 4 actions by slowing the rate of reservoir storage decline. While extreme measures can significantly reduce demand, their impact has limits. These measures can only slow the rate of consumption to a certain extent, as they cannot fully offset the effects of prolonged drought. Ultimately, recovery depends on favourable weather conditions, particularly rainfall and temperature, which influence both water availability and demand. In summary, the implementation of extreme measures aims to delay or prevent reaching dead water levels or the need for level 4 actions, providing vital time for rainfall to restore storage levels and stabilise supplies.

In addition, the extreme measures benefits are not modelled outputs, as the benefits are uncertain, therefore the adaptive pathway diagram is based on a simulation to highlight how extreme measures could follow an adaptive pathway (see Figure 34).

Figure 33: Process flow diagram of adaptive pathway approach

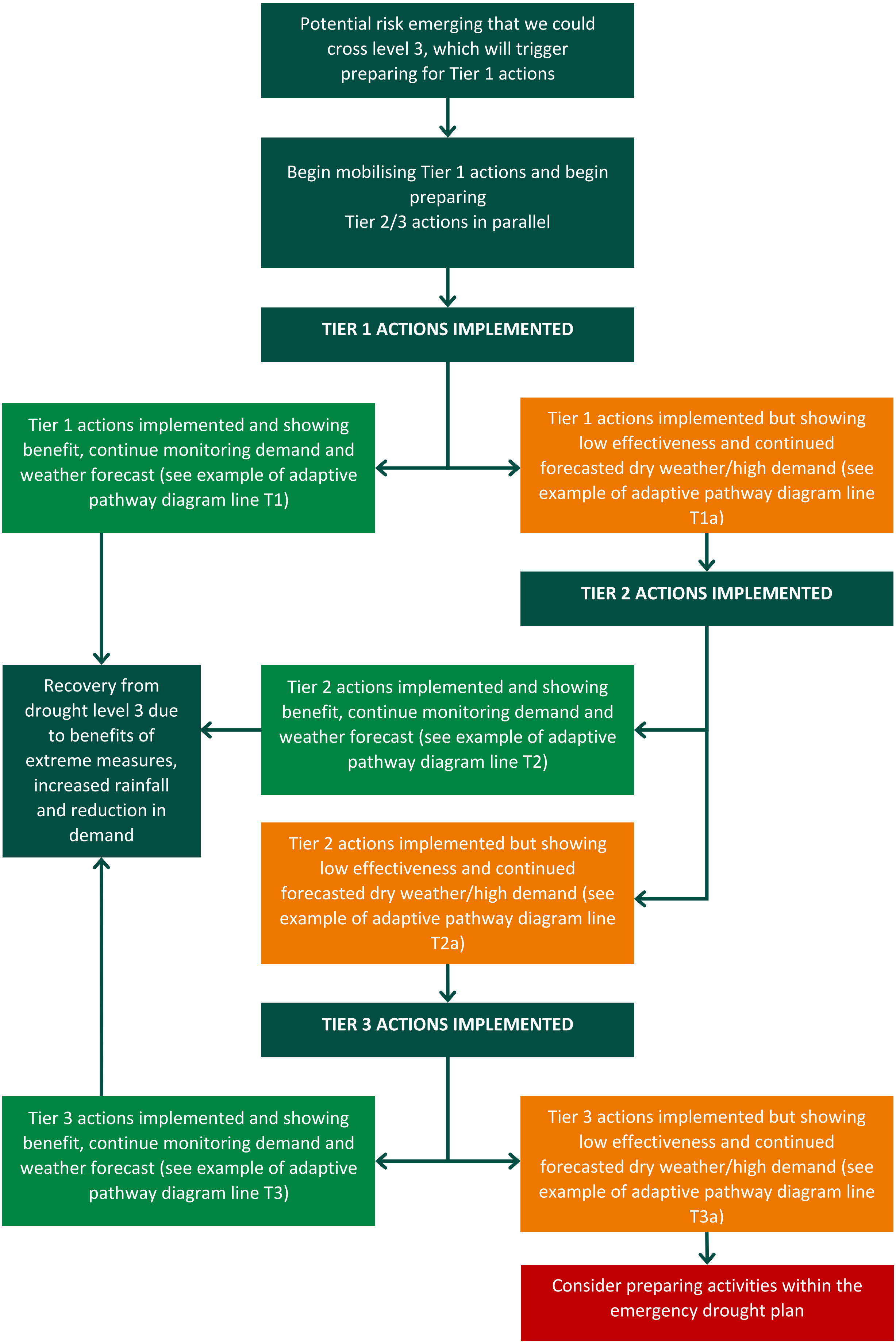
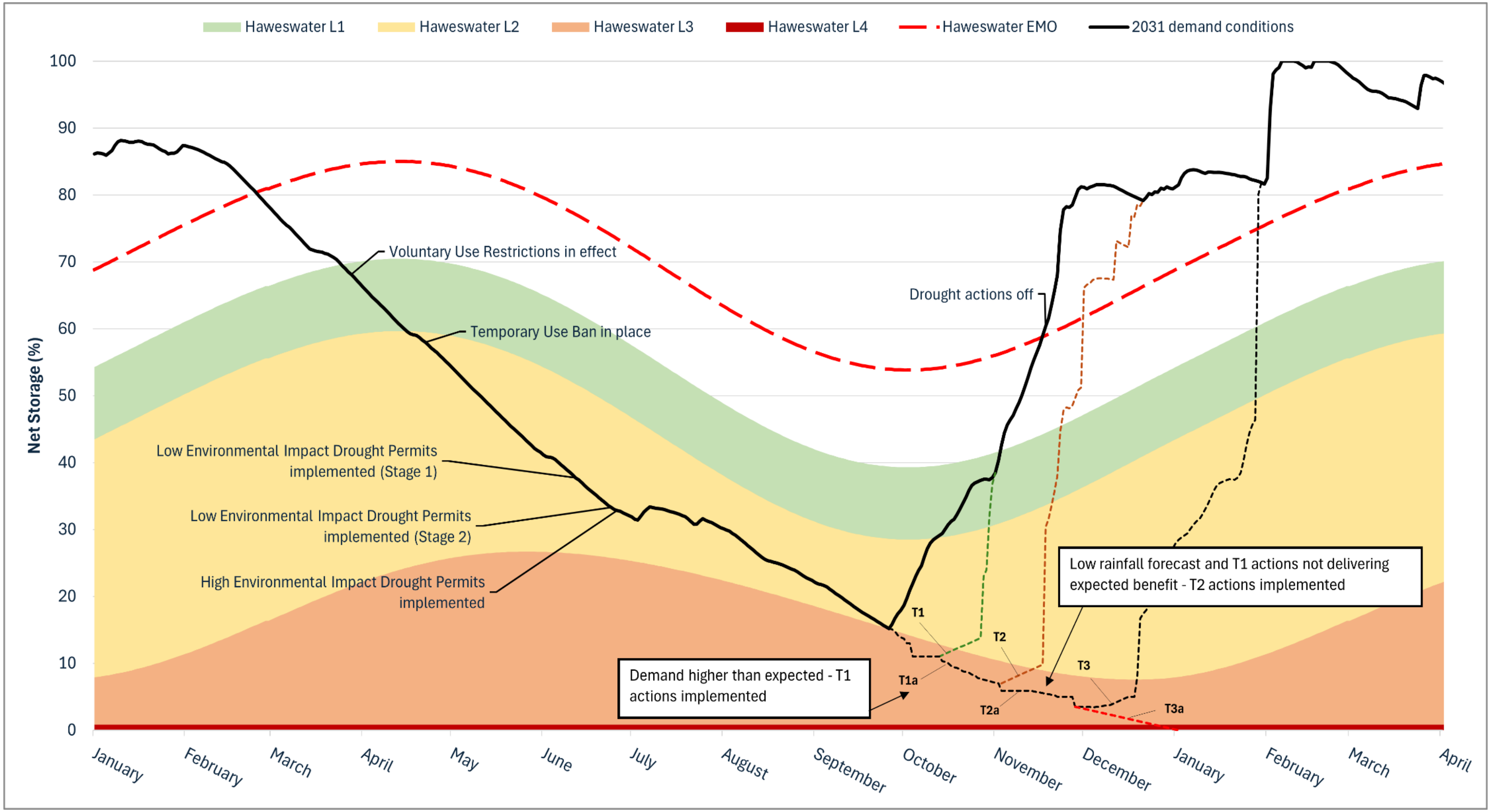


Figure 34: Example of an adaptive pathway



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