

River Lyd Drought Permit

Exceptional Shortage of Rainfall Analysis



**South West
Water**

Executive Summary

Devon, Cornwall and the Isles of Scilly remain in official “drought” status following the period of dry weather which started in November 2021. This report demonstrates the Exceptional Shortage of Rainfall (ESOR) in Roadford Water Resource Zone (WRZ) from March 2022 to August 2022 and its subsequent impacts on the hydrological and water supply system which lead to South West Water’s application for a drought permit in the Roadford WRZ in March 2023.

Rainfall analysis has been undertaken for a “main period” from March 2022 to February 2023 and a “sub period” from March 2022 to August 2022. The analysis uses established techniques outlined in the Environment Agency technical ESOR guidance using the Environment Agency’s DRT rainfall dataset for the Roadford WRZ. Analysis of additional variables has also been included to demonstrate the subsequent impacts of the ESOR on the hydrological and water supply systems.

The conclusions from this ESOR assessment demonstrate;

- Roadford WRZ rainfall for the “main period” March 2022 to February 2023 is categorised as “Normal” based on ranked rainfall probability bands. The analysis demonstrates the first 6 months covering the “sub period” had only 58.5% LTA rainfall and the second 6 months from September 2022 to February 2023 had 121.73% LTA rainfall.
- Roadford WRZ rainfall for the “sub period” from March 2022 to August 2022 was the 3rd driest on record, categorised as “Exceptionally Low” based on ranked rainfall probability bands and “Extremely Dry” based on rainfall SPI analysis.
- Soil Moisture Deficit (SMD) reached record maxima in August and September and had the longest period of deficit on record from March 2022 to November 2022.
- There was no Hydrological Effective Rainfall (HER) between April and October and total HER was only 22% of LTA from March 2022 to October 2022.
- Inflows to Roadford reservoir reached historical monthly minima in April and May 2022 and the hydrological position across the WRZ did not start to recover until modest increases from September 2022 and large increases in November 2022.
- The 2022 event is the longest sustained drawdown on Roadford Reservoir since the 1995 drought event with minimum levels of 33.5% reached in October 2022. This is a direct consequence of the length of time supply releases were being made due to the low River Tamar flows and the low resources in local sources across the WRZ.
- Dry weather in early December and from mid-January to the start of March caused reservoir storage to drop between periods of recovery and Roadford Reservoir levels are currently at 60.7% and have entered drought level 2.
- Roadford Reservoir is susceptible to multi-season impacts due to the modest potential for storage recovery between years and an Exceptional Shortage of Rainfall can have impacts into subsequent years.
- The 3-month outlook for March to May suggests a “higher than normal chance of a dry spring” which means the effects of the March 2022 to August 2022 ESOR are therefore more likely to be exacerbated due to limited further recovery before we enter the 2023 reservoir drawdown period.

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List of Acronymns

BFI – Baseflow index
EA – Environment Agency
EA DRT – Environment Agency Daily Rainfall Tool (rainfall dataset)
ESOR – Exceptional Shortage of Rainfall
HER – Hydrologically Effective Rainfall
NRFA – National River Flow Archive
SAAR – Standard Annual Average Rainfall
SMD – Soil Moisture Deficit
SPI – Standardised Precipitation Index
WRZ – Water Resource Zone

1 Introduction

Devon, Cornwall and the Isles of Scilly remain in official “drought” status following the period of dry weather which started in November 2021. This report demonstrates that although the period from March 2022 to February 2023 has not experienced an Exceptional Shortage of Rainfall due to wet winter 2022/23, the Exceptional Shortage of Rainfall in Roadford WRZ from March 2022 to August 2022 and the subsequent impact of this event on the hydrological and water supply system leads to South West Water’s application for a drought permit in the Roadford WRZ in March 2023.

1.1 Approach

1.1.1 Rainfall data

The rainfall assessment uses the Environment Agency’s Daily Rainfall Tool (EA-DRT) dataset. This dataset was provided by the Environment Agency to South West Water with data from 1890 through to the end of February 2023 for the Roadford WRZ. The Environment Agency DRT dataset uses the Met Office HadUK rainfall dataset to the end of 2020 and then uses the Environment Agency’s own gridded rainfall dataset for the period from 2021 to present day.

The long term average period for this assessment uses 1961-1990 for consistency with the approach used by the Environment Agency in the Water Situation Reporting.

1.1.2 Period of analysis

The main period of analysis considered for the ESOR is the 12 month period from March 2022 to February 2023. Roadford Reservoir started to drawdown from the middle of March 2022 which is notably early, driven by the low rainfall in March which caused a rapid flow recession in Roadford Reservoir inflows. March 2022 is therefore considered to be the point at which the water resource situation was no longer normal.

The dry weather persisted through to the end of August 2022 before some rainfall arrived in September 2022. Roadford Reservoir continued to drawdown through September 2022 and October 2022 which is a direct consequence of the ESOR from March 2022 to August 2022 causing a substantial hydrological deficit which was not overcome until November 2022, at which point Roadford Reservoir storage began to increase. The shorter 6 month period from March 2022 to August 2022 has therefore been included in this ESOR assessment as a shorter period of analysis which is the main driver of the current Roadford WRZ water resource position.

Throughout this report the period from March 2022 to February 2023 is referred to as the “main period” and the period from March 2022 to August 2022 is referred to as the “sub period”.

1.1.3 Geographical extent of analysis

The geographical extent of the analysis is for the whole Roadford WRZ as outlined in more detail in 1.2 and agreed through discussion with the Environment Agency. Whilst Roadford Reservoir is the key strategic source for the WRZ and the main source of concern in March 2023, the dynamics of how the Roadford WRZ operates means that the whole region must be included within the ESOR assessment.

1.2 Overview of Roadford WRZ

Roadford WRZ stretches from the coast of North Devon to the coast of South Devon, bordered to the West by the River Tamar and a small area of Cornwall around Bude and with the River Exe catchment bordering the East. It includes the large population areas of Plymouth and Torbay in South Devon and Bideford, Barnstaple and Ilfracombe in North Devon and Okehampton at the centre of the WRZ.

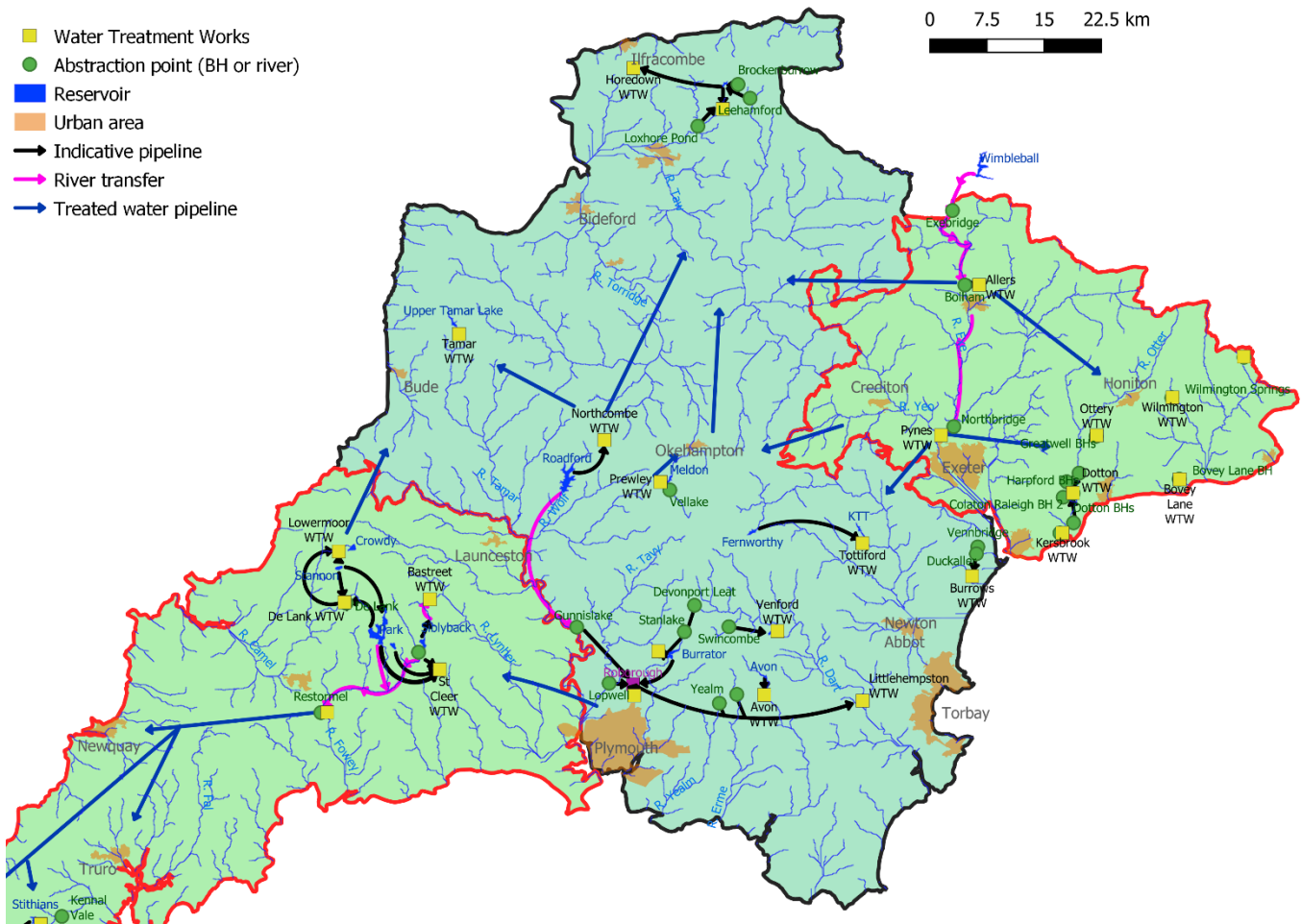


Figure 1 Map of South West Water supply area with Roadford WRZ in darker green.

Each demand area of Roadford WRZ has locally important sources which provide the primary supply, predominantly a mix of smaller reservoirs or river abstraction which are used to meet local demand during winter and whilst abstraction is available over summer months. The WRZ is supported by the large strategic reservoir Roadford Reservoir which can be used to supply all areas of the WRZ when required. During normal conditions Roadford Reservoir only provides a direct abstraction into Northcombe water treatment works which is used to supply areas of North Devon in conjunction with local sources.

When local water resources become constrained during periods of drier weather, Roadford Reservoir is used to provide additional water resource support. The North of Roadford WRZ receives additional support by increasing abstraction to Northcombe. The South of Roadford

WRZ is supported by making releases into the River Tamar which are then abstracted downstream at Gunnislake. The Gunnislake abstraction typically begins in spring without the need for Roadford supply releases. As River Tamar flows reduce towards the prescribed flow limit Roadford supply releases begin. The use of the Gunnislake abstraction is typically required as levels in Burrator Reservoir reduce and/or river flows in the River Tavy at Lopwell and the River Dart at Austins bridge are low. The abstraction from Gunnislake can support demand across the South of the WRZ from Plymouth to Torbay.

1.3 Overview of Roadford Reservoir

Roadford Reservoir has a total net capacity of 34,500 MI and sits in the River Wolf in the headwaters of the River Tamar. The catchment area upstream of Roadford Reservoir dam is 31.8 km² (QUBE¹, 2023) and it receives 1146 mm of annual rainfall (NRFA – SAAR 61-90). The catchment has a baseflow index (BFI) of 0.38 which reflects the low permeability hydrogeology of the catchment which means it generally responds quickly to rainfall events but a return to river flow recession can also occur quickly.

The hydrological catchment area is relatively small compared to the total reservoir capacity which means that it can be slow to recover its storage. The QUBE hydrological data service estimates the average annual catchment runoff rate to be 698 mm which based on the 31.8 km² catchment area provides 22,196 MI of annual runoff that could be captured by the reservoir. This runoff figure only takes account of the balance of rainfall inputs and evaporative losses but only equates to 65% of Roadford net storage.

Roadford Reservoir has a compensation release of 9 MI/d, outlined in the impoundment licence, which totals 3,285 MI per year. The abstraction from Roadford to Northcombe is typically 30-40 MI/d, the lower end of this range of 30 MI/d equates to 10,950 MI per year. In a typical year, taking account of the compensation releases and Northcombe abstraction, the runoff contributing to the reservoir storage recovery is around 7,961 MI (i.e. runoff - compensation - Northcombe abstraction) which is only 23% of Roadford net storage.

In drier years the abstraction at Northcombe increases to 45-50 MI/d as North Devon local abstractions reduce. Supply releases to support South Devon typically range between 80-100 MI/d over several months in the summer. These additional demands on the system further reduce the amount of water available to support reservoir storage recovery.

Whilst the numbers outlined above are approximate and based on average figures, they are indicative of the mass balance of the Roadford Reservoir system which is marginal at times. This means that multi-season impacts are common due to the sometimes-limited reservoir storage recovery over winter. The historical Roadford Reservoir storage is shown in Figure 2. The worst historical drought occurred in 1995 reaching a minimum level of 16.9%. The full recovery of the reservoir after this event took nearly 3 years, not reaching 100% capacity until 1998. The reservoir recovery from the 1995 event was supported by drought permits on the River Lyd and River Thrushel which provided additional pumped inflows to support recovery. There are other notable multi-season periods; the reservoir was off top water level between

¹ <https://qube.hydrosolutions.co.uk/>

2001-2008 and didn't rise above 80% capacity between 2003-2007, 2010/11 and 2016/17 both saw years with limited recovery over winter. These periods highlight the multi-season nature of the Roadford Reservoir system and the risks that one drawdown period can present to the storage position in subsequent years.

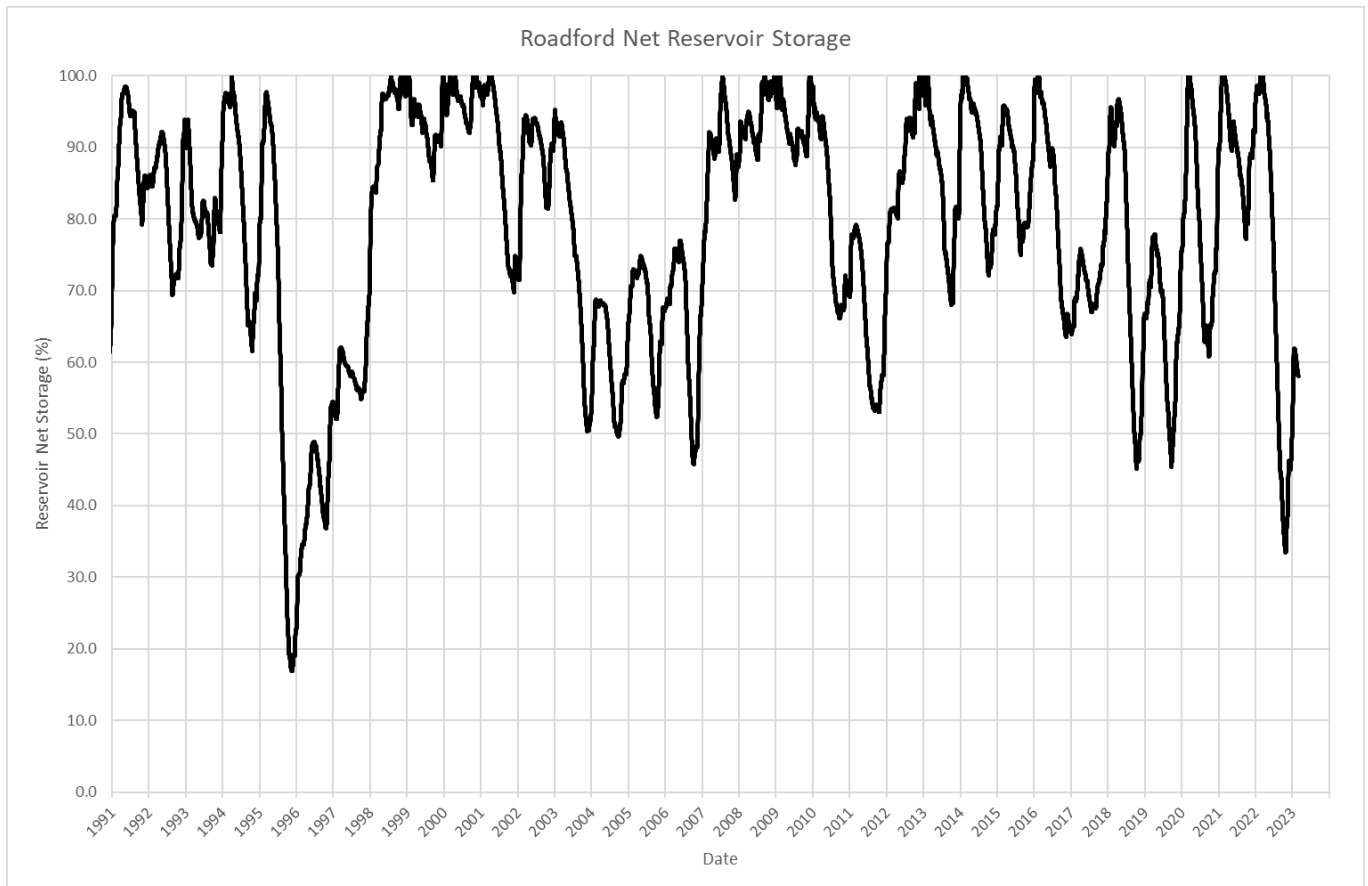


Figure 2 Roadford Reservoir historical net storage 1991-present.

2 Rainfall Analysis

This section presents the rainfall analysis to support ESOR. It uses established techniques which are outlined in the Environment Agency's technical guidance².

2.1 Cumulative Rainfall Analysis

The monthly rainfall totals from March 2022 to February 2023 are shown in Figure 3, the analysis here discusses the ESOR "main period" March 2022 to February 2023 and the "sub period" from March 2022 to August 2023. From the monthly totals the monthly cumulative rainfall was calculated (shown in Figure 4) as well as the cumulative total rainfall as percentage of the 1961-1990 LTA (shown in Figure 5).

² Hydrological guidance for the assessment of an Exceptional Shortage of Rain (ESoR). Environment Agency, 2021.

The start of ESOR “main period” had a very dry March 2022 and April 2022 finishing at just 58% LTA. The “sub period” from March 2022 to August 2022 received just 58.5% of LTA rainfall making it exceptionally dry. Comparing 2022 with other notable historical drought years in the Roadford WRZ, the 1976 event was drier and 1995 was slightly wetter.

September 2022 and October 2022 both received above average rainfall which helped the March 2022 to October 2022 rise to 78.11%. November 2022 was exceptionally wet with 190% of LTA rainfall this month and December and January were both average, although the rainfall in this period fell in a 4 week period from mid-December to mid-January. The “main period” ended with an exceptionally dry February with only 22% of LTA rainfall which concluded a dry 6 week period that began in mid-January.

The overall LTA rainfall for the “main period” from March 2022 to February 2023 was 97.16% but as the analysis demonstrates the first 6 months covering the “sub period” had only 58.5% and the second 6 months from September 2022 to February 2023 had 121.73%.

Roadford WRZ monthly rainfall totals since March 2022

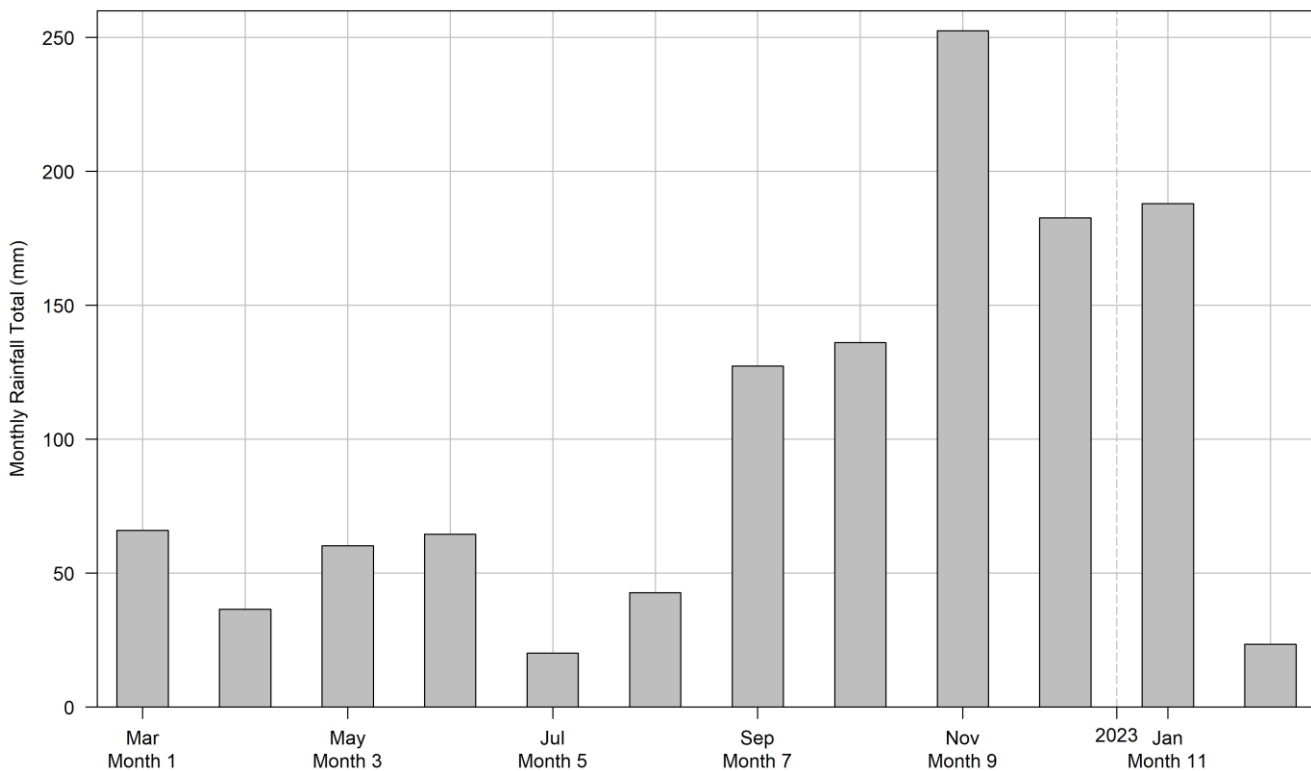


Figure 3 Roadford WRZ monthly rainfall totals March 2022 to February 2023.

Roadford WRZ cumulative monthly rainfall since March 2022

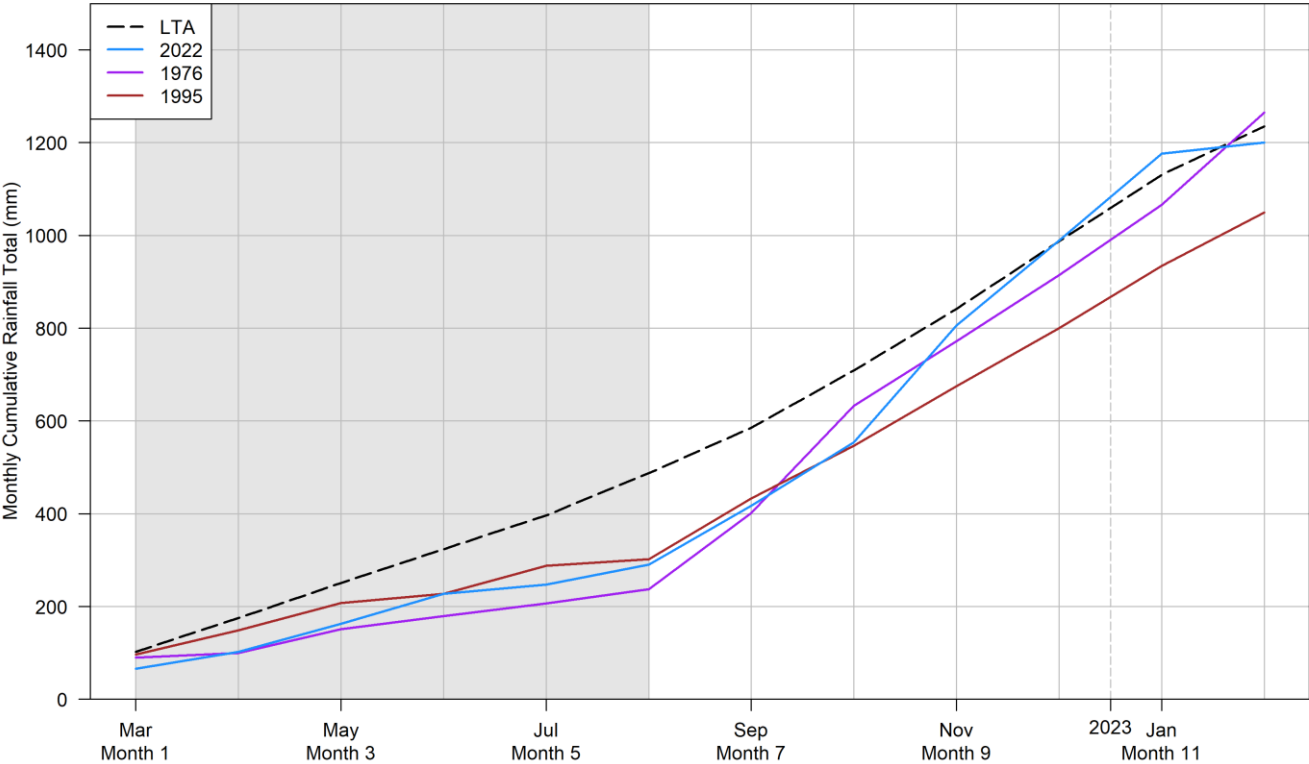


Figure 4 Roadford WRZ cumulative monthly rainfall from March 2022 to February 2023. Light grey shaded area highlights “sub period” from March 2022 to August 2022.

Roadford WRZ Long Term Average (LTA) HER since March 2022
LTA calculated relative to 1961-1990.

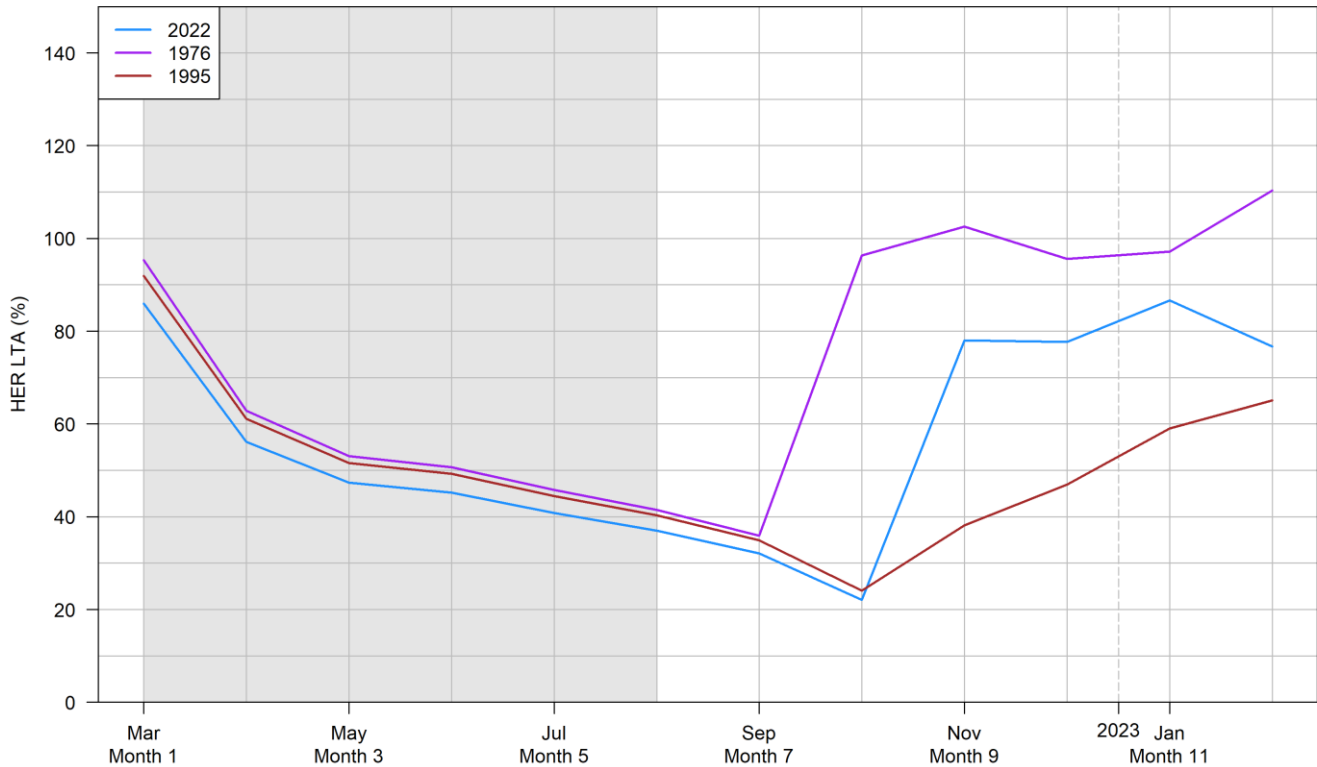


Figure 5 Roadford WRZ LTA Rainfall from March 2022 to February 2023. Light grey shaded area highlights “sub period” from March 2022 to August 2022.

2.2 Rainfall Ranking and Probability Bands

The total rainfall between March-February and March-August has been calculated for each year in the historical rainfall dataset for comparison with 2022. These have been ranked from driest to wettest and expressed as a percent of the long term average and the driest 10 years are presented in Table 1 for the “main period” and Table 2 for the “sub period”. This historical context for the full period of record is presented in Figure 6 and Figure 7 for the “main period” and “sub period” respectively.

The “main period” from March 2022 to February 2023 received 97.16% of LTA rainfall making it the 50th ranked out of 132 years. This is assigned a rainfall probability band of “Normal” which spans a range from 94.43% to 108.89% of LTA rainfall.

For the “sub period” March to August 2022 is the third driest of 132 years of record with only 59.52% of LTA rainfall. Only 1976 and 1984 recorded lower rainfall amounts than 2022 with the worst historical drawdown year in Roadford in 1995 ranked the 4th driest. The 2022 March to August period was assigned a rainfall probability band of “Exceptionally Low” meaning there is a less than 5% chance of a rainfall amount falling into this category.

Table 1 Driest 10 ranked years of rainfall totals from March to February (“main period”)

Rank	Year	Rainfall (mm)	LTA (%)	Rainfall Probability Band
1	1933	862.6	69.84	Exceptionally low
2	1975	867.6	70.24	Exceptionally low
3	1908	872.9	70.67	Exceptionally low
4	1962	908.0	73.52	Exceptionally low
5	1893	913.8	73.98	Exceptionally low
6	1921	924.2	74.83	Exceptionally low
7	1906	937.6	75.91	Exceptionally low
8	1941	941.4	76.22	Notably low
9	1892	943.7	76.41	Notably low
10	1933	862.6	69.84	Notably low
50	2022	1200.1	97.16	Normal
LTA	1961-90	1235.1	100%	

Table 2 Driest 10 ranked years of rainfall totals from March to August (“sub period”)

Rank	Year	Rainfall (mm)	LTA (%)	Rainfall Probability Band
1	1976	237.5	48.70	Exceptionally low
2	1984	273.1	56.00	Exceptionally low
3	2022	290.3	59.52	Exceptionally low
4	1995	302.3	61.98	Exceptionally low
5	1893	317.6	65.12	Exceptionally low
6	1896	331.2	67.91	Exceptionally low
7	1892	332.4	68.16	Exceptionally low
8	1921	335.4	68.77	Notably low
9	1990	338.0	69.30	Notably low
10	1926	341.3	69.98	Notably low
LTA	1961-90	487.7	100%	

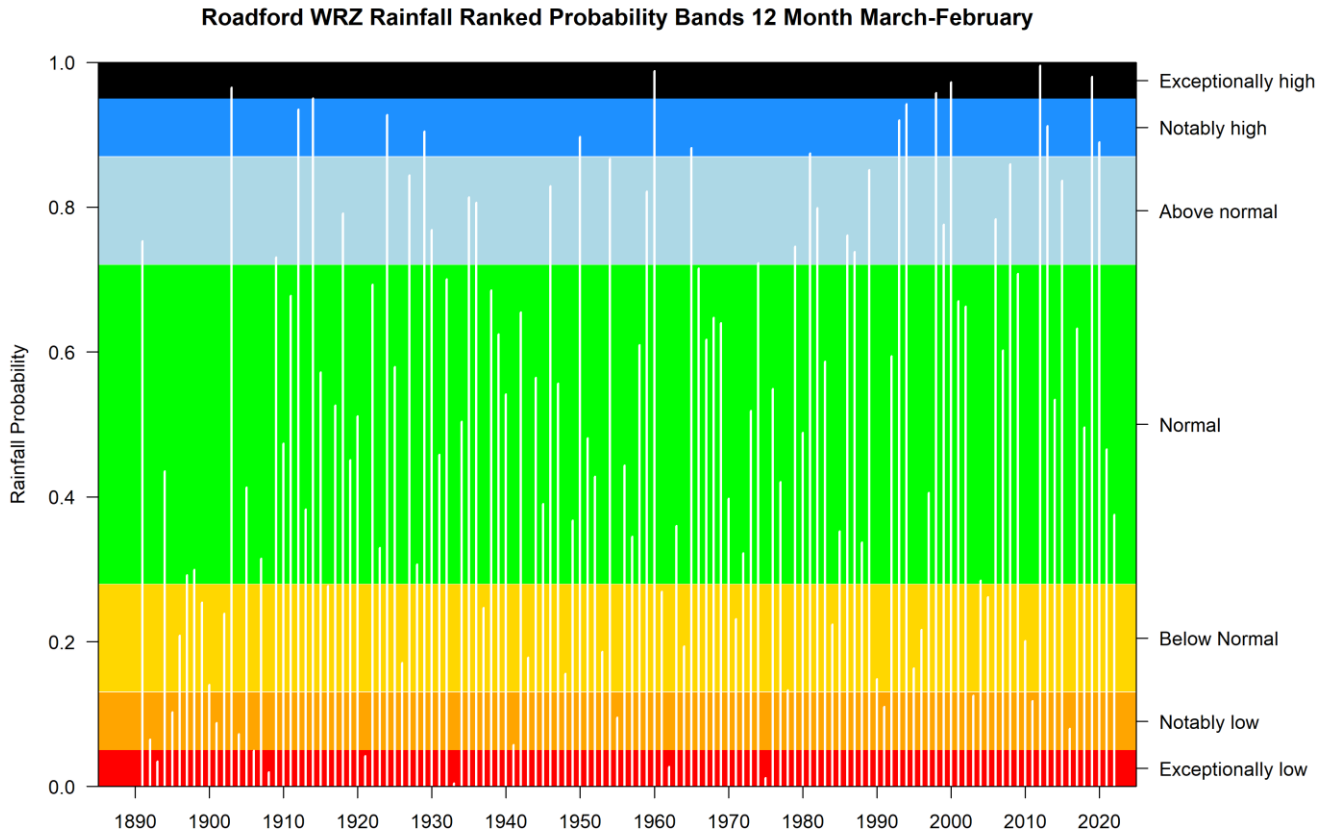


Figure 6 Roadford WRZ rainfall probability bands for March to February “main period” total rainfall.

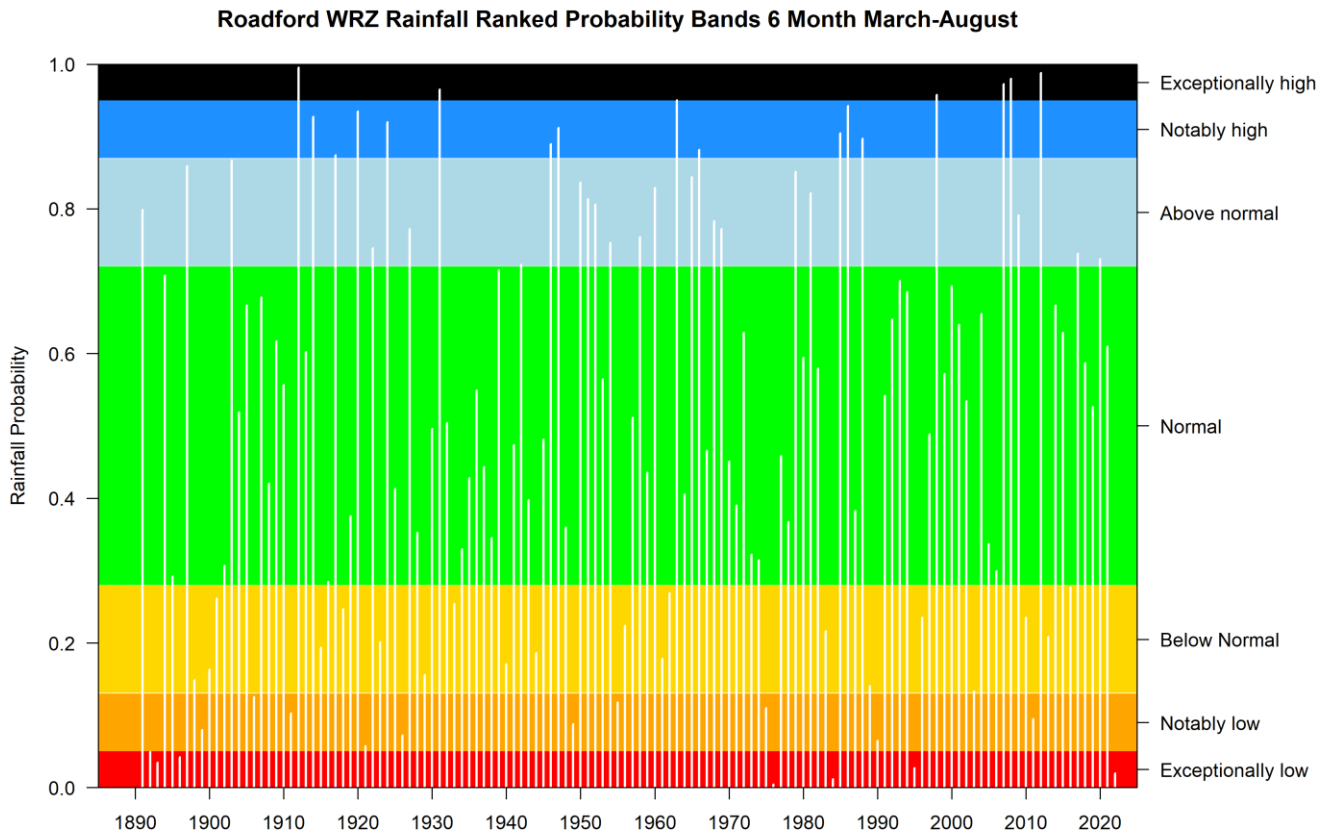


Figure 7 Roadford WRZ rainfall probability bands for March to August “sub period” total rainfall.

2.3 Standardised Precipitation Analysis (SPI)

The analysis of rainfall has been extended by calculating a Standardised Precipitation Index (SPI) for the data. This has been undertaken using the same SPI calculation as outlined in the Environment Agency’s SPI tool³. The SPI has been calculated starting from March 2022 with an additional month added whilst moving through the event (e.g. Mar, Mar-Apr, Mar-May), with a 12 month SPI covering the “main period” and a 6-month SPI covering the “sub period” March 2022 to August 2022, see Figure 8.

The SPI for the “main period” is classed as “Near Normal”. The SPI for the March to August “sub period” is classed as “Extremely Dry”. This “sub period” SPI figure was particularly influenced by the low July and August rainfall accumulations where the SPI index can be seen to decrease markedly during this period. Comparing the March to August 6 month “sub period” with all other years in the EA DRT dataset demonstrates it was the 3rd driest on record (Figure 9). Only 1976 and 1984 recorded SPI values that were drier than 2022 over the same March to August period.

³ Environment Agency Standardised Precipitation Index (SPI) Tool. Version 2.0. Environment Agency.

Roadford WRZ Cumulative SPI since March 2022

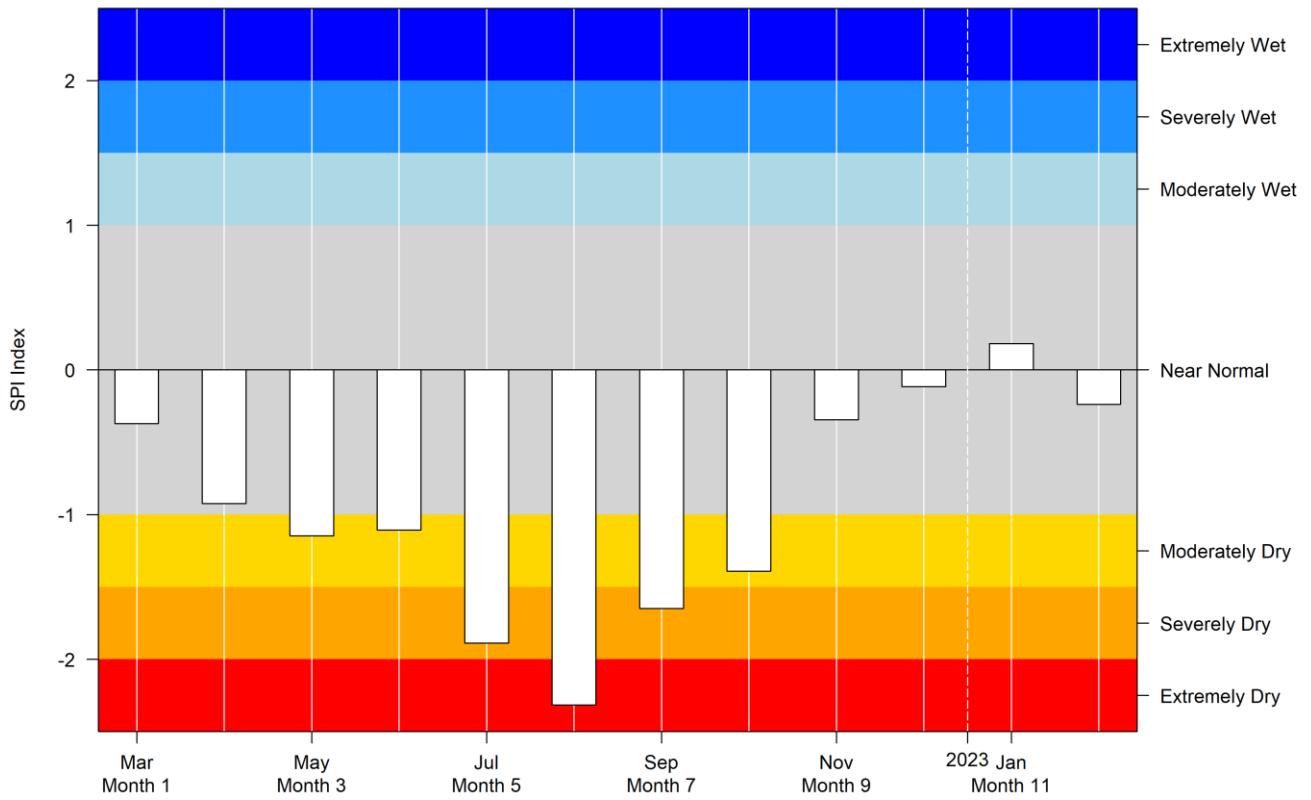


Figure 8 Roadford WRZ rainfall SPI since March 2022.

Roadford WRZ Rainfall SPI 6 Month March-August

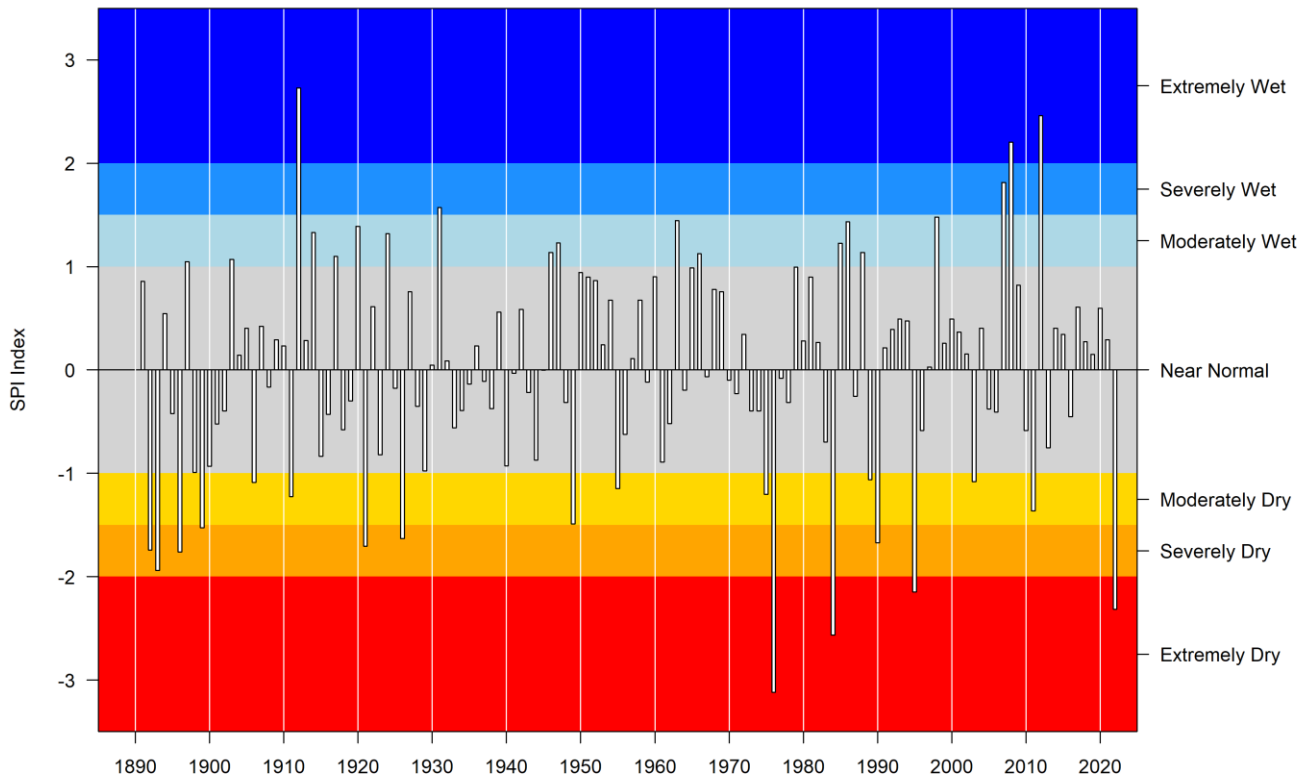


Figure 9 Roadford WRZ 6 month (March to August) SPI for full period of record.

2.4 Rainfall Analysis Summary

Analysis of the Environment Agency's DRT rainfall dataset for the Roadford WRZ rainfall from March 2022 to February 2023 demonstrate that total rainfall is considered "Normal" and that over this time period there has not been an Exceptional Shortage of Rainfall.

However analysis of the "sub period" March 2022 to August 2022 demonstrated the period was the 3rd driest on record and was categorised as "Exceptionally Low" based on ranked rainfall probability bands and "Extremely Dry" based on rainfall SPI analysis. Based on this assessment it is considered that this constitutes an Exceptional Shortage of Rainfall.

The following sections demonstrate how the ESOR in March to August impacted the wider hydrological and water supply systems and continues to impact the water resource position of Roadford Reservoir in March 2023.

3 Analysis of Additional Variables

3.1 Soil Moisture Deficit and Hydrologically Effective Rainfall

The analysis presented in this section uses the Met Office's MORECs 40km dataset for the grid square which most closely approximates the Roadford WRZ (square 177). The MORECs datasets provides information on Soil Moisture Deficit (SMD) and Hydrologically Effective

Rainfall (HER). SMD describes the hydrological position of the soil and reflects the accumulated balance of rainfall and evaporation. When evaporation exceeds the rainfall amount, a soil moisture deficit accumulates which means that the soil has the potential to capture and store rainfall when it falls rather than generating runoff which enters rivers. At the end of a dry period this effect can be witnessed where river levels do not increase even though it is raining. Whereas when it has been wet for a sustained period, and the ground is already saturated, there is no soil moisture deficit, and any rainfall leads to a subsequent increase in river flows.

The SMD for Roadford WRZ in 2022 is shown in Figure 10. The SMD began to accumulate from the beginning of March and did not recovery until the start of November. This duration of continued deficit is longer than any previous historical event in the MORECs dataset (starting in 1961). The 2022 maximum deficit occurred in early August and September and was the highest on record for those periods of year.

The high SMD after the end of the March 2022 to August 2022 “sub period” demonstrates the subsequent impact of the ESOR on the overall hydrological position of the WRZ. Although the high amount of rainfall in early September led to a substantial recovery in the SMD over this period, the end of September saw a return to dry conditions and the SMD persisted at around 60mm at the start of October. Subsequent rainfall throughout the remaining Autumn eventually overcame the soil moisture deficit by early November. Early November can be considered the point at which the hydrological position returned to “normal”.

Soil Moisture Deficit - MORECS Square 177

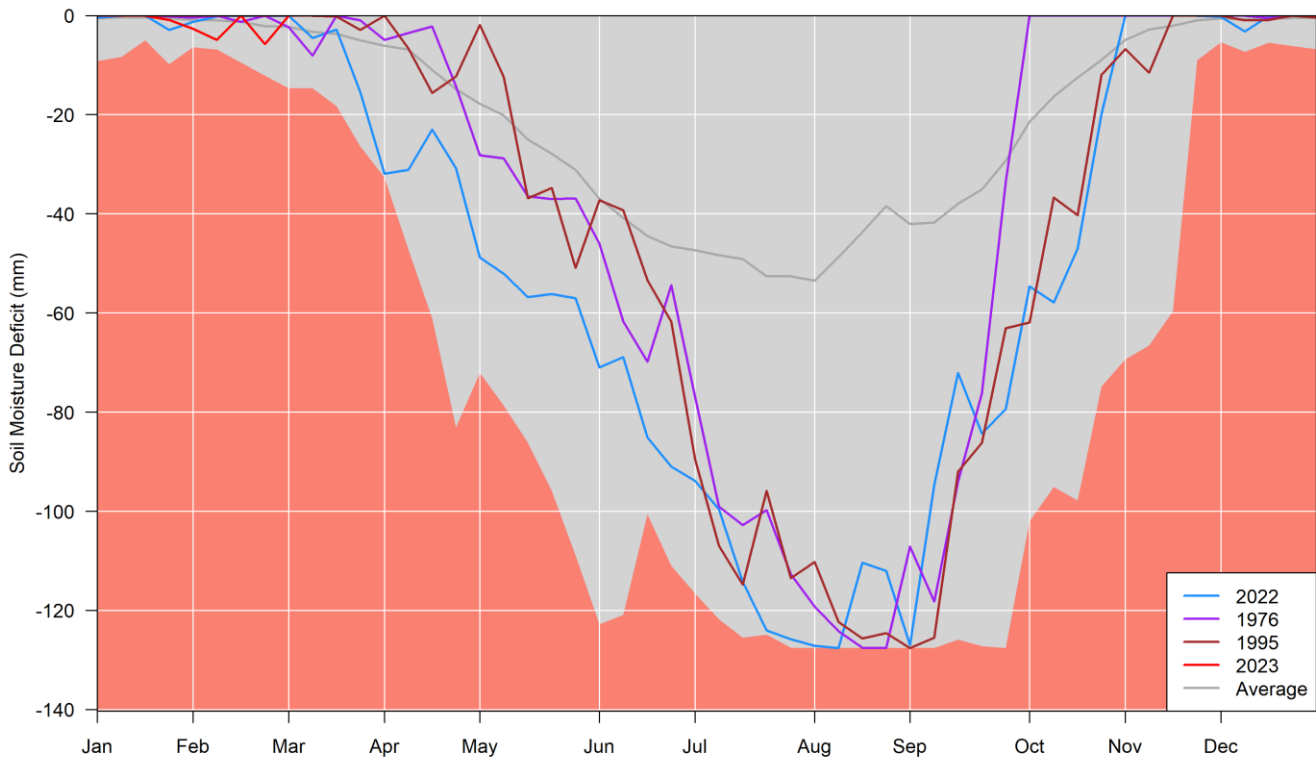


Figure 10 Soil moisture deficit (SMD) for MORECS Square 177.

During the period from March 2022 to the end of October 2022, any rainfall that fell would have had limited benefit to the water resource position due to the accumulated SMD. South West Water has undertaken analysis of the MORECS Hydrologically Effective Rainfall (HER) which only accumulates a net benefit from rainfall when the SMD is zero. The analysis is shown in a similar format to the rainfall analysis in Section 2.1; the monthly total HER is shown in Figure 11, the cumulative monthly HER is shown in Figure 12, and the cumulative monthly HER as a percent of LTA is shown in Figure 13.

The analysis demonstrates that there was no hydrologically effective rainfall from April 2022 to August 2022 during the ESOR “sub period”. This continued during September 2022 and October 2022 reaching just 22% of LTA HER (Figure 13) due to the high SMD that did not recover until the start of November. This contrasts with the rainfall analysis in Section 2 which showed LTA rainfall recovered in September and October because this does not account for the antecedent SMD conditions which is captured by HER.

The analysis of SMD and HER demonstrate that the ESOR “sub period” from March 2022 to August 2022 continued to impact on the hydrological conditions until the end of October 2022 delaying the start of recovery of the water resource position until early November.

Roadford WRZ monthly HER totals since March 2022

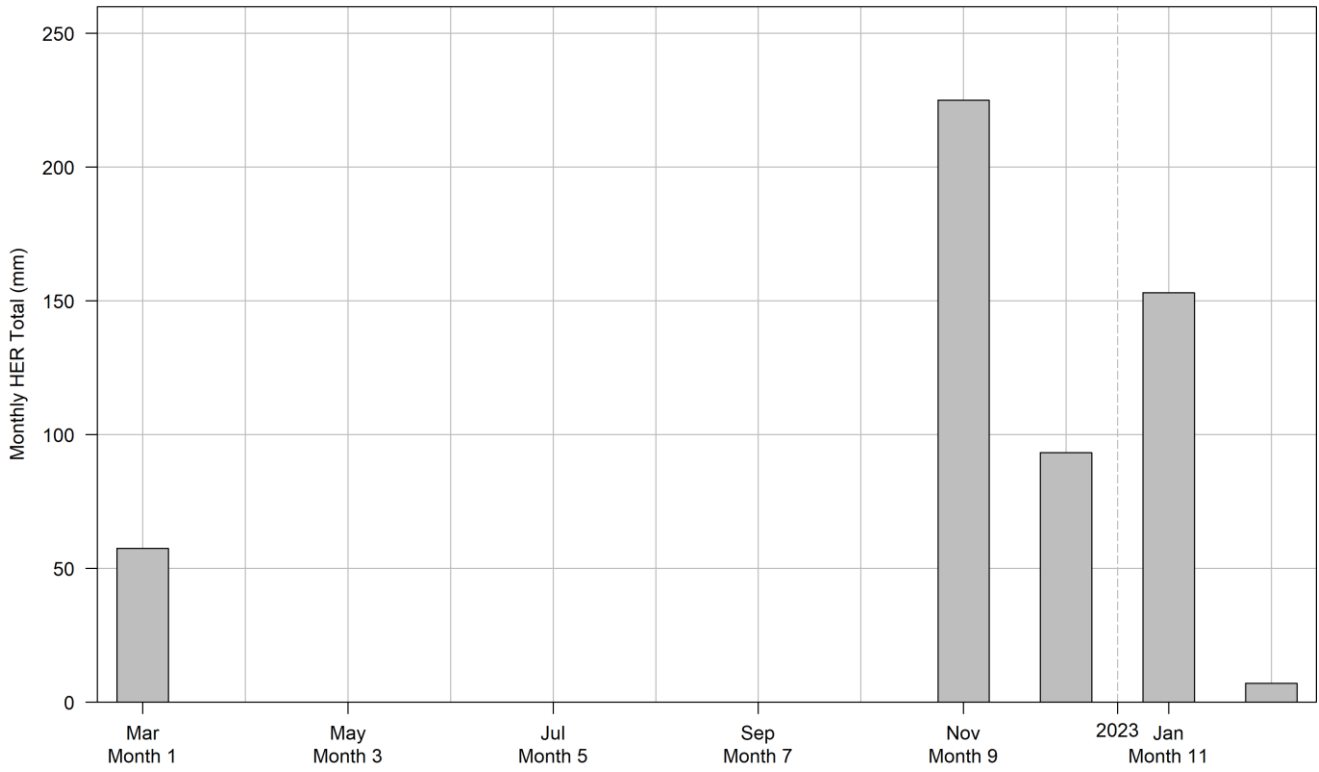


Figure 11 Roadford WRZ monthly HER totals March 2022 to February 2023.

Roadford WRZ cumulative monthly HER since March 2022

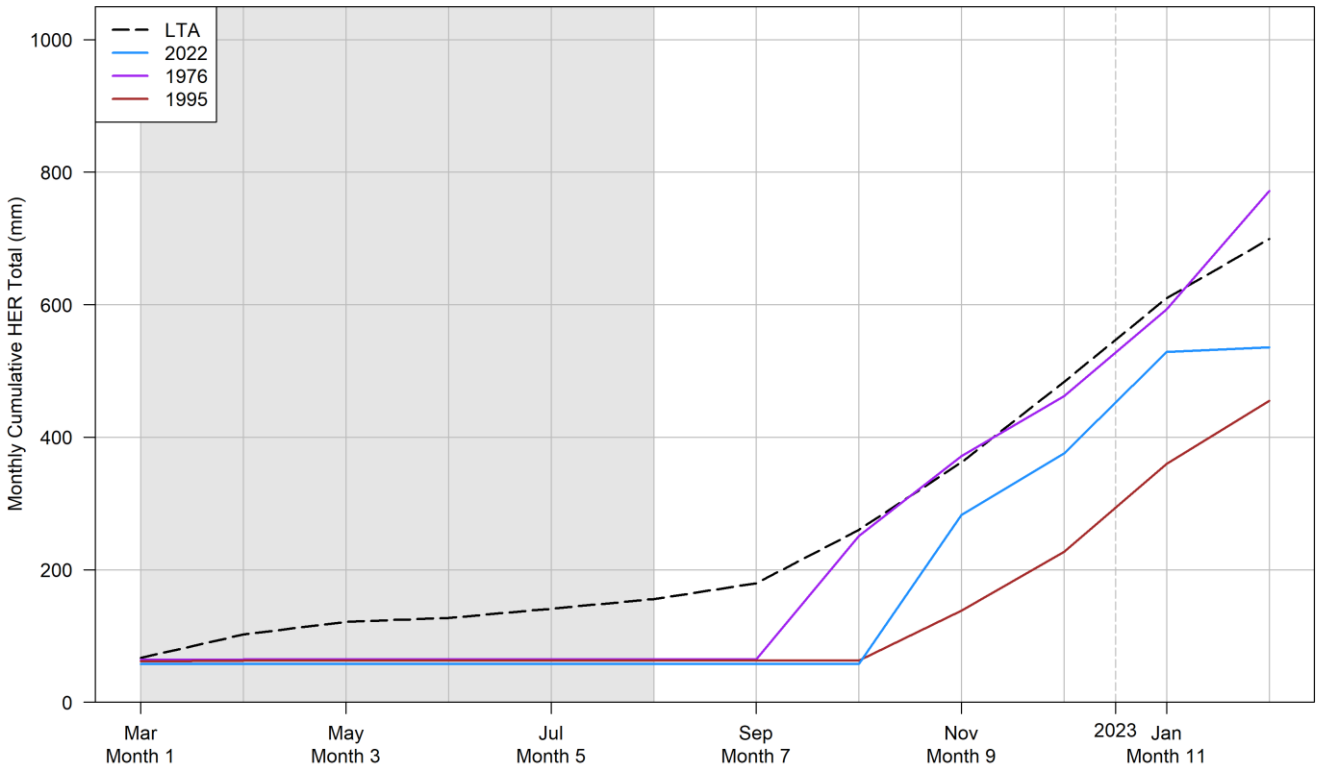


Figure 12 Roadford WRZ cumulative monthly HER from March 2022 to February 2023. Light grey shaded area highlights “sub period” from March 2022 to August 2022.

Roadford WRZ Long Term Average (LTA) HER since March 2022
LTA calculated relative to 1961-1990.

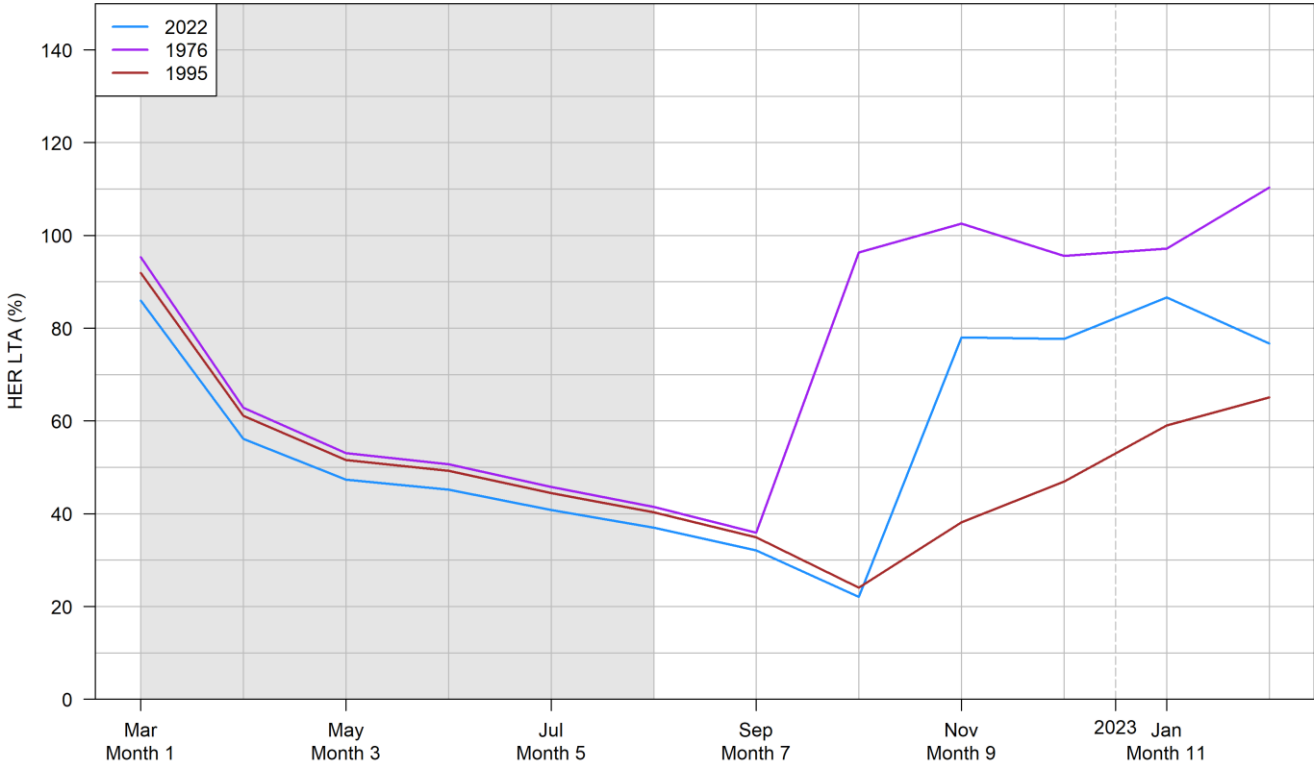


Figure 13 Roadford WRZ LTA HER from March 2022 to February 2023. Light grey shaded area highlights “sub period” from March 2022 to August 2022.

3.2 River Flows

There are several strategically important river flow sites in the Roadford WRZ, the analysis included here focuses on the strategic Roadford Reservoir system. The naturalised Roadford Reservoir inflows are shown in Figure 14 from November 2021 to the end of February 2023. The naturalised Roadford flows use the methodology agreed between the Environment Agency and South West Water. Since 2010, the inflows to Roadford Reservoir are estimated using the gauging station at Germansweek on the River Wolf upstream of the reservoir and therefore provide a good approximation of the total inflows. Winter 2021/22 was characterised by period of lower flows and flow recession and intermittent higher flows in response to rainfall. The lack of persistent rainfall during this period meant a quick return to below average river flows during periods of recession. A period of rainfall in late February did see an uplift in river flows which helped Roadford storage reach 100%. River flows began recession again in mid-March and April and May saw historically low inflows of just 17% and 7% respectively (see Table 3). Only 3 of the last 16 months have had greater than 100% LTA inflows and although January 2023 had the highest inflows on record, this was subsequently followed by the 2nd driest February on record.

Roadford Naturalised River Flows: November 2021 to February 2023

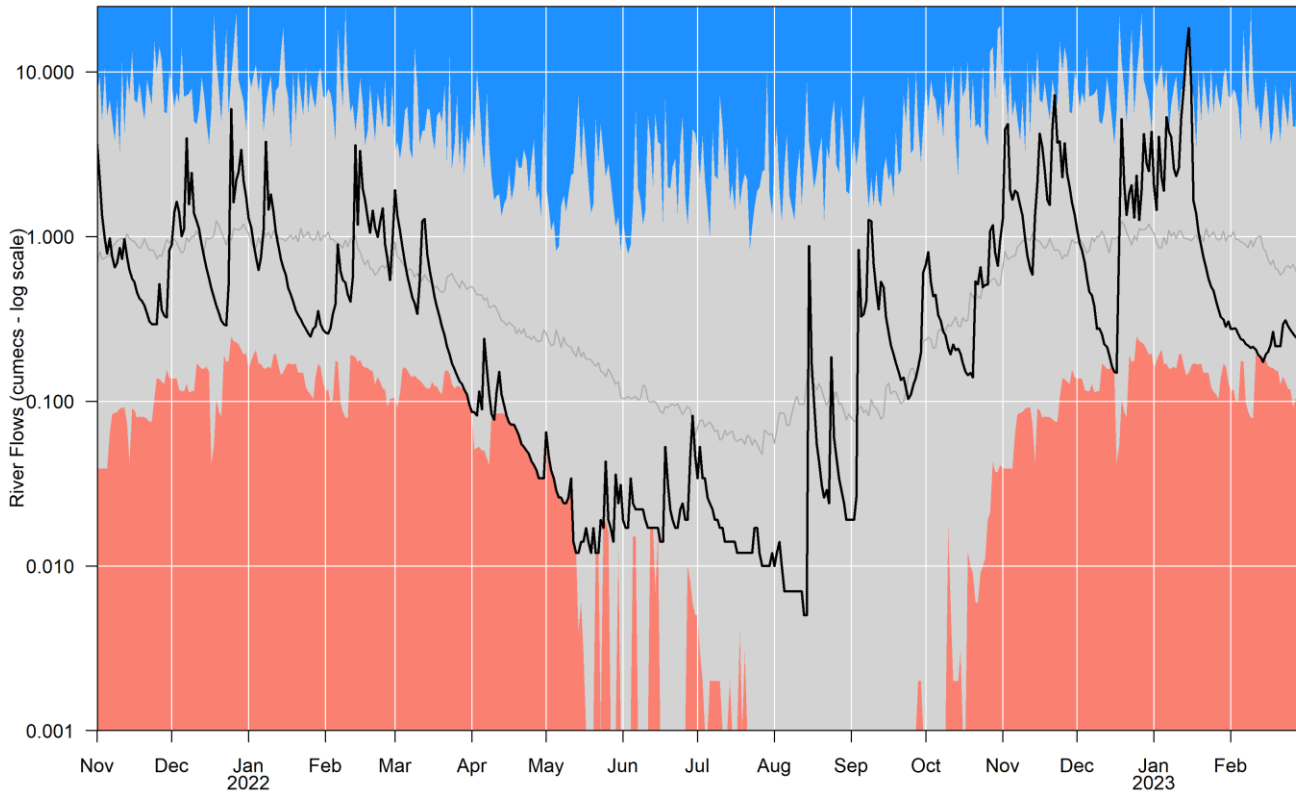


Figure 14 Roadford Reservoir naturalised inflows. Historical series shown in black, historical 50th percentile in dark grey, maximum range in blue and minimum range in red. Note the minimum range goes to zero which cannot be plotted on a log scale.

The naturalised river flows for the Tamar at Gunnislake removes the upstream effects of Roadford Reservoir to present the naturalised position (Figure 15). The winter of 2021/22 saw below average river flows in all months with notably low flows in November and January (< 70% LTA). River levels increased in the second half of February and first half of March but then began rapid recession at this point. The low flows persisted throughout the summer, although the ranked monthly severity are not as extreme as those at Roadford. Gunnislake reached its lowest flows in August 2022 at 18% of LTA, the 4th lowest August on record since 1957. The delayed recover of the hydrological system due to the still large SMD in September and October can be seen in the Gunnislake river flows which were only 46% of LTA in both months.

Gunnislake is the monitoring and abstraction point for releases from Roadford Reservoir. The abstraction licence allows South West Water to abstract 50% of the available water above the prescribed flow (purple line on Figure 15). Once river flows drop below the prescribed flows then releases from Roadford must meet 100% of the abstraction at Gunnislake. Prior to this point partial releases are required to meet abstraction an example threshold has been added to Figure 15 (gold line) based on a daily abstraction of 75 Ml/d. Gunnislake flows were below the prescribed flow, requiring 100% releases to meet abstraction, for the whole of June to August. The small intermittent peaks were not sustained for long enough to allow a change to the

operating position. Note that the log scale on Figure 15 is used to show the detail of the low flow period but this can also appear misleading, the river flows are shown on a standard scale on Figure 16 (black line).

The wider effects of these low river flows on the water supply system is discussed in the following Section 3.3.

Gunnislake Naturalised River Flows: November 2021 to February 2023

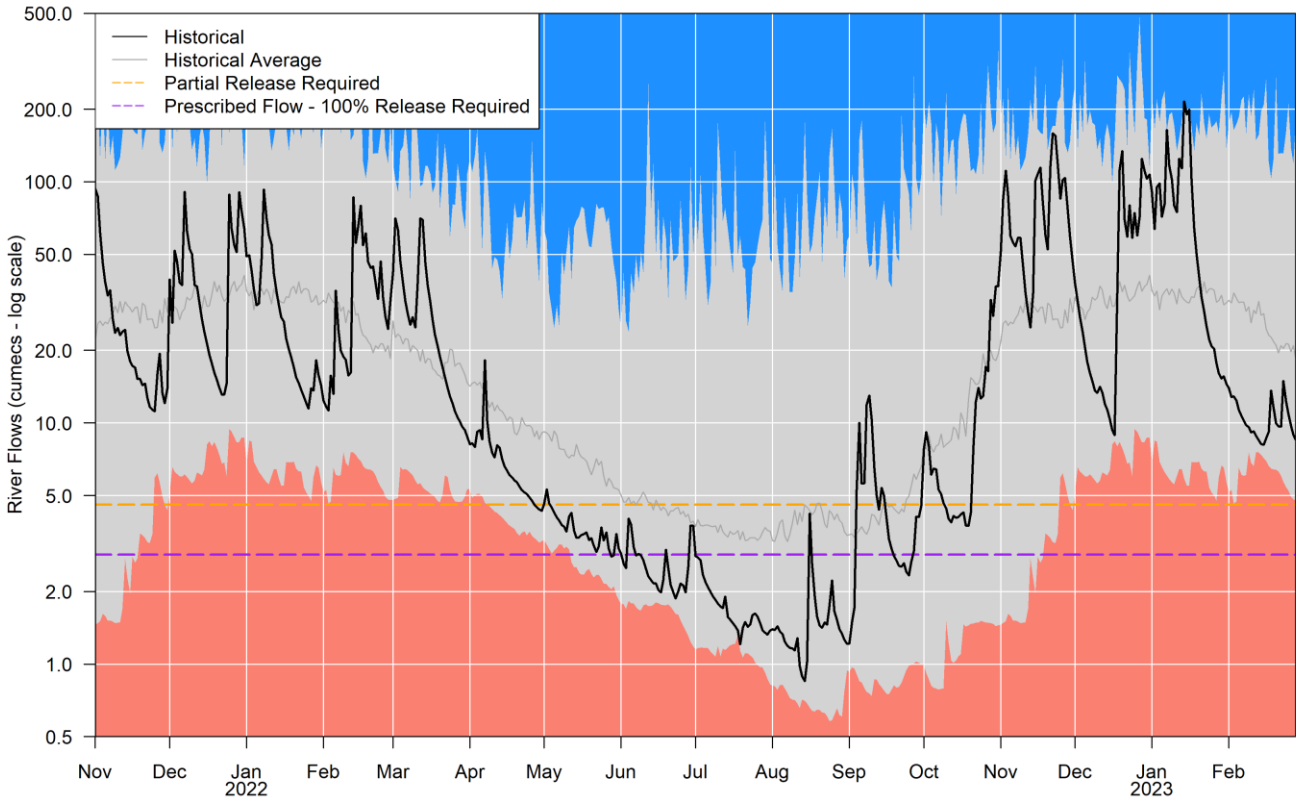


Figure 15 River Tamar at Gunnislake naturalised river flows. Historical series shown in black, historical 50th percentile in dark grey, maximum range in blue and minimum range in red. Note the minimum range goes to zero which cannot be plotted on a log scale.

Table 3 Overview of monthly flows for Roadford and Gunnislake. Ranks are out of 67 years with 1 being the driest and 67 wettest.

Year	Month	Roadford		Gunnislake	
		LTA (%)	Rank (out of 67)	LTA (%)	Rank (out of 67)
2021	11	58%	18	68%	21
2021	12	95%	34	89%	28
2022	1	51%	11	67%	13
2022	2	86%	33	92%	37
2022	3	62%	16	114%	45
2022	4	17%	1	44%	10
2022	5	7%	1	34%	6
2022	6	12%	2	36%	6
2022	7	8%	6	24%	7.5
2022	8	22%	18	18%	4
2022	9	102%	42	46%	27
2022	10	55%	26	46%	19
2022	11	190%	63	199%	64
2022	12	88%	28	103%	39
2023	1	206%	67	164%	65
2023	2	20%	2	28%	5

3.3 Water supply system

As outlined previously in Section 1.2, Roadford Reservoir provides direct abstraction to Northcombe to support North Devon and makes supply releases into the River Tamar to be abstracted at Gunnislake to support South Devon. The recent operation of the Roadford system is shown in Figure 16 for 2022 and for the past 5 years for context in Figure 17.

The abstraction from Roadford into Northcombe (red line) was around 35 MI/d over winter 2021/22 and increased to 50 MI/d in the summer period as local sources reduced their supplies. The river abstraction at Gunnislake (gold line) started in mid-February to balance the pressures on local sources in South Devon such as Burrator Reservoir and the River Dart. The Gunnislake abstraction increased in April as those local sources reduced further but the abstraction was taken directly from the River Tamar without supply releases needed from Roadford Reservoir. The supply releases (solid blue shade) began in mid-May 2022 and continued through to mid-October 2022 until such time that River Tamar flows had recovered to allow abstraction from the river without additional supply releases. Once the river flows at Gunnislake have dropped below the prescribed flow level 100% of the abstraction is supported by a supply release. Once 100% of the abstraction is having to be released from Roadford the deficit below the prescribed flow has no impact. The most important factor is therefore the duration which river flows are below the prescribed flow which as outlined in Section 3.2 lasted for 3 months from June to August.

A comparison of 2022 operation of the system with other recent years (Figure 17) is notable for three reasons. Firstly; the early use of the Gunnislake abstraction in February 2022 to April

2022 (the gold line is higher earlier in 2022). Typically Burrator Reservoir has sufficient resource to meet demand without the need for Gunnislake abstraction at this time of year. Secondly; the need to make supply releases in May (the solid blue shading starts earlier), typically flows on the River Tamar at Gunnislake support abstraction without release until mid to late June, and thirdly; supply releases were continued into October (solid blue shading is substantially larger than other years), whereas typically river flows on the Tamar and at local sources would recover from September. The 2022 event is the longest sustained drawdown on Roadford Reservoir since the 1995 drought event with minimum levels of 33.5% reached in October 2022. This is a direct consequence of the length of time supply releases were being made due to the low Tamar river flows and the low resources in local sources across the WRZ driven by the ESOR from March to August and the subsequent delayed hydrological recovery in September and October.

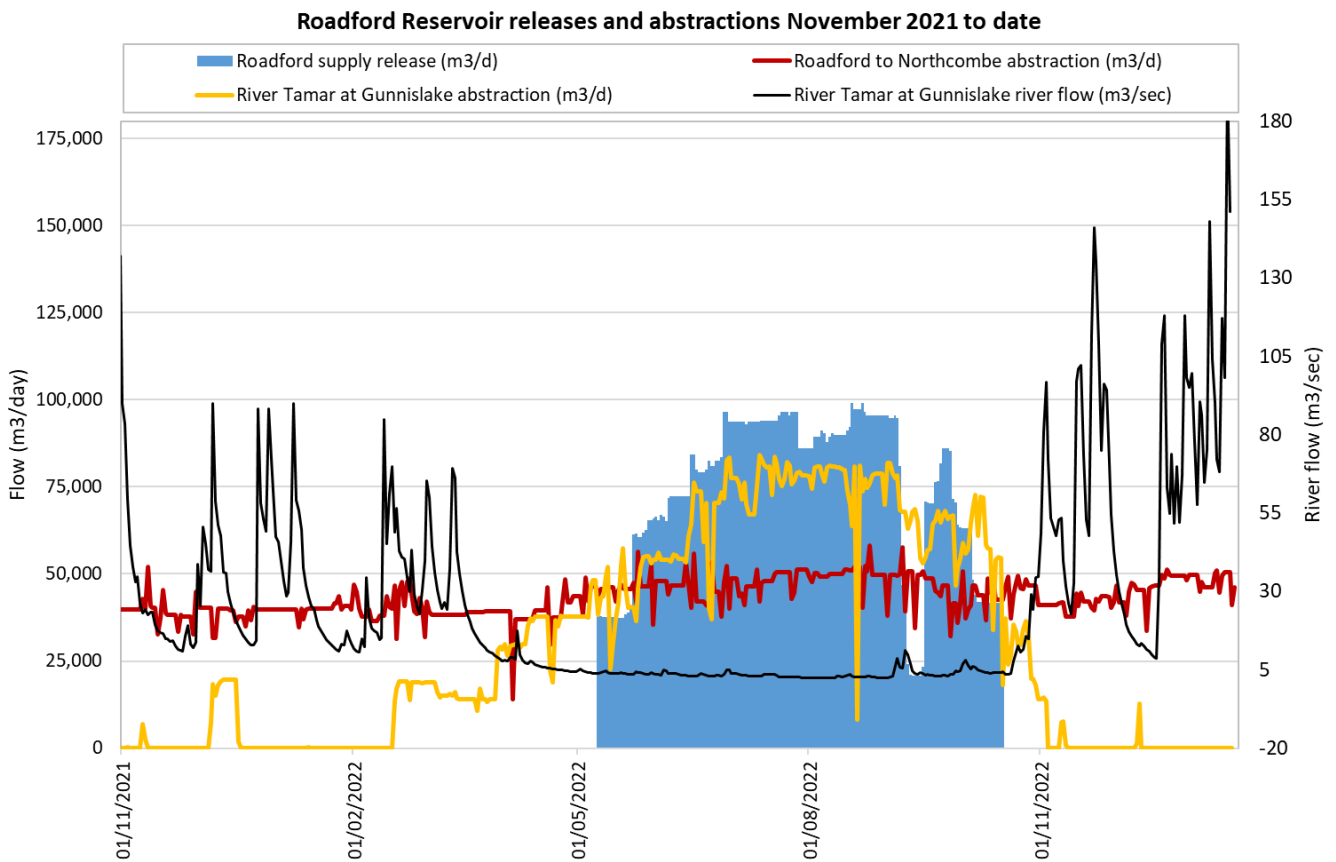


Figure 16 Overview of Roadford Reservoir releases and Gunnislake abstraction since November 2021.

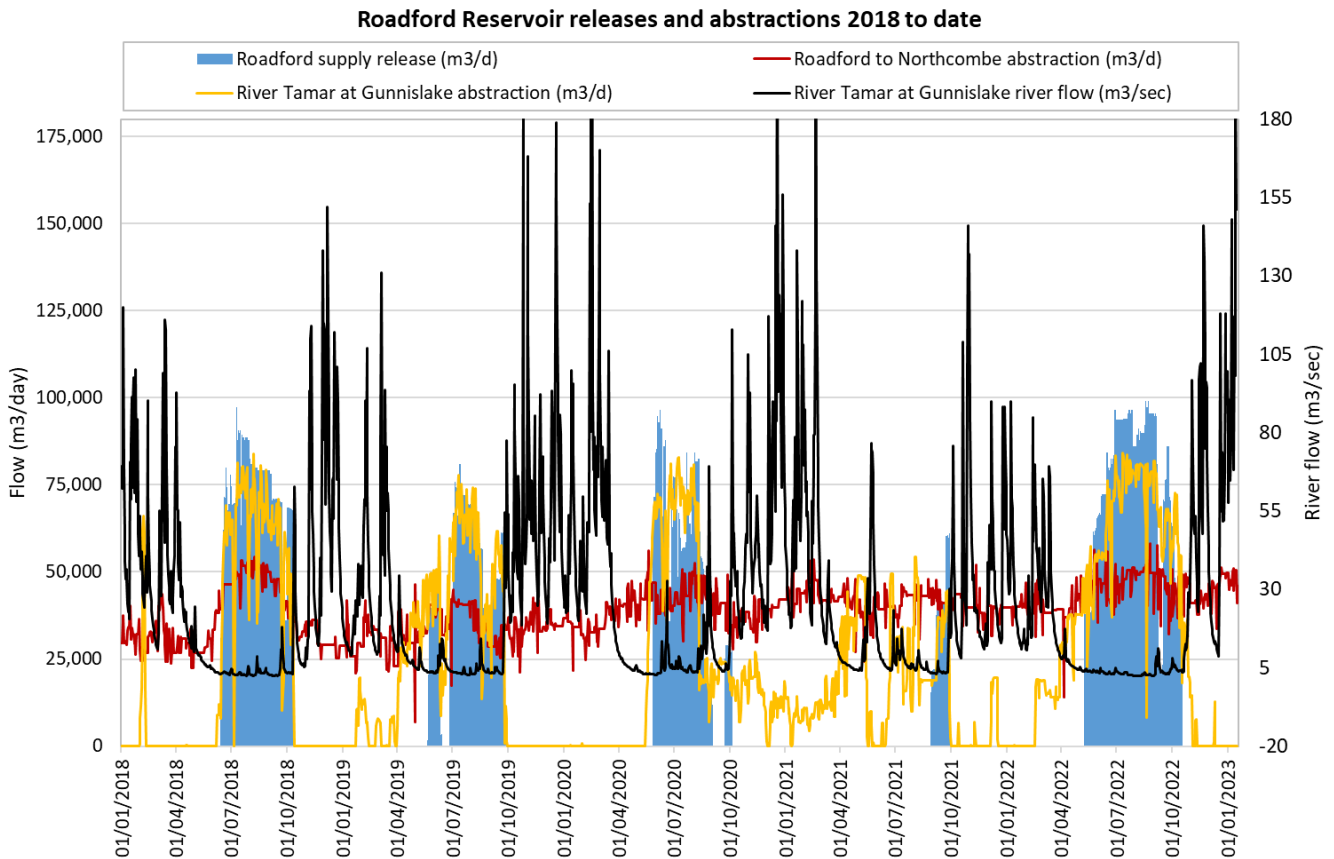


Figure 17 Overview of Roadford Reservoir releases and Gunnislake abstraction since 2018..

4 Drought Recovery Winter 2022/23

This section discusses the storage recovery over winter 2022/23 starting from November 2022 to present day following the ESOR period of March 2022 to August 2022.

The rainfall in November 2022, late December 2022 and early January 2023 was exceptionally high moving the rainfall LTA to 95% by the end of January 2023 since the start of the ESOR period of March 2022 (Figure 5). The rainfall SPI also recovered and reports as “Near Normal” (Figure 8). However there has been a period of dry weather since mid-January with very low rainfall, February total rainfall was only 22.5% of LTA, although the SPI is still categorised as “Near Normal” for the “main period” from March 2022 to February 2023 due to the previous wetter months from September to January.

River flows recovered early in November 2022 and reported record high totals for Roadford Reservoir inflows in January 2023 (Figure 14). Notably high flows were also recorded in November 2022 for Roadford Reservoir and in November 2022 and January 2023 for the River Tamar at Gunnislake. The subsequent dry 6 weeks since mid-January 2023 has resulted in low river flows. Roadford inflows were 20% of LTA in February 2023 (Table 3), the 2nd driest on record following the highest ever January. The Tamar at Gunnislake is at 28% LTA, the 5th driest February 2023 on record.

Roadford Reservoir storage is for the full period shown in Figure 18 and a shorter period from November 2022 is shown in Figure 19 in comparison with the rainfall over this period. At the start of the refill period storage was the 2nd lowest on record at 33.5% in October 2022. Storage recovery was at nearly it's fastest rate on record during November 2022 in response to high rainfall and subsequent high inflows. The dry spell in early December 2022 however led to a stall in the reservoir recovery and a small drop in reservoir levels because the Northcombe abstraction and reservoir compensation releases exceed the reservoir's inflows over this period. Recovery continued in the wet four weeks in late December 2022 and early January 2023 before stalling again in mid-January and now decreasing through February 2023 and in early March 2023. At the end of February 2023, following the 2nd driest Roadford inflows in February on record, the reservoir storage level crossed the drought level 2 control curve.

The Roadford storage position in March 2023 is a direct consequence of the ESOR between March 2022 and August 2022 and the significant drawdown over this period which extended into September 2022 and October 2022 due to the delayed hydrological recovery as outlined in Section 3.1. As outlined in Section 1.3, Roadford Reservoir is a multi-season reservoir and the drawdown in one year can pose significant risks to the supply position in subsequent years. Despite the high rainfall of 121.73% LTA between September 2022 to February 2023, Roadford reservoir storage only saw recovery of 25% from October 2022 to February 2023. The impacts of the March 2022 to August 2022 ESOR therefore continues to present substantial risk to water supply in 2023.

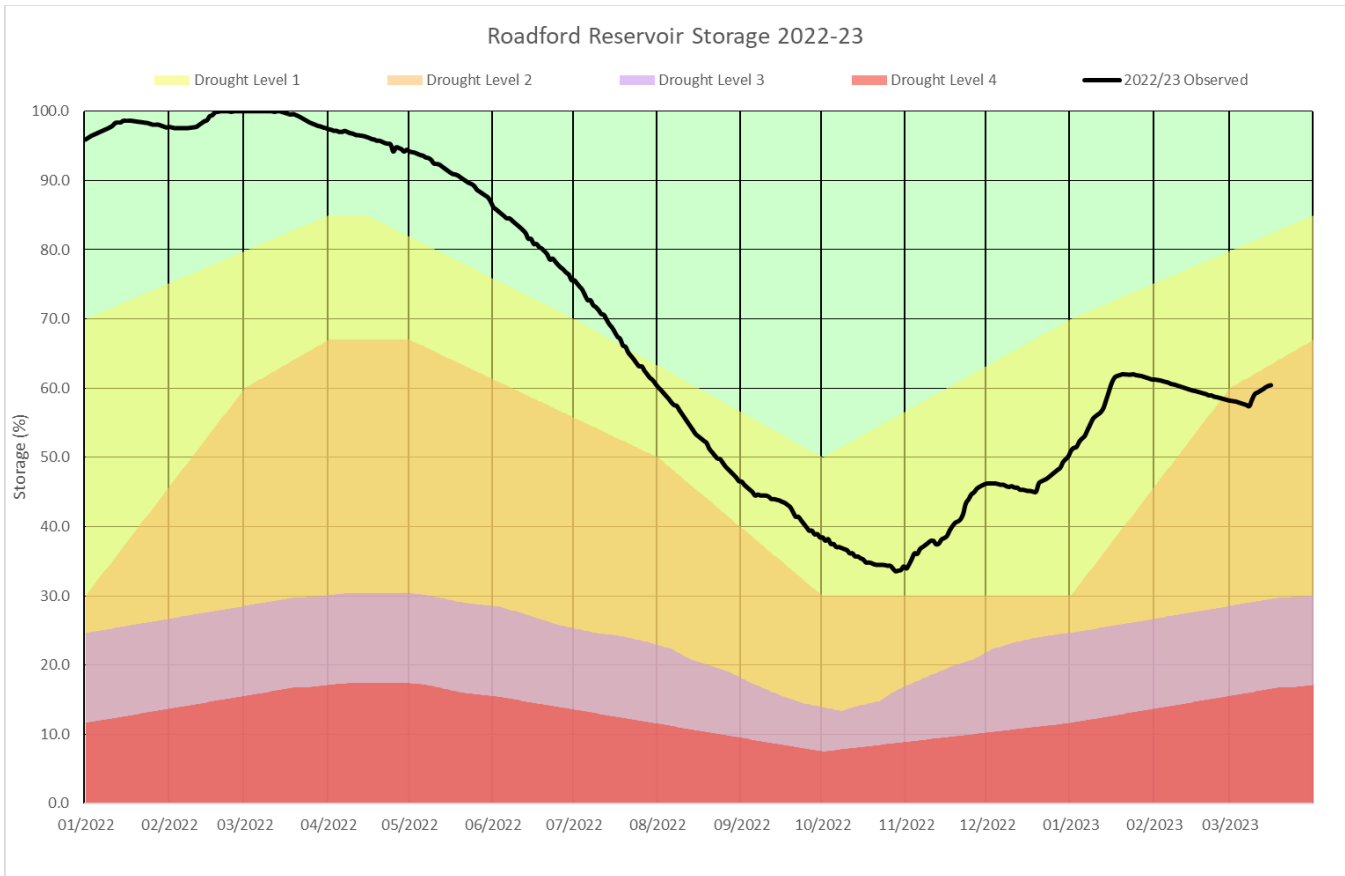


Figure 18 Roadford Reservoir storage 2022 to present

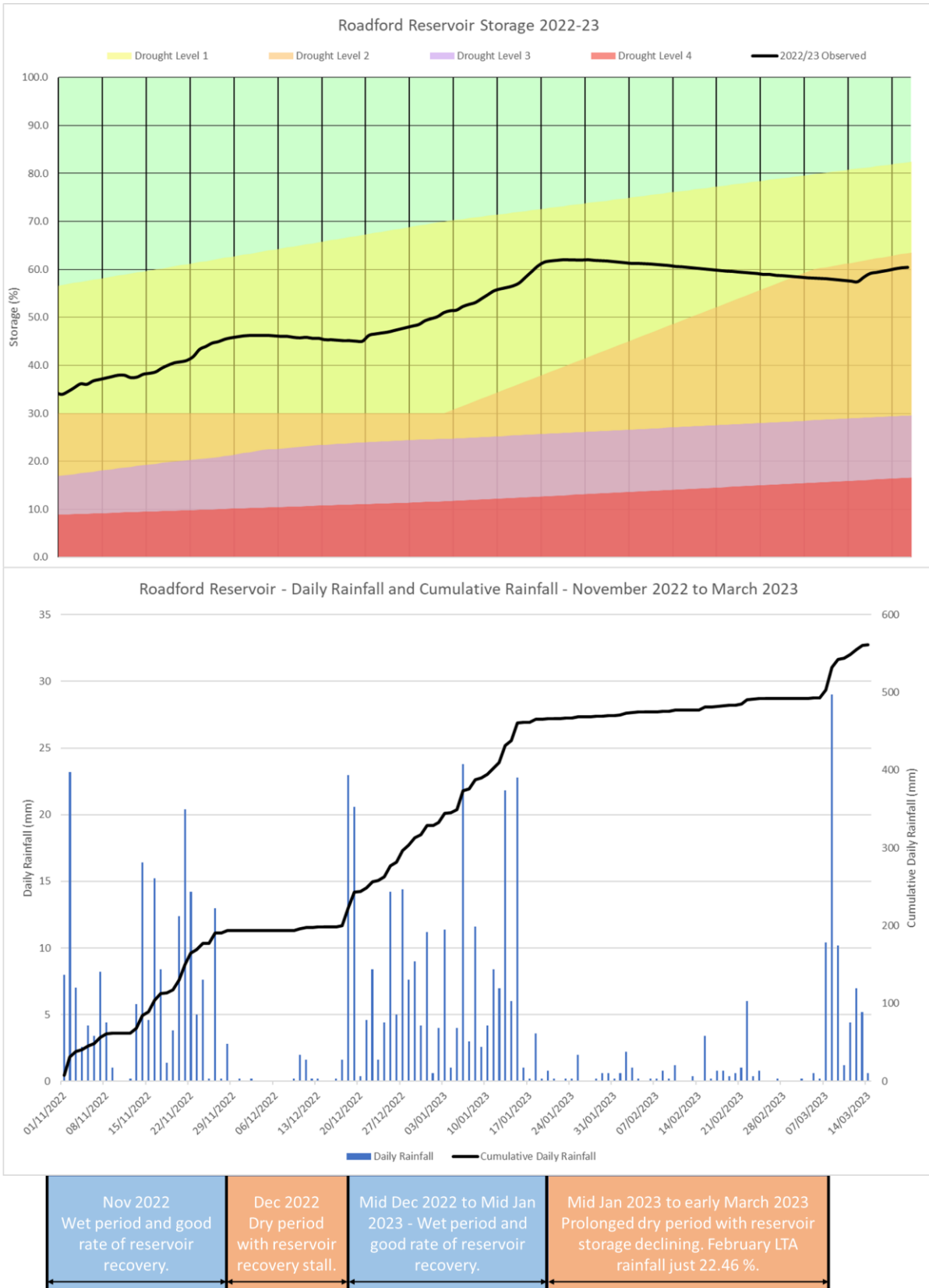


Figure 19 November 2022 to mid March 2023 showing the Roadford Reservoir storage (top panel) and daily rainfall and cumulative daily rainfall (bottom panel).

5 Forward Look

5.1 Met Office 3-month outlook

The Met Office 3-month outlook⁴ for March to May suggest that rainfall has a 30% chance of being drier than average, 60% chance of being average and a 10% chance of being wetter than average and that this means there is a “higher than normal chance of a dry spring”. Whilst on the balance of probabilities this suggest it is most likely that spring will still be “average”, there is an increased likelihood of high pressure dominating our weather through March due to the recent Sudden Stratospheric Warming.

The UK Hydrological Output⁵ uses the Met Office 3-month outlook to simulate the impacts on rivers flows which takes account the antecedent conditions of the recent hydrological position. The current outlook for “March and for March-April-May as a whole is for river flows and groundwater levels to be normal to below normal across the UK”.

These forecasts suggest that it is unlikely that we will experience a wet spring which would support additional reservoir storage recovery and delay the need to use Roadford Reservoir to support the wider WRZ. The effects of the March 2022 to August 2022 ESOR are therefore more likely to be exacerbated into the 2023 reservoir drawdown period by the current 3-month outlook.

5.2 South West Water Reservoir Projections

South West Water have been developing reservoir projections to the end of March 2024 to help plan the summer 2023 drawdown period and also the recovery through next autumn/winter. The projections in Figure 20 are based on building risk profiles from our historical period of record assuming 95th, 75th and 50th percentiles of risk. The dashed lines represent our risk curves with interventions we are currently doing and the solid lines represent interventions that we are planning and will come “online” providing benefit in the future. With reference to the 3-month outlook and the “higher than normal chance of a dry spring” it is unlikely that reservoir storage will outperform the 50th percentile projection and increases the likelihood that we would follow either of the 75th or 95th percentile projections and therefore increases the risk to our water resource position.

⁴ [3_month_outlook_only_template \(metoffice.gov.uk\)](https://www.metoffice.gov.uk/forecast/outlook/3-month-outlook-only-template)

⁵ https://hydoutuk.net/sites/default/files/2023-02/2023_02_HO_Complete.pdf

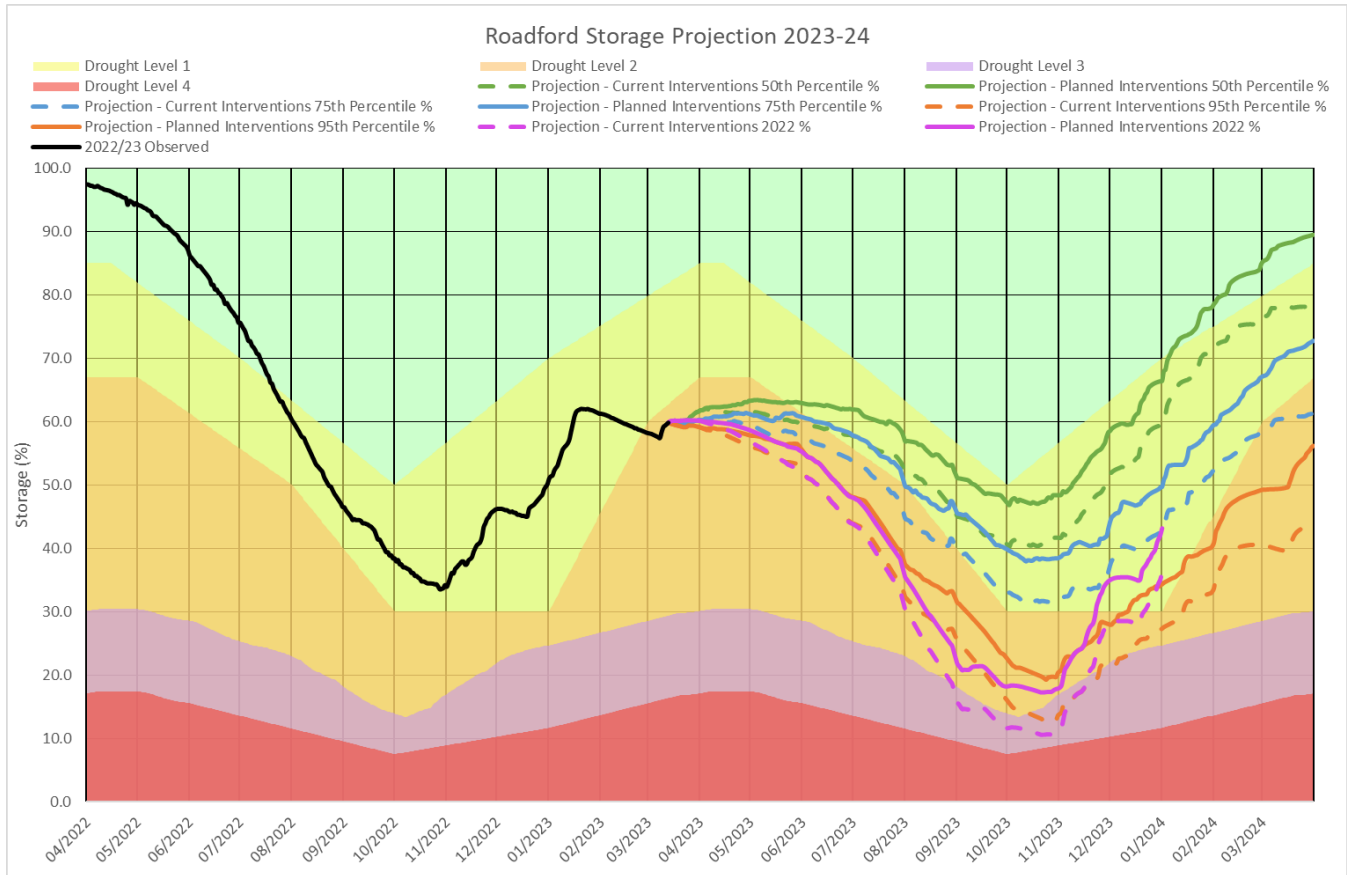


Figure 20 Roadford Reservoir projection to end of March 2024.

6 Summary

An ESOR assessment for the Roadford WRZ has been presented for the “main period” of March 2022 to February 2023 and a “sub period” of March 2022 to August 2022. Whilst there has not been an ESOR for the “main period” due to a period of higher than average rainfall from September 2022 to February 2023 the “sub period” does demonstrate an ESOR and was the 3rd driest period on record. This rainfall “sub period” subsequently caused knock on impacts to hydrological and water supply systems with Roadford Reservoir drawdown starting in March 2022 and continuing until October 2022. The 2022 event is the longest sustained drawdown on Roadford Reservoir since the 1995 drought event with minimum levels of 33.5% reached in October 2022. This is a direct consequence of the length of time supply releases were being made due to the low River Tamar flows and the low resources in local sources across the WRZ.

Analysis of the Environment Agency’s DRT rainfall dataset for the Roadford WRZ Roadford WRZ rainfall from March 2022 to August 2022 demonstrated the period was the 3rd driest on record and was categorised as “Exceptionally Low” based on ranked rainfall probability bands and “Extremely Dry” based on rainfall SPI analysis. Based on this assessment it is considered that this constitutes an ESOR.

Supplementary analysis of soil moisture deficit, river flows, and the water supply system demonstrate how the ESOR from March 2022 to August 2022 impacted the wider hydrological

and water supply systems and continues to impact the water supply position in Roadford Reservoir in March 2023.

The weather and hydrological outlook for spring 2023 is for a “higher than normal chance of a dry spring” which means the effects of the March 2022 to August 2022 ESOR are therefore more likely to be exacerbated as we enter the 2023 reservoir drawdown period.