Drought Plan 2019
Annex 2: Scenario testing and what ifs

July 1, 2019
Version 1

from Southern Water

Contents

Introduction

This annex provides a description of how Southern Water would typically respond to historic and stochastic drought patterns if they were repeated under current supply system capability and customer demand patterns.

This annex has been presented using a mixture of tables and descriptions and figures to explain the overall process and timing, and reflects the inclusion of the overall supply / demand analysis as a key part of the drought decision process. However, the timing of actions and breaching of respective trigger levels are broadly based on analyses of historic conditions against the trigger values and charts presented in Annex 1.

It should be noted that all trigger curves have been developed based on return period analysis using historically and stochastically generated sequences. Therefore, whilst only the more severe droughts are presented for full scenario analyses within this section, breaches of trigger curves during less severe droughts have been specifically designed to occur at the intervals stated within Annex 1. The drought scenarios presented in this Annex are designed to demonstrate that the system and triggers used by Southern Water provide sufficient time for effective intervention; they are not designed to show how often specific triggers are breached.

Contact with statutory consultees

Under normal conditions the company is in regular contact with statutory consultees regarding a range of issues. Under all the drought scenarios assessed below, the statutory consultees will be informed as soon as the company is in a situation of impending drought in order to agree an enhanced schedule of reporting, face-to-face and telephone meetings for the duration of the drought and, following cessation of the drought, the period of de-escalation. This schedule would be adapted as required to ensure that the formal requirements for consultation with the statutory consultees are fulfilled with regard to each Drought Permit and Drought Order application.

In relation to the Test Drought Permit and Drought Order, the Candover Augmentation Scheme Drought Order and the Lower Itchen sources Drought Order, the Section 20 Operating Agreement (s20 agreement) sets out specific engagement activities with the Environment Agency and Natural England which are required in ‘normal’ weather conditions as well as in a situation of impending drought. In particular this includes regular 6-month reviews of the Test Drought Permit application documents.

Further information on our communication and management activities during drought can be found in Annex 8 of this plan.

Analysis of plan using historic droughts

When we write drought plans we test them using historic droughts. The following sections provide an overview of some of the testing that we have undertaken during the development of this Drought Plan. This analysis is important to us to ensure that the plans are robust and we can put in place interventions in a timely manner.

The next section describes the historical droughts that were selected. We use these droughts in our scenario testing phase, which is presented in a subsequent section. Due to the fragmented nature of our supply area and the mix of source types in each supply area there are a number of different historical droughts that have been selected.

Selected historical droughts

Eastern area

In order to demonstrate timescales and the suitability of drought responses during critical drought conditions, information on the 1901-03 and 1921-22 droughts is provided in this annex. Details for other droughts have not been provided as these are either less severe (and hence involve fewer triggers) or stop suddenly (e.g. 1976 is very similar to 1921, but stops abruptly in the September of 1976).

In terms of recent droughts, 2004-07 was similar to the 1921-22 event, but extended into a second dry winter that just touched the 1 in 20 year control curve for Bewl Water reservoir. Hosepipe bans were therefore imposed during 2005 and Drought Permits for the River Medway Scheme were applied for during the 2005-06 winter to enhance the winter refill of Bewl Water reservoir. Drought Order applications (including a ban on non-essential use (NEUB)) were applied for in the spring of 2006 but in practice wet spring and summer conditions meant that these did not need to be implemented.

Central area

In order to demonstrate timescales and the suitability of drought responses during critical drought conditions, information on the 1921-22 drought and the 1976 drought are provided in this annex. Details for other droughts have not been provided as these are less severe (e.g. 1933-34), or only affect groundwater resources (e.g. 1973).

In terms of recent droughts, 2004-07 was similar to the 1921-22 event, but there was greater rainfall in the autumn of 2005 that delayed the need for Drought Orders. Following the second dry winter in 2006, it became necessary to apply for a ban on non-essential use, but the wet summer meant that this did not need to be implemented.

Western area

The Western area has not historically been vulnerable to drought. However, as a result of changes to licence conditions, the Western area is now more vulnerable to drought than it was previously. In order to minimise this risk an agreement was reached between Southern Water and the Environment Agency as part of the River Itchen, River Test and Candover abstraction licence Public Inquiry process (the s20 agreement). Consequently the Western area is now more vulnerable to drought than it was previously.

Due to the signficiant change in position three droughts have been selected for analysis here: 1921-22, 1976 and 2011-2012. These example droughts represent different levels of severity, demonstrating how our Drought Plan would operate under a range of conditions.

The situation for the Isle of Wight is complicated by the fact that it is supported by the cross-Solent transfer main. Due to the risk to supply on the Isle of Wight through dependency on this transfer, precautionary measures such as temporary bans on water use and preparation of a Drought Permit for Lukely Brook would be applied during certain droughts. The Isle of Wight is generally most vulnerable to shorter, severe drought sequences such as 1921 or 1976 and measures such as Temporary Use Bans or Drought Permits would be introduced when triggers fell below the relevant thresholds and the risks to supply from even partial outages of the cross-Solent main became too great.

Scenario testing and timelines for critical historic droughts

Eastern area

This section provides analysis for key indicators in the Eastern area during severe, historically based, drought scenarios. It concentrates on the most significant surface, groundwater and reservoir storage indicators, which would be supported operationally during an actual drought by other indicators, including supply / demand forecasts, other reservoirs, groundwater levels at Little Bucket and cumulative rainfall deficit charts. These have not been included because they would either depend on exact operations in the year prior to the drought (e.g. supply / demand forecasts), are not available for historic droughts such as the ones being modelled (e.g. Little Bucket) or would simply reflect the timelines on the charts that are shown (other reservoirs and cumulative rainfall deficits).

When the company reaches impending drought, this will be formally communicated to the statutory consultees and at this point a schedule of face-to-face and telephone meetings with the relevant bodies will be agreed. The schedule would also include sharing the fortnightly water situation reports produced by the company's Drought Technical Group, which would be convened as soon as it is confirmed that the company is in impending drought. The regularity of these reports, which detail water levels and triggers, would be reviewed as the drought progresses and following the cessation of the drought through to the end of the drought de-escalation process. Annex 6 of this Drought Plan has more information on the management process the company will use in a drought event.

When the company reaches the point of needing drought permits / orders, these will be selected based on the guiding principle that, where there is a choice in which permit / order to apply for in order to resolve a threat to supplies, the Company will select the option on the basis of the current state of the environment and the potential impact after implementing the licence relaxation.

1901-03 type drought event

The 1901-03 drought is overall the most severe drought for the Eastern area in the historical record due to the length of the drought. Very limited refill occurs between the winter of 1900/01 to spring 1903 resulting in a continuous recession over an extended period and persistent very low groundwater levels.

Key selected trigger profiles for the 1901-03 drought are provided in Figure 1. This shows that the following drought actions and timings would be taken in response to the drought:

- Going into the drought, the long term (30 month) rainfall indicator (not shown) would already indicate concern with deficits from the previous dry period (1897-1899), but reservoir levels would be reasonable. Groundwater levels in the Medway area (as shown by Oad Street observation borehole) would also be already relatively low, approximately at the impending drought trigger . Enhanced company management, and source drought operation would therefore be in place for this zone.
- Poor winter refill, and short term (12 month) rainfall would be a concern following the winter of 1900-01, but the later recharge in spring that year (1901) would mean that further action would not be taken prior to the summer.
- Concerns over groundwater levels would trigger the relevant media campaigns prior to the summer event, but as reservoir stocks and rainfall would not be past the impending drought trigger thresholds, it is unlikely that restrictions would be considered necessary.
- The lack of recharge in autumn / winter 1901 would lead to concerns in all indicators, and supply / demand forecasting would commence. Preparations would be made for a winter Drought Permit for the River Medway Scheme, with activities commencing in November or early December. The continuing decline of long term rainfall and groundwater levels towards

the drought trigger threshold would then result in a winter Drought Permit for the River Medway Scheme being implemented during January 1902, by which time the drought trigger threshold would have been breached.

- The lack of later winter / spring recharge and the resulting very low groundwater levels would result in temporary restrictions being introduced in early spring 1902. Supply / demand forecast scenarios and a continuing decline in groundwater levels would then result in non essential use bans being considered at the start of summer 1902, with the intention that these should be in place by late summer / early autumn.
- The continuing lack of recharge would lead to autumn Drought Permits being sought for the River Medway Scheme, along with a winter Drought Permit for Darwell and / or Powdermill. The company would then prepare for and implement Phase 2 restrictions in spring 1903. The very wet conditions in spring 1903 would then be shown through the shorter term rainfall and reservoir responses, preventing the need for further escalation. Groundwater recovery and longer term indicators would result in the gradual removal of restrictions through the summer and autumn of 1903.

1921-22 type drought event

The 1921-22 event was a two-year drought, although 1921 was much more severe than 1922. 1921 represents a 'whole season' single year drought, where dry winter was followed by very little rainfall right through the summer and autumn. Rainfall deficits were less severe than those experienced further west.

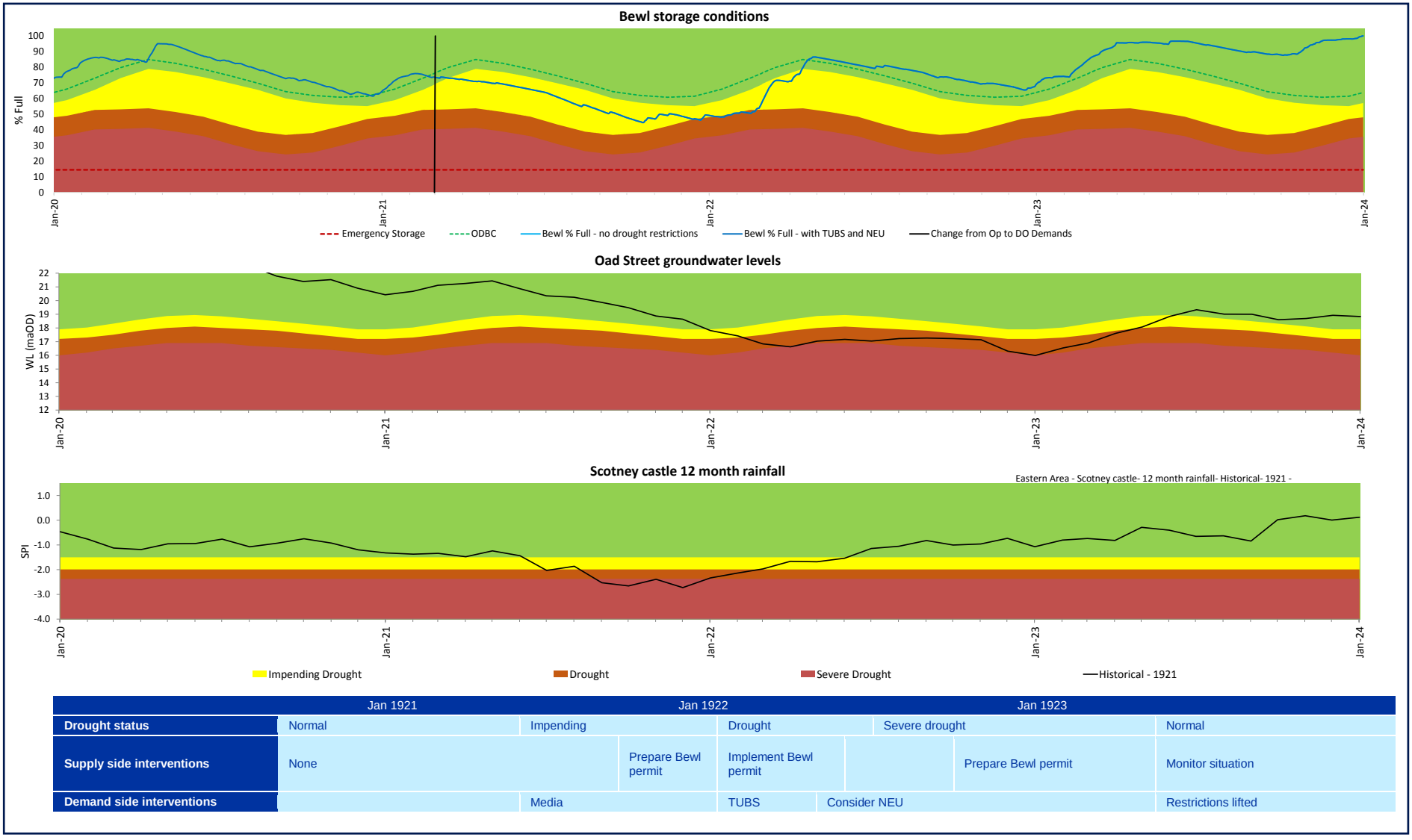
Key selected trigger profiles for the 1921-22 drought are shown in Figure 2. The key differences between this and the 1901-03 style event are as follows:

- Groundwater would be relatively high prior to the drought, and for the purposes of this scenario analysis the assumed demand on Burham has been modelled as being relatively low prior to the drought event. The rainfall triggers would therefore provide the lead warning indicators in this case, although it should be noted that reservoir levels at Bewl could be lower depending on actual operational behaviour prior to the drought. Media notices would therefore be issued prior to the summer of 1921, but temporary bans during that summer are unlikely unless reservoir levels were lower than shown. There would be a clear warning of deteriorating conditions during the autumn of 1921, so a River Medway Scheme Drought Permit would be applied for relatively early in the winter season and used during the latter half of the 1921-22 winter.
- Conditions severe enough to require non essential use bans would be threatened during winter / spring 1922, and the supply / demand forecast would indicate that these might be necessary. The required application would therefore be made, but the spring rainfall as evidenced in the 12 month deficit indicator, and reflected in the 30 month indicator, would likely be sufficient to delay the imposition of this level of restriction or further supply side interventions. There may be concerns over early winter recharge in 1922 (particularly in relation to groundwater), and a second winter Drought Permit for the River Medway Scheme would be applied for, but probably not used following rainfall later on. Temporary water use restrictions would be lifted in spring 1923.

Figure 1 Analysis of '1901-1903' style event responses for the Eastern area

	Jan 1901			Jan 1902		Jan 1903		
Drought status	Normal	Impending	Drought (GW levels)	Drought		Severe drought		Normal
Supply side interventions	Conditions monitored		Prepare River Medway permit	Implement River Medway permit		Autumn River Medway permit, Darwell or Powdermill permit	Monitor situation	
Demand side interventions	Conditions monitored	Enhanced management	Media	TUBS		NEU	Phase 2	Restrictions lifted

Figure 2 Analysis of '1921-1922' style event responses for the Eastern area



	Jan 1921		Jan 1922		Jan 1923	
Drought status	Normal	Impending	Drought	Severe drought		Normal
Supply side interventions	None	Prepare Bewl permit	Implement Bewl permit		Prepare Bewl permit	Monitor situation
Demand side interventions		Media	TUBS	Consider NEU		Restrictions lifted

Central area

This section provides analysis for key indicators in the Central area during severe drought scenarios. It concentrates on the most significant surface, groundwater and rainfall indicators, which would be supported operationally during an actual drought by other indicators, including supply / demand forecasts, Weir Wood reservoir levels, groundwater levels at Chilgrove and cumulative rainfall deficit charts. These have not been included here because they would either depend on exact operations in the year prior to the drought (e.g. supply / demand forecasts), or are of secondary concern during the droughts highlighted here.

When the company reaches impending drought, this will be formally communicated to the statutory consultees and at this point a schedule of face-to-face and telephone meetings with the relevant bodies will be agreed. The schedule would also include sharing the fortnightly water situation reports produced by the company's Drought Technical Group, which would be convened as soon as it is confirmed that the company is in impending drought. The regularity of these reports, which detail water levels and triggers, would be reviewed as the drought progresses and following the cessation of the drought through to the end of the drought de-escalation process.

When the company reaches the point of needing drought permits / orders, these will be selected based on the guiding principle that, where there is a choice in which permit / order to apply for in order to resolve a threat to supplies, the Company will select the option on the basis of the current state of the environment and the potential impact after implementing the licence relaxation.

1921-22 type drought event

The 1921-22 event was a two-year drought, although 1921 was much more severe than 1922. For the Central area, 1921 represents a very severe 'whole season' single year drought, where an extremely dry winter was followed by very little rainfall right through the summer and autumn. 1922 was also very dry, but summer rainfall kept flows higher at Pulborough, and provided much larger inflows to Weir Wood reservoir.

Key selected trigger profiles for the 1921-22 drought are provided in Figure 3. This shows that the following drought actions and timing would be taken in response to the scenario conditions:

- Both the key groundwater indicator in the Sussex coastal area (Whitelot Bottom) and the evaluation of river flow deficit at Pulborough reflect the poor winter recharge that occurred during 1920-21, with both indicators below the impending drought trigger from April onwards. Although short term (12 month) rainfall deficits would not yet have breached the impending drought trigger level, the long term (24 month) rainfall deficits would have, and their rapid recession combined with the surface and groundwater indicators would mean that drought operations (including the Portsmouth transfer) would be instigated for existing water resources. Enhanced monitoring and forecasts (including supply / demand assessments) and media messages would be introduced. Due to the rapid recession, enhanced environmental monitoring and preparation for a Drought Permit would commence at Pulborough.
- Once the rainfall reached the drought trigger in June, temporary use bans would be introduced and preparation for a Pulborough drought permit undertaken.
- During July, continuing dry conditions would result in all indicators heading towards drought triggers, and therefore non essential use bans prepared and an autumn / winter Drought Permit at Pulborough implemented. In September, the lack of rain and delayed recharge would see both non essential use bans and an autumn / winter Drought Permit at Pulborough being applied for, with an implementation in October prior to the minimum groundwater level conditions. This would provide essential extra resources at Pulborough during very low flows in the autumn period.

- Winter rainfall in 1921-22 was limited, but would be sufficient to prevent further action being required, and a spring Drought Permit would not be sought at Pulborough. The non essential use bans may be lifted. The continuing drought conditions would mean that these may need to be re-introduced in the autumn, along with a further Drought Permit at Pulborough. These would be lifted once significant rainfall occurred in winter 1922-23.

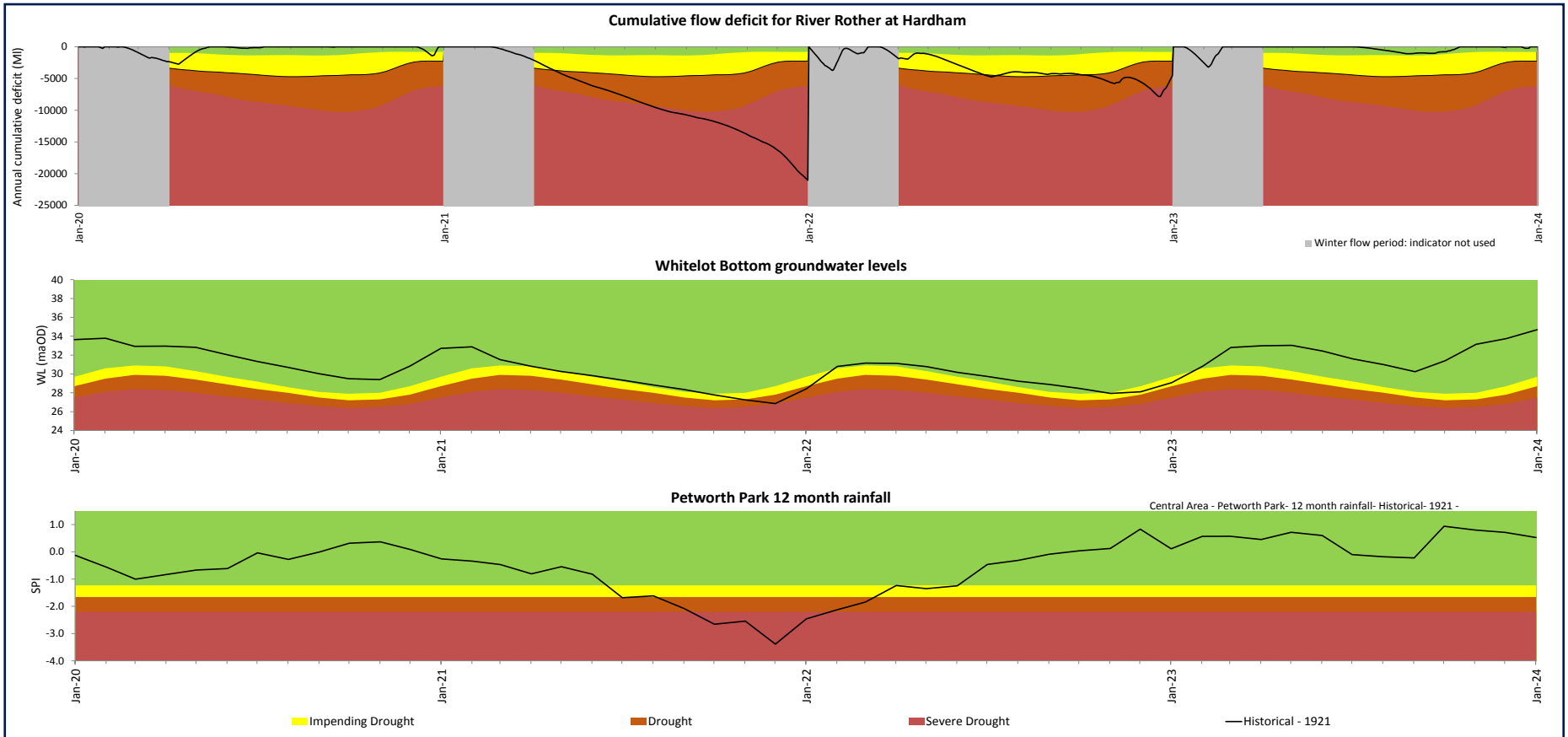
1976 type drought event

The 1976 event was a one-year drought. This drought was a combination of an extremely dry period from winter 1975-76 through to September 1976, combined with extremely high demand.

Key selected trigger profiles for the 1976 drought are provided in Figure 4. The actions and timelines are very similar to the 1921-22 style drought, but obviously the interventions would be curtailed as a result of the drought breaking in September. However, there are some notable exceptions that would affect the timing of interventions:

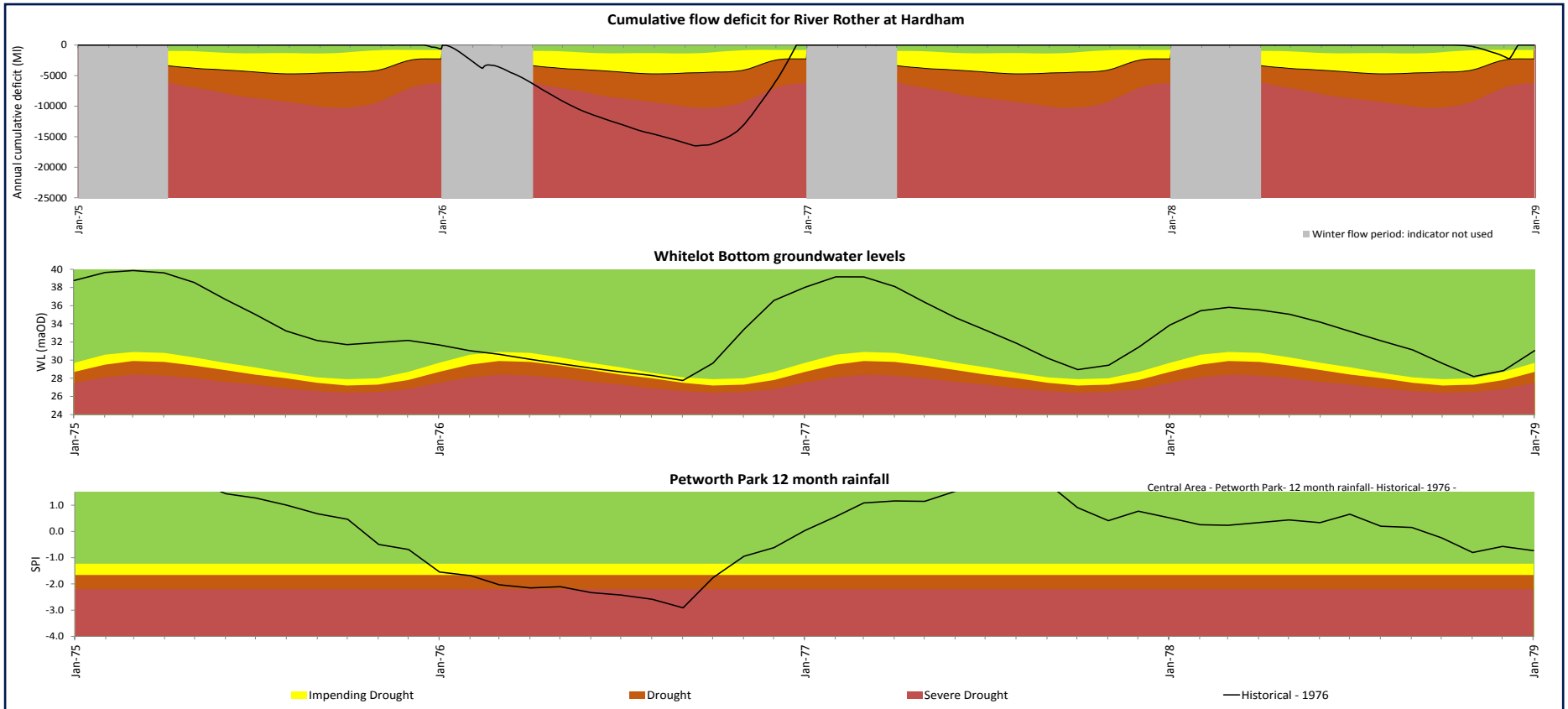
- Because of relatively higher rainfall and hence groundwater levels in 1974-75 prior to the event, 1976 would not be as significant a concern for Sussex Brighton and Worthing WRZs as the 1921 style event. The 24 month rainfall indicator would not show a significant drought, and even the 12 month indicator would not show a severe drought trigger breach until May. Although groundwater indicators would breach the impending drought trigger relatively early (March), the recession would clearly remain within the impending drought trigger zone.
- However, the 12 month rainfall deficit would be more severe in the Sussex North WRZ and the surface water recession at Pulborough would be of significant concern from very early on in the spring, with both indicators breaching the drought threshold in March. Overall, the balance of intervention would therefore be to introduce early temporary use bans to maintain groundwater resources in Sussex Brighton and Worthing so they could provide support to Sussex North during the summer.
- The deteriorating trend would then be enough so that non essential use bans and a Drought Permit at Pulborough would be prepared and applied for during the summer, with a planned September implementation. In the event, the very high rainfall in September would quickly result in recovery in all measures and they would not need to be implemented, except possibly for a brief period during early September.

Figure 3 Analysis of '1921-1922' style event responses for the Central area



	Jan 1921		Jan 1922		Jan 1923		
Drought status	Normal	Impending	Drought	Severe drought	Drought		Normal
Supply side interventions	None	Drought operations. PW transfer. Prepare Pulborough drought permit	Implement Pulborough permit	Implement second stage Pulborough permit.		Implement Pulborough permit	Monitor situation
Demand side interventions		Media	TUBS	NEU	Lifr NEUs		Lift restrictions

Figure 4 Analysis of '1976' style event responses for the Central area



	Jan 1976		Jan 1977			Jan 1978
Drought status	Normal	Impending	Drought	Severe drought	Drought	Normal
Supply side interventions	None		Prepare Pulborough drought permit	Implement Pulborough permit for short period then remove		Monitor situation
Demand side interventions		Media	TUBS	NEU	Lift NEU	Lift restrictions

Western area

This section provides analysis for key indicators in the Western area during severe, historically based, drought scenarios. It concentrates on the most significant surface water and rainfall indicators, which would be supported operationally during an actual drought by other indicators, including supply / demand forecasts, groundwater levels at Meon, near Andover and Newport and cumulative rainfall deficit charts. These have not been included here because they would either depend on exact operations in the year prior to the drought (e.g. supply / demand forecasts), or are of secondary concern during the droughts highlighted here.

Analysis has concentrated on events in south Hampshire, as this provides a key transfer to the Isle of Wight that is more significant in water resources terms than the impact of drought upon the indigenous sources on the Isle of Wight. Drought Permits and Orders on the Isle of Wight would be implemented based on the trigger thresholds set out in Table 7 of Annex 4. These options would reduce the the risk to supply on the Isle of Wight through dependency on the cross-Solent transfer. The order of implementing Drought Permits and Orders on the Isle of Wight relative to those in south Hampshire will be influenced by the potential environmental impact of each option, taking account of the prevailing environmental conditions during an actual drought (see Annex 4 for more details).

There is no gauged record for the Total Test Flow, although the period 1996 – 2015 is available as a compiled/estimated record from a number of measuring points. As a result, model output from the Aquator model run DP1008_h (with drought orders) has been used to assess the drought response against the 1921-22 and 1976 droughts. The compiled record (usually referred to as DG100) has been used in the assessment of the 2012 drought.

Although Western area has previously not been vulnerable to drought conditions, recent changes in the licence conditions mean the area is more vulnerable to drought than it was previously, as evidenced in Figure 5 to Figure 7.

In line with the provisions of the s20 agreement, the Test Surface Water Drought Permit will be ‘application ready’ during ‘normal’ conditions and there will also be regular 6-monthly dialogue with statutory consultees and interested stakeholders about the risk of needing to apply for and implement the permit. This reflects the risk of needing to apply for the Test Surface Water Drought Permit during ‘normal’ drought conditions due to the rate at which flows in the lower River Test can fall towards the trigger flow for making an application. If an application is made, we will adopt the same approach to managing the drought as we adopt in other areas during ‘impending’ drought conditions, but focused only on the River Test.

When the impending drought triggers are reached for Western area, this will be formally communicated to the statutory consultees and interested stakeholders. At this point a more regular schedule of face-to-face and telephone meetings with the relevant bodies will be agreed. The schedule would also include sharing the fortnightly water situation reports produced by the company’s Drought Technical Group, which would be convened as soon as it is confirmed that the company is in impending drought. The regularity of these reports, which detail water levels and triggers, would be reviewed as the drought progresses and following the cessation of the drought through to the end of the drought de-escalation process. Annex 6 of this Drought Plan has more information on the management process the company will use in a drought event.

As specified in the s20 agreement, a range of actions are set out for implementation in relation to the drought management measures for the lower River Test and the River Itchen. These include: a specified sequence of actions; specified flows for implementing Drought Permits/Orders; a specified flow for applying for a Drought Order to authorise Non-Essential Use restrictions (but not a flow for implementation) for example. These arrangements dictate the 'flat' profiles for Drought and Severe Drought that are shown in Figure 5 to Figure 7. Some actions specified in the Section 20 Agreement need to be carried out in 'normal' conditions, in particular providing regular 6 monthly updates to the Environment Agency of the Test Drought Permit application documents.

When the company reaches the point of needing drought permits / orders, these will be selected based on the guiding principle (and which is included in the s20 agreement) that, where there is a choice in which permit / order to apply for in order to resolve a threat to supplies, the company will select the option on the basis of the current state of the environment and the potential impact after implementing the licence relaxation.

1921-22 type drought event

Key selected trigger profiles for the 1921-22 drought are provided in Figure 5. This shows that the following drought actions and timing would be taken in response to the scenario conditions:

- The flow in both the River Test and Itchen drop to the impending drought trigger around April and continue to decline throughout the year as the drought progresses. Even though the 12 month rainfall indicator is just above the impending drought threshold, drought operations would be instigated for exisiting water resources in April, and the bulk supply from Portsmouth Water would be intitiated. Enhanced monitoring and forecasts (including supply / demand assessments) and media messages would be introduced.
- Enhanced environmental monitoring and application for a Drought Permit would commence at the River Test in July, in anticipation of an ongoing recession and the need for a 60-day pre-consultation lead in period and a 35 day application lead-in period for the Test Surface Water Drought Permit (as specified in the Section 20 Agreement).
- As the flow drought threshold is breached in September, Phase 1 temporary water use restrictions are implemented. The severe drought threshold is breached soon after, triggering the Test Surface Water Drought Permit then application for a Drought Order to authorise implementation of the Phase 1 non essential water use ban. .
- As the flow on the Itchen approaches 205 Ml/d, treated water transfers from Hampshire Southampton West WRZ to Hampshire Southampton East WRZ would be initiated to help maintain supplies to customers. Preparations for the Drought Orders for the River Test, Candover Augmentation Scheme or the River Itchen (taking account of the prevailing ecological conditions in each river) and Lukely Brook Drought Permit would commence.
- By December, the Candover Drought Order would likely be implemented (but this will depend on the prevailing ecological conditions) to enable flows at Allbrook & Highbridge to remain above 205 Ml/d and thereby defer the need to apply for Drought Orders for the Lower Itchen sources (Southern Water and Portsmouth Water sources). This will result in a slight increase in flow at Allbrook & Highbridge.
- With the recovery in rainfall, flows in both the River Test and River Itchen rapidly recover, with normal conditions being obtained by February. Rainfall recovery continues longer, with normal conditions only being reached in April.

1976 type drought event

Key selected trigger profiles for a modelled 1976-type drought are provided in Figure 6 (noting that these are modelled flows not actual observed flows from 1976).

For the lead-in to the drought, the actions and timelines are very similar to the 1921-22 style drought, but obviously the interventions would be curtailed as a result of the drought breaking in September:

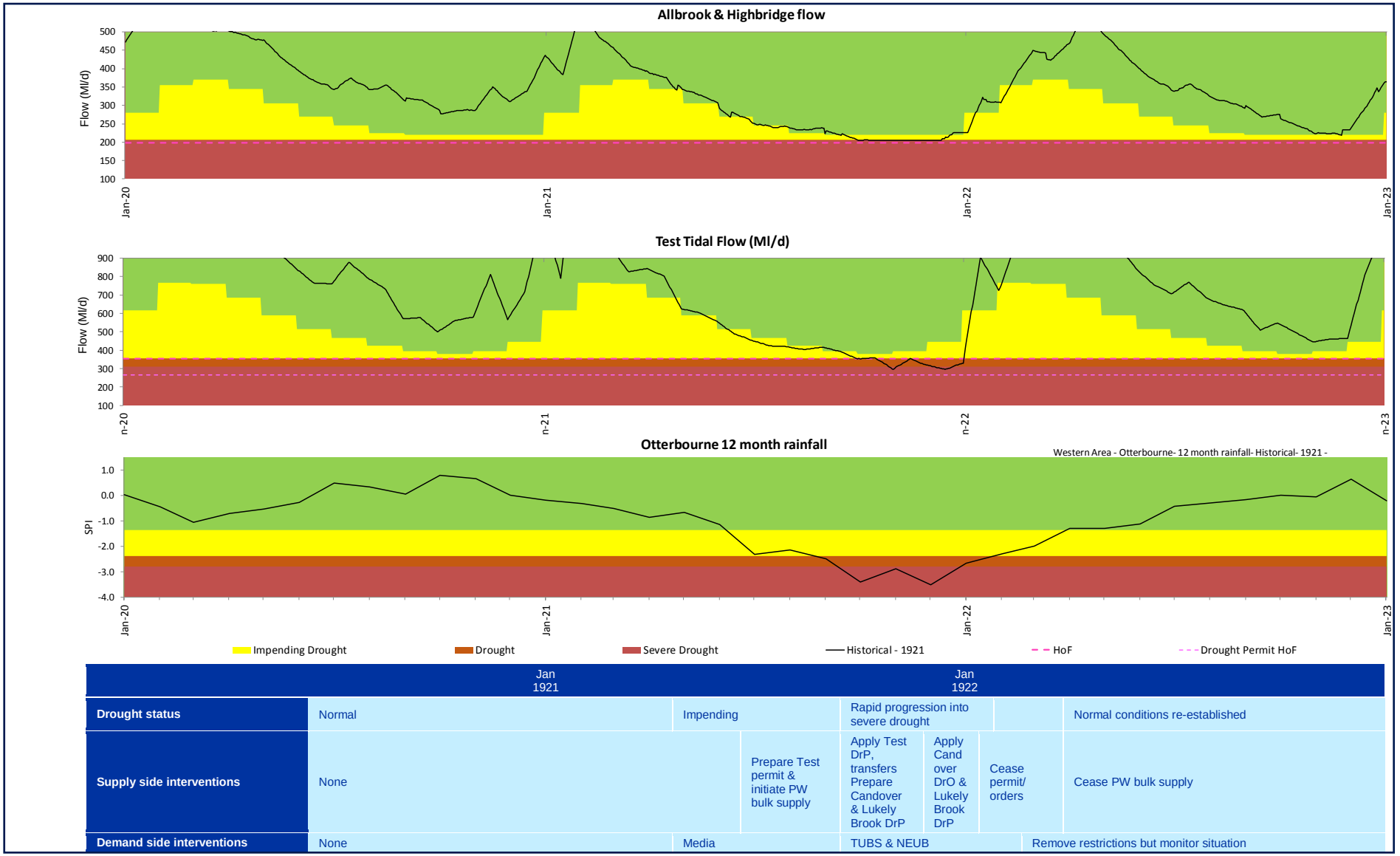
- Due to the relatively higher rainfall in 1974-75 prior to the event, 1976 would not be as much of a concern as 1921-22. The 12 month rainfall indicator falls into the impending drought level in January, with the equivalent threshold being reached slightly later in the River Test and Itchen flows (February and March respectively). At this point, the bulk supply from Portsmouth Water would be iniitated along with enhanced monitoring and forecasts (including supply / demand assessments) and media messages.
- Enhanced environmental monitoring and preparation for a Drought Permit would commence at the River Test in May in anticipation of an ongoing recession and allowing a 35 day lead-in period for the Permit (and 60-day pre-consultation lead-in period)
- The rainfall indicator drought threshold is reached in July, althought flows in the two rivers are still just above the equivalent thresholds (noting the reservations regarding model representation of this event). Phase 1 Temporary Use Ban (TUB) restrictions would be introduced in August when flows in the River Test breached the drought threshold.
- The severe drought threshold is only just reached in the rainfall indicator; flows remain within the 'drought' threshold for the whole drought event. As such alternative Drought Orders, such as Candover Augmentation Scheme, would not be required. Neither are Phase 1 NEUB restrictions necessary.
- The permit on the River Test would only be required for a limited period in August and September, before levels recovered due to increased rainfall. During this period treated water transfers from Hampshire Southampton West WRZ would be required to support demand in Hampshire Southampton East WRZ (with the Portsmouth Water bulk supply having already been maximised to this WRZ). By end September, normal flow conditions would have resumed with rainfall reaching normal levels by November.

2011-12 type drought event

Key selected trigger profiles for the 2012 drought are provided in Figure 7. The 2012 drought is the least severe of the three historical droughts presented and is driven by the low rainfall in 2011. For the lead-in to the drought, a similar profile of measures as set out in the earlier two events would be initiated.

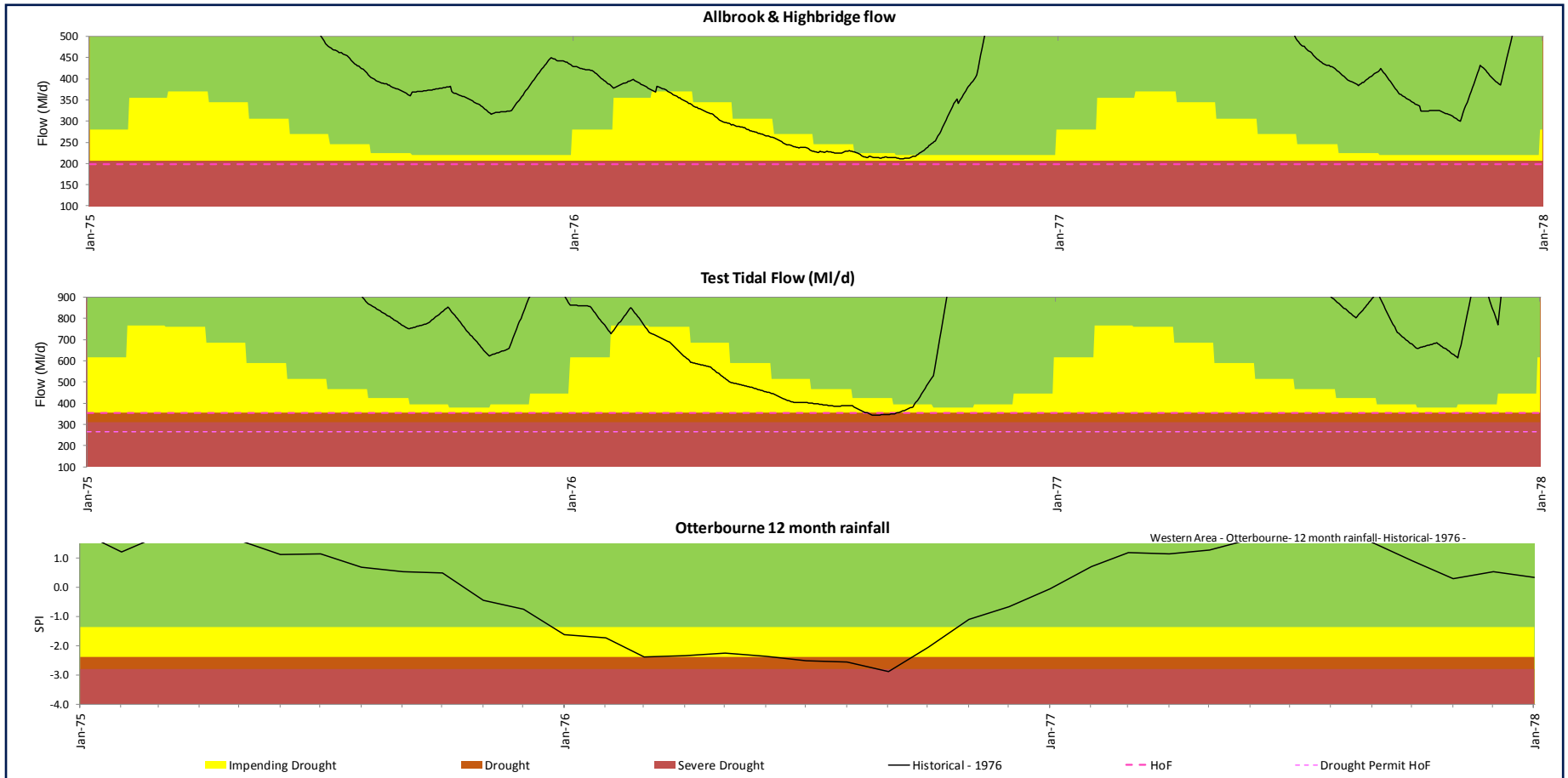
- Rainfall indicators enter impending drought status whist flows in the River Test and Itchen remain above trigger levels. During this period flows in the two rivers will be carefully monitored, with drought activities initiated during April when the River Test flows also tend towards the impending drought threshold.
- Media campaigns and the Portsmouth Water bulk supply would be initiated around April.
- Preparation of the Test Drought Permit will be initated around June as flows in the Test continue to fall, in line with the pre-consultation and application lead-in times specified in the s20 agreement. However, due to recovering conditions, implementation of this Drought Permit would not actually have been required. Neither are Phase 1 Temporary Use Ban restrictions implemented, as flows remain above this threshold.
- Conditions would continue to be monitored coming out of the drought so that the company is able to respond to the deteriorating conditions in early 2012. This event is short lived, and would only trigger the media campaigns.

Figure 5 Analysis of '1921' style event responses for the Western area



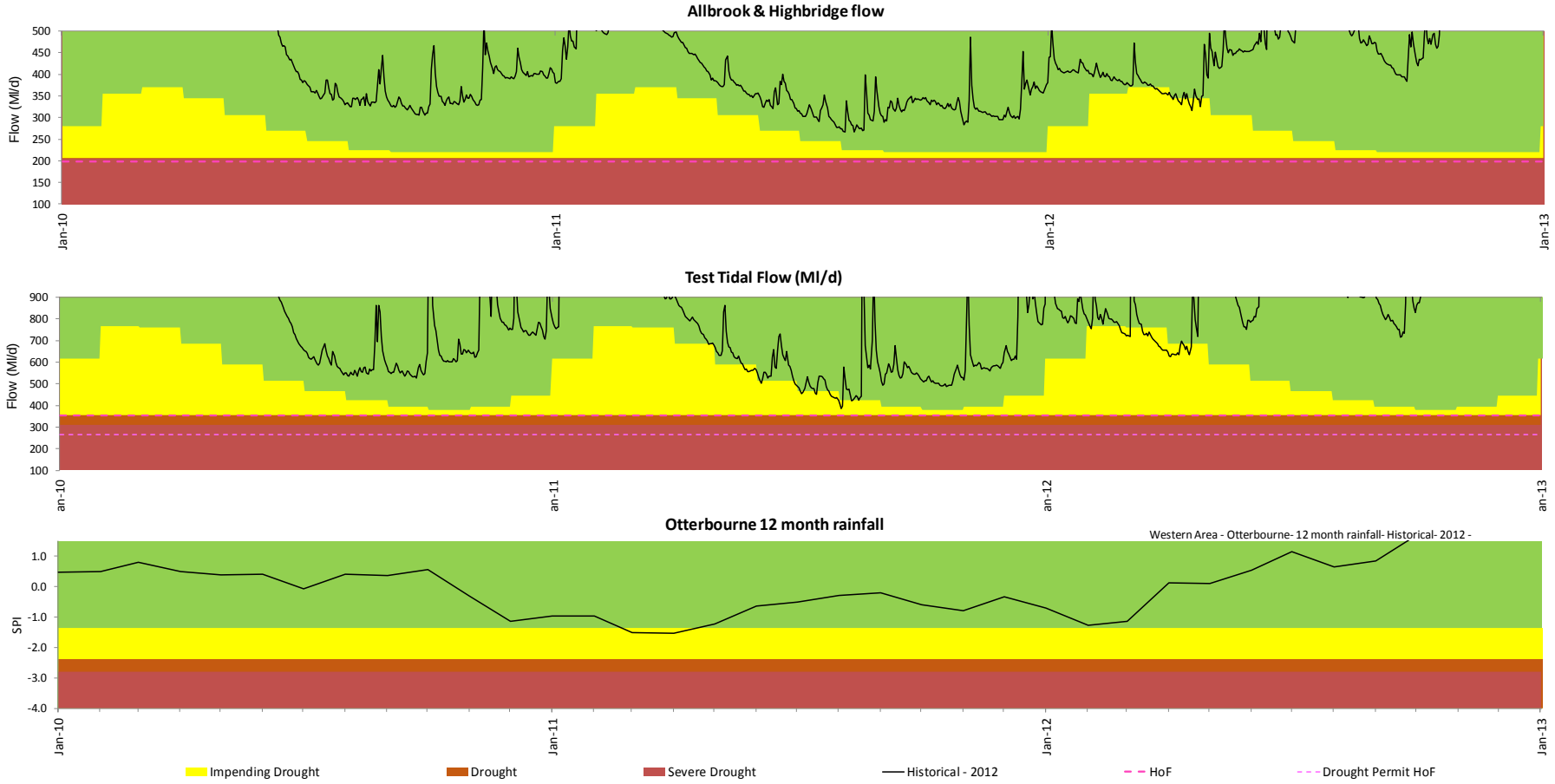
	Jan 1921			Jan 1922			
Drought status	Normal	Impending		Rapid progression into severe drought			Normal conditions re-established
Supply side interventions	None		Prepare Test permit & initiate PW bulk supply	Apply Test DrP, transfers Prepare Candover & Lukely Brook DrP	Apply Cand over DrO & Lukely Brook DrP	Cease permit/ orders	Cease PW bulk supply
Demand side interventions	None	Media		TUBS & NEUB			Remove restrictions but monitor situation

Figure 6 Analysis of '1976' style event responses for the Western area



	Jan 1976			Jan 1977
Drought status	Normal	Impending	Drought	Normal
Supply side interventions	None	Initiate bulk supply from Portsmouth Water	Prepare Test Permit	Test permit & transfers	Cease bulk supply
Demand side interventions	None	Media		Impose TUBs	Remove restrictions, but monitor situation

Figure 7 Analysis of '2012' style event responses for the Western area



	Jan 2011			Jan 2012		
Drought status	Normal	Impending		Recovery to normal	Impending	Normal
Supply side interventions	None	Initiate PW Bulk Supply	Prepare Test Permit	No need to implement Test permit due to recovery of levels	Initiate Portsmouth Water Bulk Supply	
Demand side interventions	None	Media			Media	

Testing against a range of alternative drought scenarios

An alternative range of drought scenarios was developed using the stochastic weather data set that was originally generated for the 2014 Water Resources Management Plan (WRMP14). This weather generator produced a large number of artificial droughts of known relative severity through the direct generation of daily rainfall and Potential Evapotranspiration (PET). Because the output was daily rainfall and PET it was possible to run the outputs through the same recharge, rainfall-runoff, groundwater modelling and water resources simulation tools that form the basis of the historic scenario assessment described in the previous section. This means all of the stochastically generated drought inputs can be plotted against the same triggers as described for the historic droughts above.

Two droughts with different characteristics were analysed at two levels of severity (i.e. four droughts per area) for Central and Eastern area, both of which were more severe than the worst droughts contained in the historic record. For Western area, due to the changes in the abstraction licences, more worked examples have been included, one example from each severity level:

- 'Severe' droughts – equivalent in severity to a drought that might be expected to occur once every couple of centuries. In the context of shorter (12 and 18 month) events, this represents a drought similar to 1921, but where the early winter before the drought was somewhat drier (the 1921 drought actually had reasonable rainfall totals in December 1920). For longer droughts these are similar to the 1901-03 event, but with a slightly lower rainfall across the period. Southern Water plans to be resilient to these droughts as the basis of the design of its Water Resources Management Plan.
- An 'extreme' drought – a plausible drought, but very rare and of a type that might only be expected to occur a couple of times in a thousand years. Long-term academic studies have shown the existence of this type of event in Northern Europe within long term historic analyses.

The terms 'severe' and 'extreme' are used in this context to denote the likelihood of a drought event occurring and these are consistent with the drought severities that we used to test our WRMP19. They do not link to our Drought Plan stages.

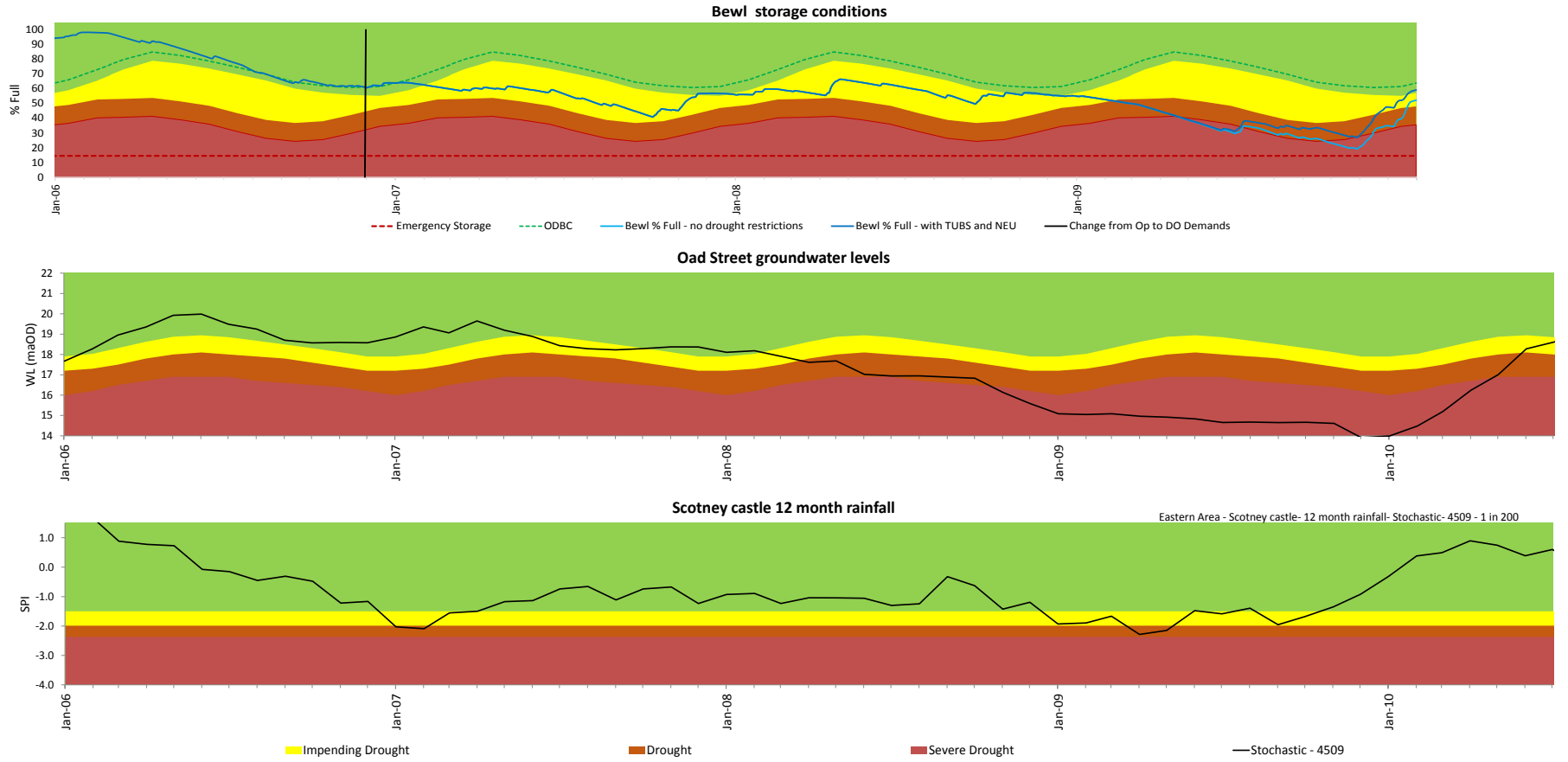
For our Eastern and Central areas, these droughts were selected from the full WRMP14 available data set based on their ranking according to deployable output for the drought event. The analysis for Western area makes use of more recent stochastic data used for the draft WRMP19. The results of the rainfall, reservoir and groundwater monitoring points for each drought, set against the relevant trigger curves, are provided in Figure 8 to Figure 17 below, along with a theoretical timeline for the drought interventions that would be triggered if such a drought occurred. Whilst three main monitoring outputs are shown for each area, more outputs are considered on the company's drought dashboard.

For the Western area the analysis has concentrated on south Hampshire, as this provides a key transfer to the Isle of Wight that is more significant in water resources terms than the impact of drought upon the indigenous sources on the Isle of Wight. However, the company has a number of Drought Permit and Order options for the Isle of Wight (set out in Annex 4) which will reduce the the risk to supply through dependency on the cross Solent transfer. The order of implementing Drought Permits and Orders on the Isle of Wight relative to those in south Hampshire will be influenced by the potential environmental impact of each option, and where the environment is most stressed by drought at that time.

In general, when the company reaches the point of needing Drought Permits / Orders, these will be selected (unless otherwise specified under the s20 agreement for the Test and Itchen) based on the guiding principle that, where there is a choice in which permit / order to apply for in order to resolve a threat to supplies, the company will select the option on the basis of the current state of the environment and the potential impact after implementing the licence relaxation.

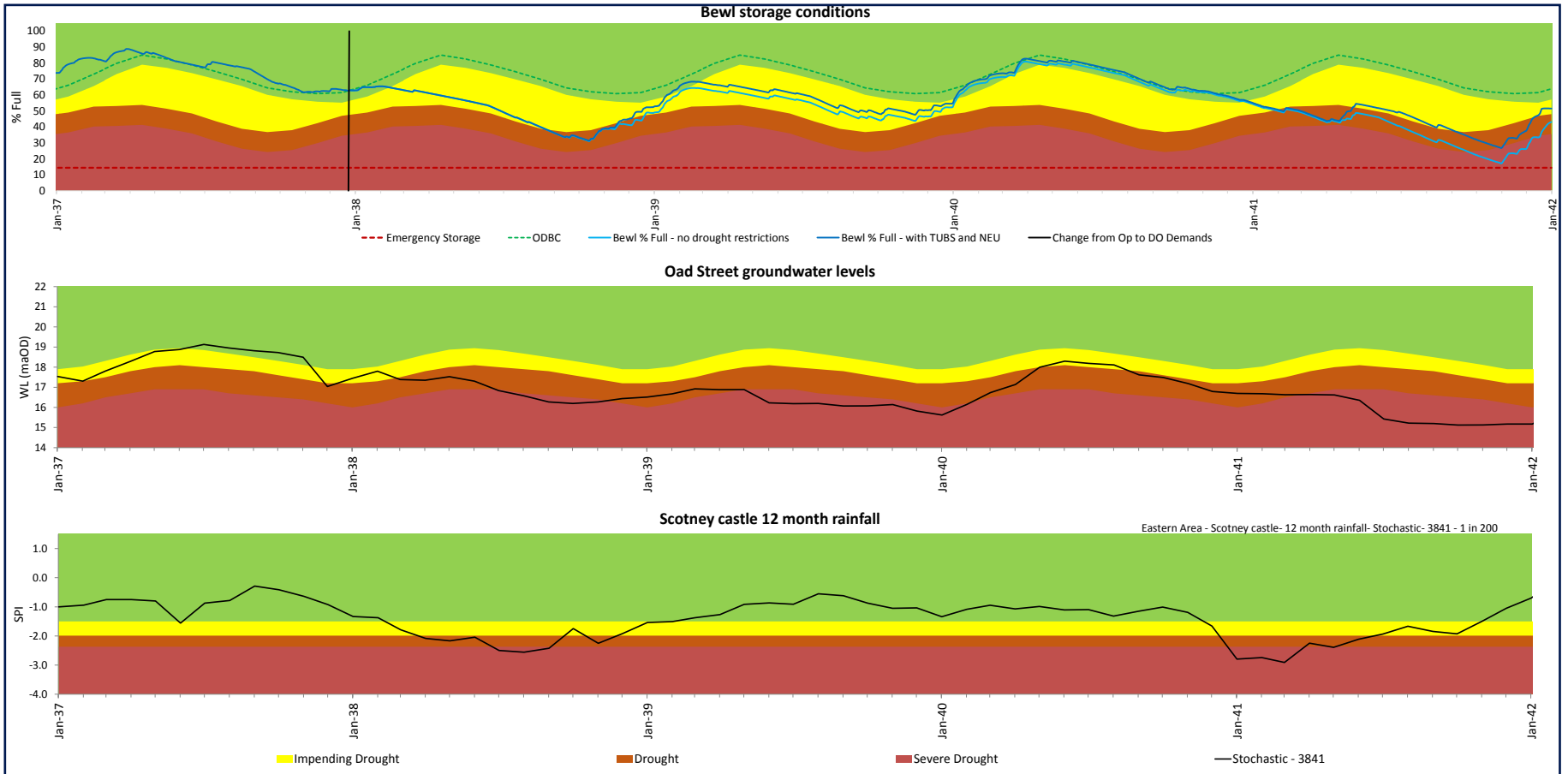
A summary of the key points raised by the analysis in each area is provided after the figures.

Figure 8 Analysis of 'severe' drought responses for the Eastern area (2-3 year event)



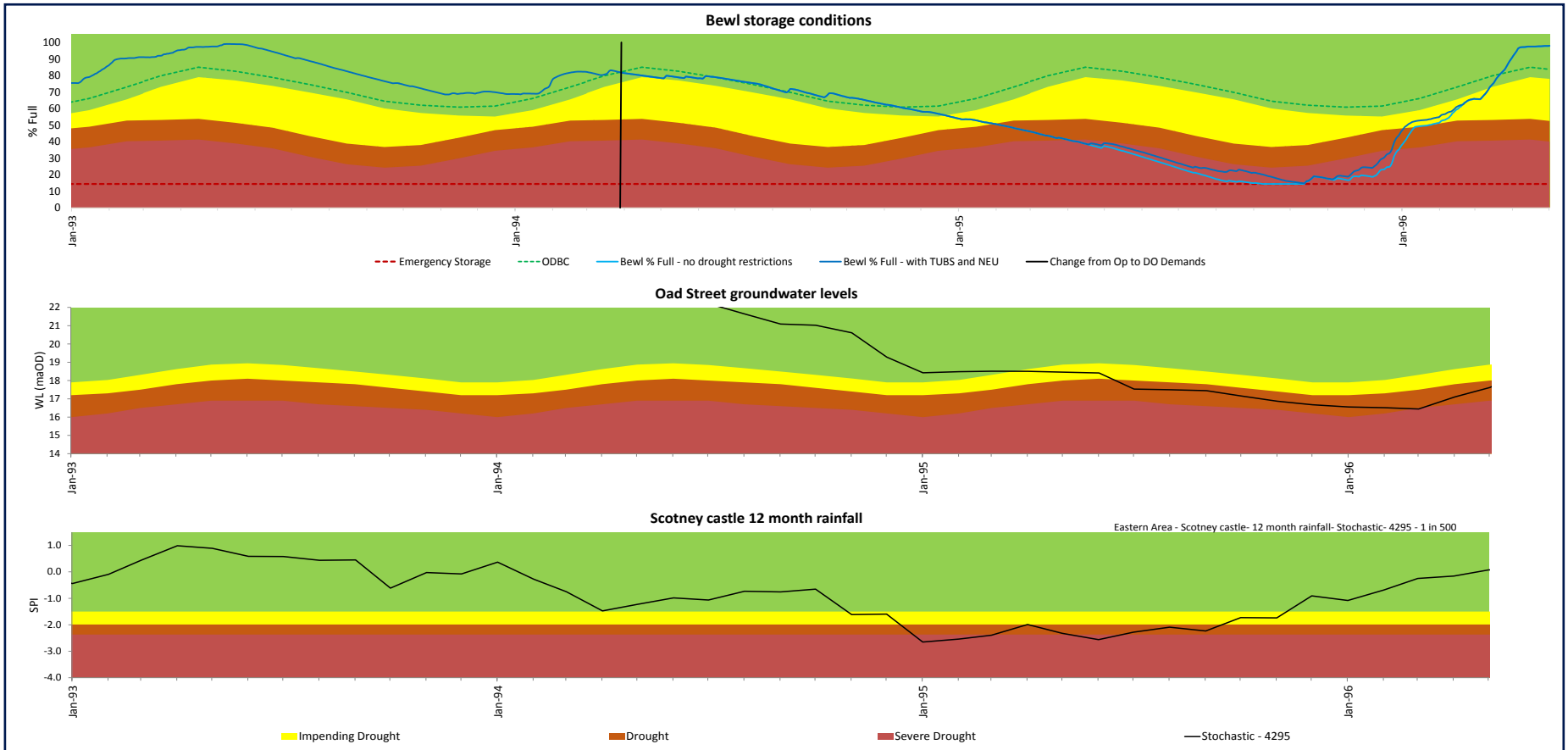
	Jan 4507	Jan 4508		Jan 4509		Jan 4510
Drought status	Normal	Impending	Drought (GW)	Drought	Severe drought	Normal (groundwater lags)
Supply side interventions	None	Operational Drought Bounding Curve (ODBC – the rules which limit abstraction to sustainable levels linked to reservoir storage). When ODBC breached, River Medway Scheme abstraction is limited to deployable output (DO)		Prepare for summer Drought Permit	Implement summer and winter Drought Permit	Remove Drought Permits, but keep a watching brief
Demand side interventions	None	Media messaging		Apply TUBs	Impose NEUB	Remove restrictions

Figure 9 Analysis of 'severe' drought responses for the Eastern area (4 year event)



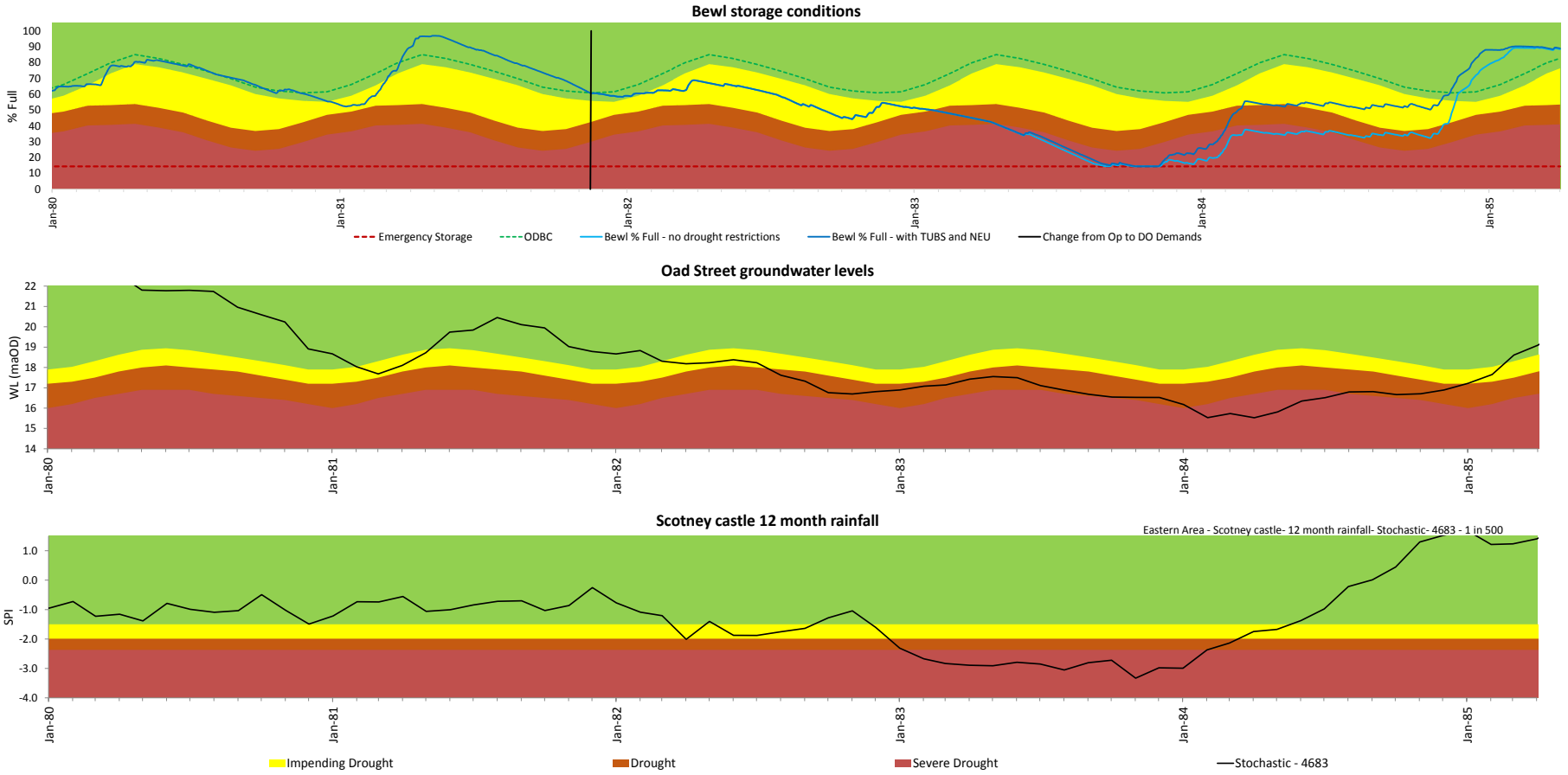
		Jan 3838	Jan 3839	Jan 3840	Jan 3841	
Drought status	Normal	Impending	Drought	Some drought relief, but not back to ODBC	Drought	Severe drought
Supply side interventions	None	ODBC breached – River Medway Scheme abstraction limited to DO	Winter Drought Permit applied	Remove Drought Permits	Prepare Drought Permit	Drought Permit/Order implemented
Demand side interventions	None	Media messaging	No TUBs as reservoir levels reasonable		Impose TUBs	Apply NEUB

Figure 10 Analysis of 'extreme' drought responses for the Eastern area (rapid 1-2 year event)



	Jan 4294		Jan 4295		Jan 4296	
Drought status	Normal	Dry conditions & ODBC breached	Impending	Drought'	Severe drought	Normal
Supply side interventions	None	ODBC breached – River Medway Scheme abstraction limited to DO		Prepare for summer Drought Permit	Implement summer Drought Permits followed by winter Drought Permit/Orders	Remove Drought Permits
Demand side interventions	None	Media messaging		Apply TUBs	Impose NEUB	Remove restrictions

Figure 11 Analysis of 'extreme' drought responses for the Eastern area (2 year event)



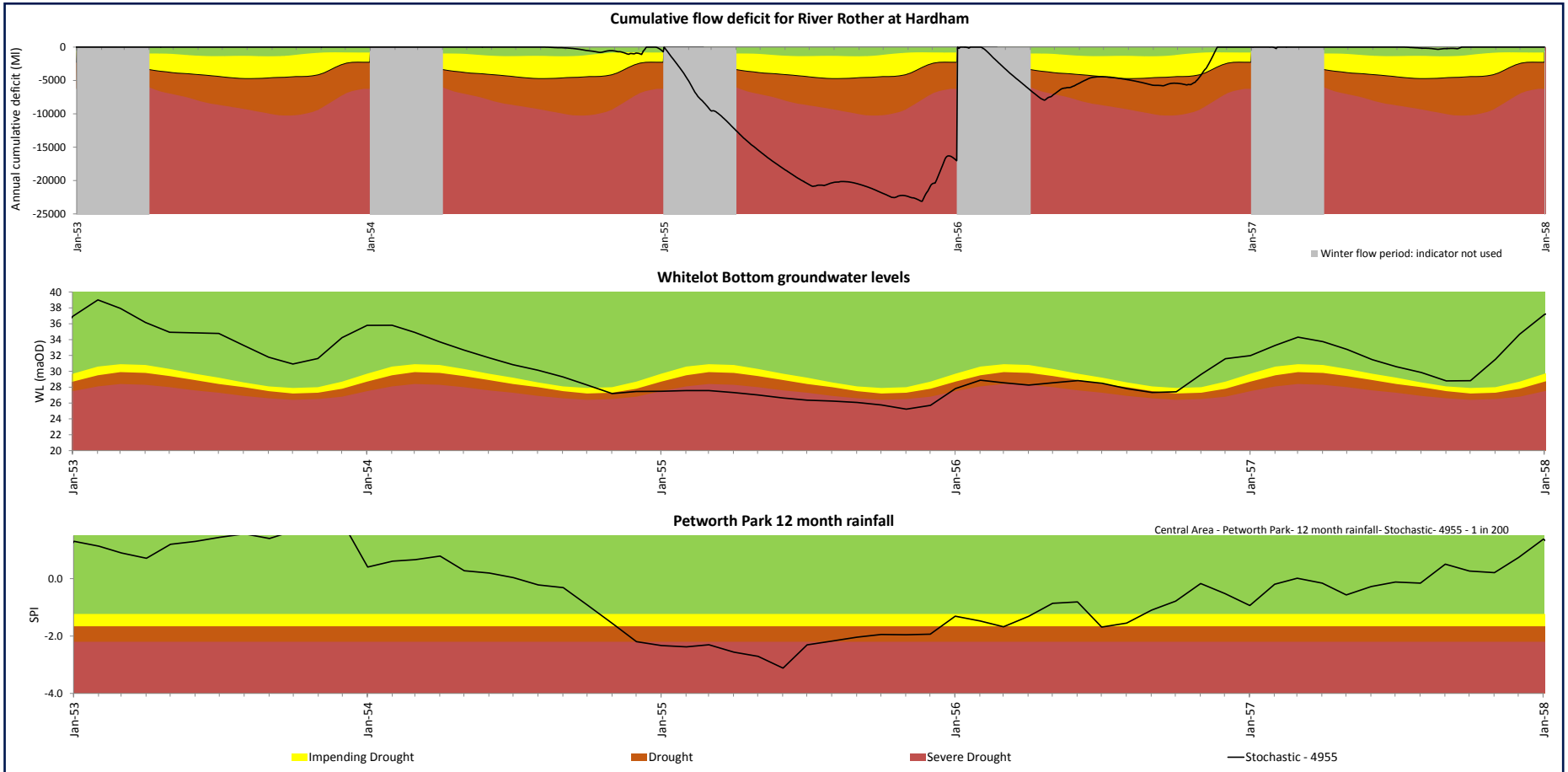
	Jan 4681		Jan 4682	Jan 4683	Jan 4684	Jan 4685	
Drought status	Normal, but with some recovery		Impending	Drought	Severe drought incl. 'failure' of surface water	Drought	Normal
Supply side interventions	River Medway Scheme abstraction limited to DO	Normal operations	ODBC breached – River Medway Scheme abstraction limited to DO	Prepare for summer Drought Permit	Implement summer Drought Permits/Orders	Continue with winter Drought Permit, significantly improves recovery	Remove Drought Permits/ Orders
Demand side interventions	Possible media messaging in early winter		Media messaging	Apply TUBs	Impose NEUB	Continue restrictions	Remove restrictions

There are a number of conclusions about the effectiveness of the drought response in the Eastern area that can be drawn from this analysis. These are summarised in Table 1.

Table 1 Summary of drought scenario testing for the Eastern area

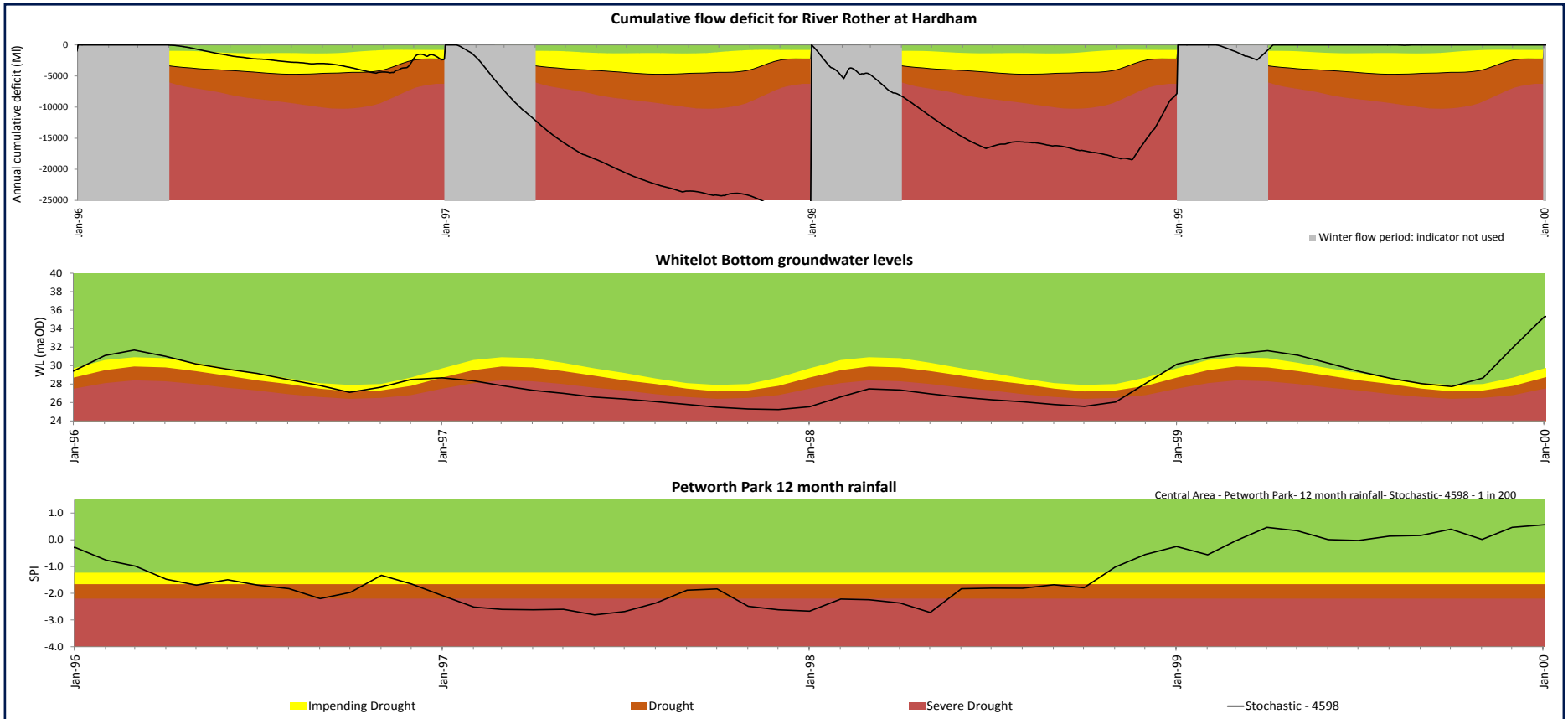
Severity level	Drought Plan response	Timing and implementation risks
Severe	The supply system has been designed to be resilient to such an event, irrespective of the duration. Drought Plan measures provide risk mitigation during such an event.	Although the scenarios that were tested represented multiple winter events, and it usually takes more than one dry winter to generate low enough flows and groundwater levels to result in 'severe' drought conditions, there can be single 'critical' year drought events where the storage (surface water and groundwater) in the system can pass from 'impending' to 'severe' drought conditions during the course of a single winter. Much of the risk mitigation for severe events will therefore rely on rapid implementation of TUBs (i.e. within 4 weeks or so of breaching the trigger curve) followed by NEUB restrictions, coupled with summer Drought Permits and Orders. Groundwater recovery can lag behind surface water recovery, so there is a high likelihood that winter Drought Permits would be sought even after the summer / autumn critical point of the drought has passed.
Extreme	The measures described within this Drought Plan would be needed to manage such events without 'failure' of the supply system	Extreme events typically have a 'critical' year, where there is a rapid deterioration of storage in the late winter. This means that managing such an event would require rapid implementation of summer Drought Permits and Orders, along with water use restrictions, to avoid the need for emergency measures.

Figure 12 Analysis of 'severe' drought responses for the Central area (1 year event)



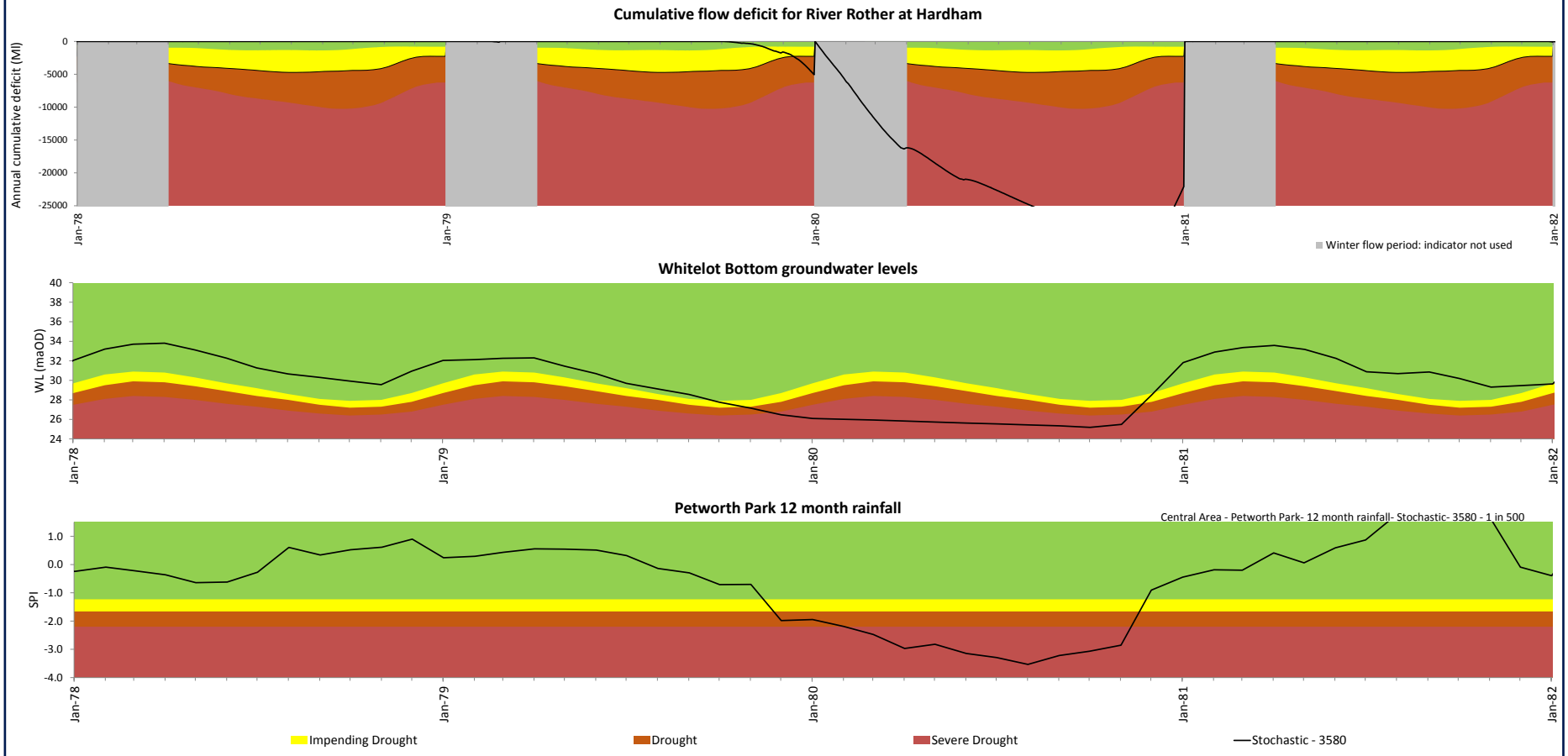
	Jan 4954	Jan 4955		Jan 4956		Jan 4957
Drought status	Normal	Impending to Drought	Severe	Some recovery in 2nd winter	Drought	Normal
Supply side interventions	Normal operations	Review/ monitor	Apply for and implement summer Drought Permit	Implement winter Drought Permit	Monitor but do not apply summer Drought Permit	Continue with winter Drought Permit, significantly improves recovery
Demand side interventions	None	Media	TUBs	Rapid move to NEUB	Reduce to TUBs	Remove restrictions

Figure 13 Analysis of 'severe' drought responses for the Central area (2 year event)



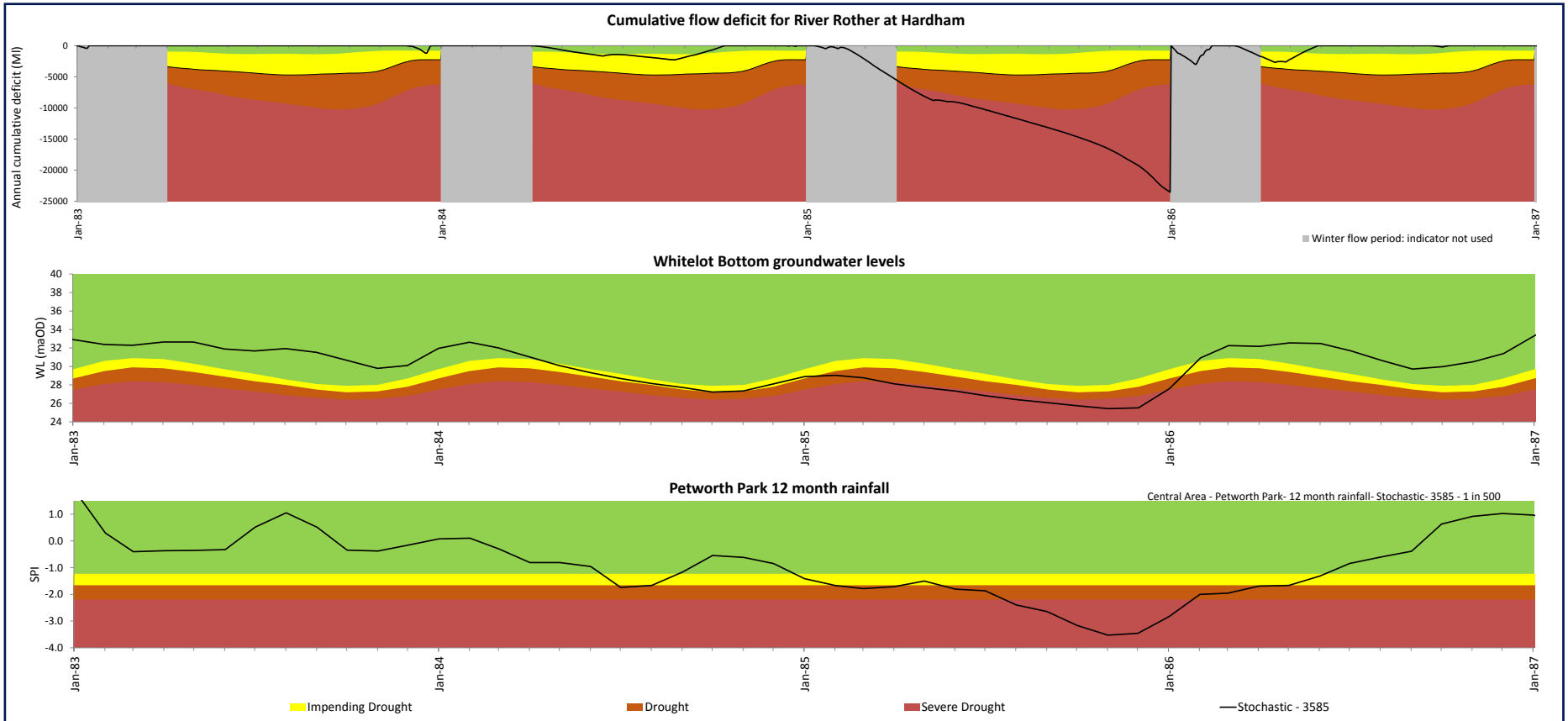
	Jan 4597			Jan 4598			Jan 4599
Drought status		Impending to drought	Severe				Normal
Supply side interventions		Drought operation of groundwater sources	Prepare Drought Permit	Apply for and implement summer Drought Permit	Implement winter Drought Permit	Progress to second summer Drought Permit	Continue with winter Drought Permit, significantly improves recovery
Demand side interventions	None		Media messaging	TUBs	Rapid move to NEUB	Maintain NEUB	Remove restrictions

Figure 14 Analysis of 'extreme' drought responses for the Central area (1 year event)



	Jan 3579	Jan 3580		Jan 3581	
Drought status	Normal conditions	Impending to drought	Severe	Rapid recovery in 2nd winter,	Normal
Supply side interventions	Normal operations	Review / monitor and drought operation of groundwater sources	Apply for and implement summer Drought Permit	Implement winter Drought Permit	Remove Drought Permits
Demand side interventions	None	Media messaging & TUBS	Rapid move to NEUB		Remove restrictions

Figure 15 Analysis of 'extreme' drought responses for the Central area (18 month event)



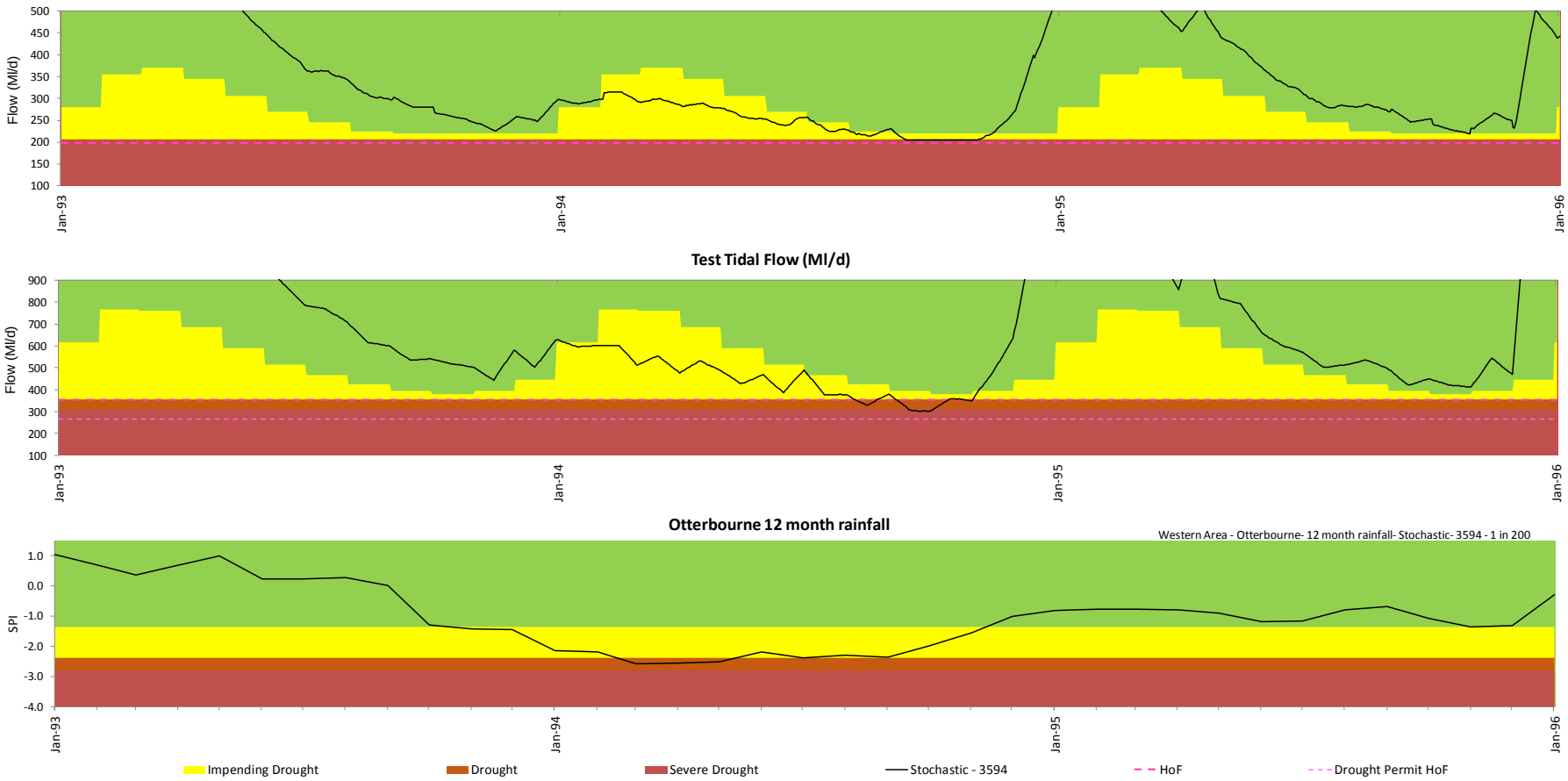
	Jan 3584		Jan 3585		Jan 3586	
Drought status	Normal	intermittent impending / drought conditions	Severe	Drought to impending	Normal	
Supply side interventions	Normal operations	Review/monitor and drought operation of groundwater sources	Prepare summer Drought Permit	Implement summer followed by winter Drought Permit	Remove Drought Permit	
Demand side interventions	None	Media messaging	TUBs	Implement NEUB	Reduce to TUBs	Remove restrictions

There are a number of conclusions about the effectiveness of the drought response in the Central area that can be drawn from this analysis. These are summarised in Table 2.

Table 2 Summary of drought scenario testing for the Central area

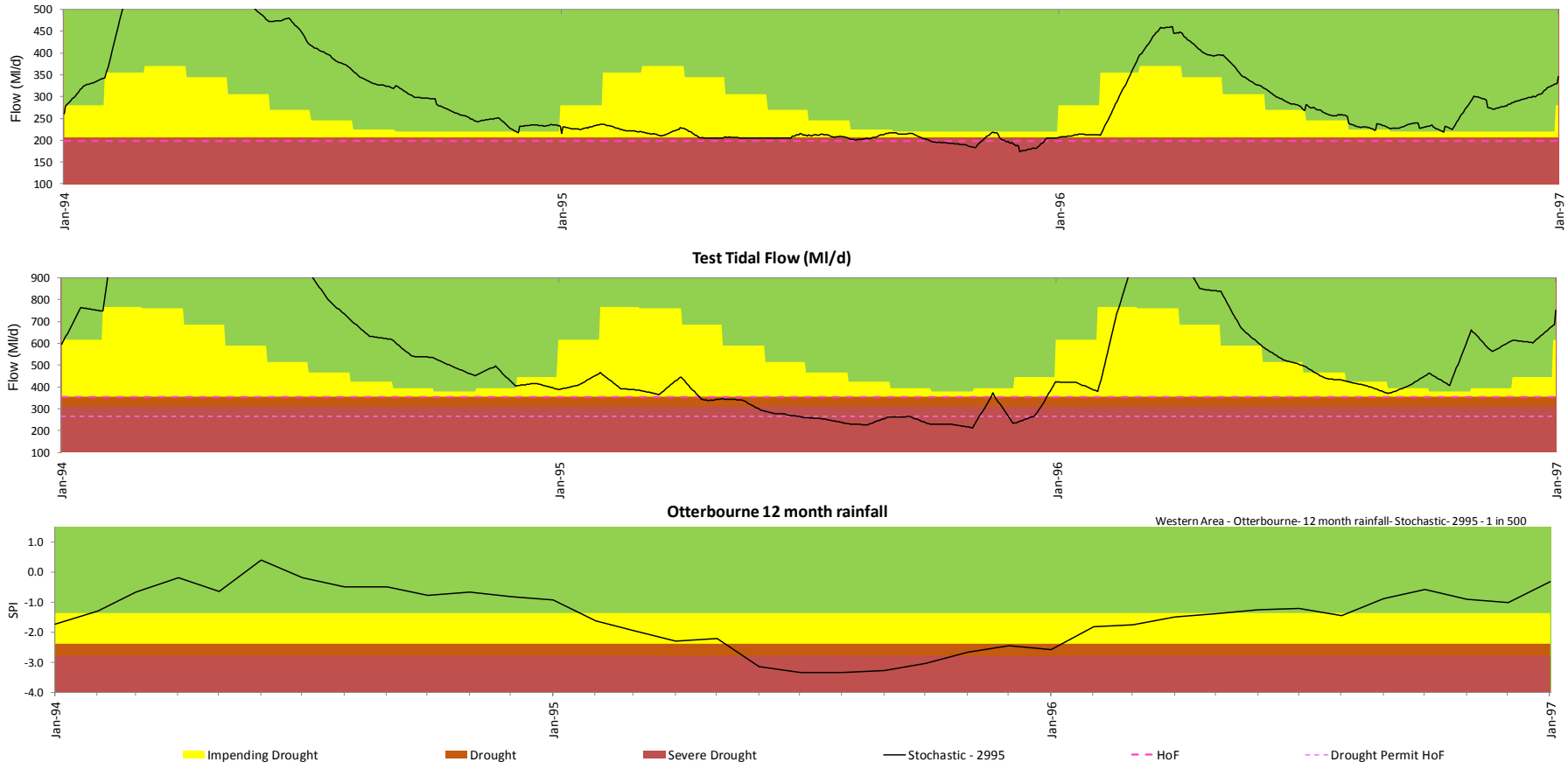
Severity level	Drought Plan response	Timing and implementation risks
Severe	Drought Permits / Orders would generally be required to manage a drought of this severity.	Some 'severe' droughts could result from a preceding dry summer/autumn leading into the winter recharge period, which would provide some warning to allow preparation for Drought Permits / Orders. However, the area is similarly likely to experience a very rapid onset of severe drought conditions as a result of winter recharge failure, so it would be difficult to make an early decision to pursue Drought Permits / Orders, as the water resources position is generally not clear until near the end of the winter recharge season. Minimum river flow conditions do not occur until later in the summer, so there should be sufficient time in the March-July period to apply for and implement the Drought Permit for the River Rother at Pulborough and (if required) a non-essential use ban (NEUB). However, there would likely be a short time period between the preparation and implementation of the Drought Permit...
Extreme	Theoretically the situation is similar to the severe events, however the actual benefits of the key intervention at Pulborough (the Drought Permit) are less clear, as river flows may be very low. Other Drought Permits / Orders may be required.	As above; there is little difference in timing between a severe and extreme event – it is largely the intensity or persistence of the very low rainfall period that creates the difference in the events. Of the events that were tested, only one did not involve the rapid onset of severe conditions immediately following a very dry winter recharge season, so timescales for the application and implementation of the key summer Drought Permit at Pulborough are tight.

Figure 16 Analysis of 'severe' drought responses for the Western area (year 3594)



	Jan 3594			Jan 3595		
Drought status	Normal	Impending		Drought		Normal
Supply side interventions	None	Initiate Portsmouth Water bulk supply	Prepare Test Permit	Implement Test Permit & transfers. Prepare Candover & Test DrO		Cease bulk supply & continue to monitor
Demand side interventions	None	Media		TUBs	NEUs	None

Figure 17 Analysis of 'extreme' drought responses for the Western area (year 2995)



	Jan 2995				Jan 4598	
Drought status	Nomal	Impending	Drought	Severe drought	Impending	Normal
Supply side interventions	None	Prepare Test Permit. Initiate Portsmouth Water bulk supply	Implement Test Permit & transfers Prepare Test / Candover DrO	Implement Test & Candover DrO. Prepare Lower Itchen and Gaters Mill DrO.	Implement Lower Itchen and Portsmouth Water DrO.	Cease DrO & transfers then cease bulk supply. Continue to monitor situation
Demand side interventions	None	Media	TUBS & NEUB	Phase 2 TUBs/NEUB	NEUB lifted	TUBS lifted and situation continued to be monitored

There are a number of conclusions about the implementation of Drought Plan measures in the Western area that can be drawn from this analysis. These are summarised in Table 3.

Table 3 Summary of drought scenario testing for the Western area

Severity level	Drought Plan response	Timing and implementation risks
Severe	The Test Drought Permit is critical to maintaining supplies, along with the bulk supply from Portsmouth Water and transfers of treated water from the Hampshire Southampton West to Hampshire Southampton East WRZs. Analysis of alternative 'severe' droughts (not presented here) also require the use of Test Drought Order, and more frequently, Candover Drought Order.	Early introduction of the bulk supply helps to maintain flows in River Itchen downstream of SWS's Lower Itchen sources. Implementation of the Test Surface Water Drought Permit is critical in all droughts. Consequently, a 60-day pre-consultation lead-in period is included in the s20 agreement and a 35-day application programme, detailing how the permit approval will be progessed from the point of application. This includes provision for early consideration of the Exceptional Shortage of Rainfall test using forecast rainfall data initially if necessary. The Drought Permit enables additional abstraction from the Test to support water supplies to both the Hampshire Southampton West and Southampton East Water Resource Zones. By implementing early Drought Plan measures, Southern Water would be able to reduce its River Itchen sources abstraction to slow the rate of flow recession so that flows remain at or above 205 Ml/d. Temporary Use Ban Phase 1 restrictions would be in place in tandem with the Test Drought Permit. Applications for the Test and/or Candover Drought Orders would need to have been submitted, along with application for a NUEB Drought Order, in order to avoid the risk of requiring emergency measures, even if subsequently these Orders are not required. Drought measures on the IoW such as TUBs and the Lukely Brook Drought Permit may be implemented as a precaution due to reliance on the cross-Solent main.
Extreme	All drought measures described within this Drought Plan would be needed to manage such events without a 'failure' of the supply system.	Timing and risks as above. Phase 2 water use restrictions along with additional Drought Orders likely to be required. Since the Candover Drought Order, transfers and NEUB maintain flows at Allbrook & Highbridge at 205 Ml/d further into the drought, there is no steady recession on the River Itchen. Therefore applications for the Lower Itchen sources Drought Order and Phase 2 water use restrictions need to be timely such that these measures are ready for when the preceeding actions fail to support flows.