River Severn Drought Order Environmental Assessment Report

August 2026

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We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

We are Natural Resources Wales. We work to protect and enhance Wales' natural resources and environment for the benefit of people, nature and future generations.

Tackling climate change and supporting adaptation to its impacts are central to everything we do. We work to build resilience in our ecosystems and communities, helping Wales respond to the environmental challenges of today and the future.

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Environment Agency
Horizon House, Deanery Road,
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www.gov.uk/environment-agency

Executive summary

Droughts are infrequent events in the UK but when they do occur their impact can be significant. The Environment Agency has responsibility in England and Natural Resources Wales in Wales, for alleviating the effects of drought on people, businesses and the environment through sensible management of water resources.

The River Severn is the UK's longest river. The majority of its catchment sits in England but substantial parts are in Wales. Since April 2013 the Environment Agency and Natural Resources Wales (NRW) have had joint responsibility for drought planning in the River Severn catchment. We are committed to working together where there is an environmental need or benefit; for drought planning it has been agreed the Environment Agency will take the lead in the River Severn catchment.

This environmental assessment report has been written to support an application should a River Severn Drought Order be required. A drought order outlines the procedures we will use to better manage our water resources during prolonged or extreme spells of dry weather. Around six million people rely on the River Severn catchment for drinking water as well as a huge number of businesses, leisure clubs and wildlife. The Environment Agency and NRW aim to ensure that the River Severn is able to support all of these uses without compromising the environment. We must decide how much water needs to be released to the river from both surface water and groundwater storage sources to balance the needs of the river and the demands of abstraction. This is called River Severn regulation and involves legal responsibility under the Clywedog Reservoir Joint Authority Act (1963).

The robustness of the water supply in the River Severn is judged by water levels in Llyn Clywedog reservoir in Wales. Procedures from the River Severn Drought Order will only be enforced when critical water levels in the reservoir are reached. The River Severn Drought Order would allow us to reduce the quantity of water released from the reservoir and restrict abstractions from the River Severn. This would preserve the remaining water resources and allow support to continue for longer to protect people and the environment against extended droughts.

Llyn Clywedog reservoir is the main surface water store used to support the River Severn. Without its support the river levels we need to protect could not be achieved. This would result in a reduction of flow and water levels down the River Severn.

The River Severn Drought Order is our final option for managing the impact of a severe drought in the catchment. It aims to protect public water supply and the environment along the river. We believe it is safer for everyone if we limit our water use earlier in order to be able to continue supporting the River Severn for longer during a drought. We believe that taking no precautionary action risks running out of water in the reservoir, which could lead to severe environmental and human impacts.

This report looks at the positive and negative impacts to the environment and people of implementing and not implementing a drought order for the River Severn. It considers the short (Acute) and long term (Chronic) impacts from modelled drought conditions; whether the impacts could result directly or indirectly because of the drought order; and whether they are likely to be temporary or permanent.

In the short-term the River Severn Drought Order would lower flows and water levels along the River Severn to conserve water in Llyn Clywedog in case the drought continues. Water Framework Directive (WFD) standards would not be expected to fail as a result of the River Severn Drought Order and water quality would not be significantly impacted. Flows along the majority of the River Severn should not fall greatly below what is expected under natural drought conditions.

Our models found that if the drought continued and the drought order was not operated, water supply from Llyn Clywedog reservoir could run out. This would result in a severe impact on river levels, the environment and communities as no releases could be made. By reducing input from the reservoir earlier we preserve the stores for longer and enable releases to continue during the worst part of the drought. This would benefit all river users and the environment by preventing the upper River Severn catchment (below Llyn Clywedog reservoir) from drying up and maintaining higher flows and levels throughout the river.

In the long-term, the River Severn Drought Order would seek to conserve storage in Llyn Clywedog reservoir for subsequent years. This should accelerate refill by reducing the amount of rainfall needed to restock the reservoir in time for the following year. This would greatly reduce the impacts of any further dry winters and drought summers on the River Severn. More water would be available for a subsequent dry year and potentially prevent the need for a second River Severn Drought Order application. This means that the river could be regulated normally, which would maintain flows significantly higher than would naturally occur. People and the environment of the River Severn would benefit greatly, whilst neighbouring unsupported rivers may be suffering another drought year.

The impacts from operating the River Severn Drought Order are predicted to be temporary and are not expected to cause any new WFD failures. Once normal rainfall returns, the environment should improve naturally and recover within one to three years. This is consistent with the expected natural drought recovery period. This means that although the drought conditions may cause environmental stress, the River Severn Drought Order is not predicted to make conditions worse, and would provide benefits to people and the environment, especially in the long term.

The assessment of the River Severn Drought Order with the maximum abstraction for the Gloucester & Sharpness Canal, found that the lower part of the River Severn and important migratory fish could be at risk of negative impacts under extreme conditions. To satisfy the Habitats Directive and reduce the risk to the Severn Estuary, during River Severn Drought Order operation an abstraction cap of 300 Ml/d will be imposed on the Canal & River Trust when flows drop below 1200 Ml/d at Deerhurst.

Reports and data from previous periods when a drought order has been in operation have been used to assess the impact of the River Severn Drought Order. Drought orders have been in operation in 1976, 1984 and 1989. Using this data we have modelled the likely impacts of the River Severn Drought Order on hydrology, water quality, ecology, including fish, and designated sites. A separate Habitat Regulation Assessment (including Appropriate Assessment) has been produced for the Severn Estuary National Site Network (Annex 1).

Crynodeb gweithredol

Digwyddiad prin yw sychder yn y Deyrnas Unedig ond pan fydd yn digwydd gall ei effaith fod yn sylweddol. Mae gan Asiantaeth yr Amgylchedd gyfrifoldeb yn Lloegr a Cyfoeth Naturiol Cymru yng Nghymru, am liniaru effeithiau sychder ar bobl, busnesau a'r amgylchedd trwy reolaeth synhwyrol ar adnoddau dŵr.

Afon Hafren yw afon hiraf y DU. Mae rhan fwyaf ei dalgylch yn Lloegr ond mae rhannau sylweddol ohono yng Nghymru. Ers Ebrill 2013 mae Asiantaeth yr Amgylchedd a Cyfoeth Naturiol Cymru (CNC) wedi bod â chyfrifoldeb ar y cyd am gynllunio ar gyfer sychder yn nalgylch Afon Hafren. Rydym yn ymrwymedig i gydweithio lle mae angen neu fudd amgylcheddol; o ran cynllunio ar gyfer sychder cytunwyd y bydd Asiantaeth yr Amgylchedd yn arwain yn nalgylch Afon Hafren.

Ysgrifennwyd yr adroddiad asesu amgylcheddol hwn er mwyn cefnogi cais pe bai angen Gorchymyn Sychder Afon Hafren. Mae gorchymyn sychder yn amlinellu'r gweithdrefnau y byddwn yn eu defnyddio i reoli ein hadnoddau dŵr yn well yn ystod cyfnodau hir neu eithafol o dywydd sych. Mae tua chwe miliwn o bobl yn dibynnu ar ddalgylch Afon Hafren am ddŵr yfed yn ogystal â nifer anferth o fusnesau, clybiau hamdden a bywyd gwyllt. Mae Asiantaeth yr Amgylchedd a CNC yn sicrhau bod Afon Hafren yn gallu cefnogi'r holl ddefnyddiau hyn heb beryglu'r amgylchedd. Mae'n rhaid inni benderfynu faint o ddŵr sydd angen ei ryddhau i'r afon o ffynonellau storio dŵr wyneb a dŵr daear er mwyn cydbwyso anghenion yr afon a gofynion o ran tynnu dŵr. Gelwir hyn yn rheoleiddio Afon Hafren, ac mae'n cynnwys cyfrifoldeb cyfreithiol dan Ddeddf Cyd-awdurdod Cronfa Ddŵr Clywedog (1963).

Bernir cadernid y cyflenwad dŵr yn Afon Hafren gan lefelau dŵr yng nghronfa ddŵr Llyn Clywedog yng Nghymru. Gorfodir gweithdrefnau Gorchymyn Sychder Afon Hafren dim ond pan gyrhaeddir lefelau dŵr critigol yn y gronfa ddŵr. Byddai Gorchymyn Sychder Afon Hafren yn caniatáu inni leihau faint o ddŵr a ryddheir o'r gronfa ddŵr a chyfyngu ar dynnu dŵr o Afon Hafren. Byddai hyn yn cadw'r adnoddau dŵr sy'n weddill a chaniatáu i gymorth barhau am gyfnod hwy er mwyn amddiffyn pobl a'r amgylchedd yn erbyn cyfnodau estynedig o sychder.

Cronfa ddŵr Llyn Clywedog yw'r prif storfa ar gyfer dŵr wyneb a ddefnyddir i gefnogi Afon Hafren. Heb ei chymorth ni allem gyflawni'r lefelau mae angen inni eu cynnal yn yr afon. Byddai hyn yn achosi gostyngiad yn lefelau llif a dŵr i lawr Afon Hafren.

Gorchymyn Sychder Afon Hafren yw ein hopsiwn olaf ar gyfer rheoli effaith sychder difrifol yn y dalgylch. Ei nod yw amddiffyn y cyflenwad dŵr cyhoeddus a'r amgylchedd ar hyd yr afon. Credwn ei bod yn fwy diogel i bawb os cyfyngwn ar ein defnydd o ddŵr ynghynt er mwyn gallu parhau i gefnogi Afon Hafren am gyfnod hwy yn ystod sychder. Credwn y gallai peidio â chymryd camau gweithredu rhagofalus olygu ein bod yn rhedeg allan o ddŵr yn y gronfa ddŵr, a allai arwain at effeithiau difrifol ar yr amgylchedd a phobl.

Mae'r adroddiad hwn yn edrych ar yr effeithiau cadarnhaol a negyddol ar yr amgylchedd a phobl sydd ynghlwm wrth weithredu a pheidio â gweithredu gorchymyn sychder ar gyfer Afon Hafren. Mae'n ystyried effeithiau tymor byr (acíwt) a hirdymor (cronig) amodau sychder a fodelwyd; a allai'r effeithiau ymddangos yn uniongyrchol neu'n anuniongyrchol oherwydd y gorchymyn sychder; ac a ydynt yn debygol o fod dros dro neu'n barhaol.

Yn y tymor byr byddai Gorchymyn Sychder Afon Hafren yn lleihau llif a lefelau dŵr ar hyd Afon Hafren er mwyn cadw dŵr yng nghronfa ddŵr Llyn Clywedog rhag ofn bod y sychder yn parhau. Ni fyddai disgwyl i safonau'r Gyfarwyddeb Fframwaith Dŵr fethu o ganlyniad i Orchymyn Sychder Afon Hafren ac ni fyddai effaith sylweddol ar ansawdd dŵr. Ni ddylai llifoedd ar hyd y rhan fwyaf o Afon Hafren syrthio llawer yn is na'r hyn a ddisgwylir dan amodau sychder naturiol.

Canfu ein modelau y gallai'r cyflenwad dŵr o gronfa ddŵr Llyn Clywedog ddod i ben pe bai'r sychder yn parhau ac na weithredid y gorchymyn sychder. Gallai hyn achosi effaith ddifrifol ar lefelau afonydd, yr amgylchedd a chymunedau gan na ellid gwneud unrhyw ollyngiadau. Trwy leihau mewnbwn o'r gronfa ddŵr ynghynt rydym yn cadw'r storfeydd am gyfnod hwy ac yn galluogi i ollyngiadau barhau yn ystod rhan waethaf y sychder. Byddai hyn o les i holl ddefnyddwyr yr afon a'r amgylchedd trwy atal rhan uchaf dalgylch Afon Hafren (islaw cronfa ddŵr Llyn Clywedog) rhag sychu a chynnal llifoedd a lefelau uwch trwy'r holl afon.

Yn y tymor hir, byddai Gorchymyn Sychder Afon Hafren yn ceisio cadw storfeydd yng nghronfa ddŵr Llyn Clywedog ar gyfer blynyddoedd dilynol. Dylai hyn gyflymu ail-lenwi trwy leihau faint o law y byddai ei angen ar gyfer ail-lenwi'r gronfa ddŵr mewn da bryd ar gyfer y flwyddyn ddilynol. Byddai hyn yn lleihau effeithiau unrhyw aeafau sych a hafau o sychder ar Afon Hafren yn fawr. Byddai mwy o ddŵr ar gael ar gyfer blwyddyn sych ddilynol ac o bosibl byddai'n atal yr angen am ail gais am Orchymyn Sychder Afon Hafren. Mae hyn yn golygu y gellid rheoleiddio'r afon yn arferol, a fyddai'n cynnal llifoedd sylweddol o uwch na'r hyn a fyddai'n digwydd yn naturiol. Byddai pobl ac amgylchedd Afon Hafren yn elwa'n fawr, tra gallai afonydd na chynhelir gerllaw ddioddef blwyddyn arall o sychder.

Rhagwelir y bydd effeithiau gweithredu Gorchymyn Sychder Afon Hafren dros dro yn unig ac ni ddisgwylir y byddent yn achosi unrhyw fethiannau newydd o ran y Gyfarwyddeb Fframwaith Dŵr. Ar ôl i law arferol ddychwelyd, dylai'r amgylchedd wella'n naturiol ac adfer o fewn un i dair blynedd. Mae hyn yn gyson â'r cyfnod naturiol disgwyliedig ar gyfer adfer ar ôl sychder. Mae hyn yn golygu, er y gallai'r amodau sychder achosi pwysau amgylcheddol, na ragwelir y bydd Gorchymyn Sychder Afon Hafren yn gwneud pethau'n waeth, ac y byddai'n darparu manteision i bobl a'r amgylchedd, yn enwedig yn yr hirdymor.

Canfu'r asesiad o Orchymyn Sychder Afon Hafren gyda'r gyfradd tynnu dŵr fwyaf ar gyfer camlas Caerloyw a Sharpness, y gallai rhan isaf Afon Hafren a physgod mudol pwysig fod mewn perygl oherwydd effeithiau negyddol dan amodau eithafol. I fodloni'r Gyfarwyddeb Cynefinoedd ac i leihau'r risg i Aber Afon Hafren, yn ystod gweithrediad Gorchymyn Sychder Afon Hafren, gosodir terfyn tynnu dŵr o 300 Ml/d ar Ymddiriedolaeth y Camlesi a'r Afonydd pan fydd llif yn gostwng islaw 1200 Ml/d yn Deerhurst.

Mae adroddiadau a data o gyfnodau blaenorol pan fu gorchymyn sychder ar waith wedi cael eu defnyddio i asesu effaith Gorchymyn Sychder Afon Hafren. Gweithredwyd gorchmynion sychder yn 1976, 1984 a 1989. Gan ddefnyddio'r data hwn rydym wedi modelu effeithiau tebygol Gorchymyn Sychder Afon Hafren ar hydroleg, ansawdd dŵr, ecoleg, gan gynnwys pysgod, a safleoedd dynodedig. Lluniwyd Asesiad Rheoleiddio Cynefinoedd ar wahân (gan gynnwys Asesiad Priodol) ar gyfer Rhwydwaith Safleoedd Cenedlaethol Aber Afon Hafren (Atodiad 1).

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Non Technical Summary

Purpose of this Environment Assessment Report

Droughts are infrequent events in the UK but when they do occur their impact can be significant. The Environment Agency has responsibility for alleviating the effects of drought on people, businesses and the environment through sensible management of water resources in England. The Environment Agency also leads on drought management for the River Severn in Wales, in consultation with Natural Resources Wales.

Drought order applications must be accompanied by an environmental assessment report, which provides an assessment of the potential environmental effects of the order alone or in combination with other known plans, drought permits/orders and abstractions. The requirements of an environmental assessment report are defined in Defra and Environment Agency guidance, and on the Natural Resources Wales website[1]. This environmental assessment report is to accompany an application for the River Severn Drought Order.

Catchment Background

The River Severn is the longest river in the UK, travelling approximately 354 km (220 miles) from its source in Plynlimon down to the Severn Estuary. Excluding the River Wye, the catchment covers approximately 11,420 km^2 with an estuary over five miles wide. The Severn has twenty one tributaries and flows through four counties, Powys, Shropshire, Worcestershire and Gloucestershire.

The River Severn is augmented from water stored within Llyn Clywedog and Lake Vyrnwy reservoirs in Powys, and from boreholes that form the Shropshire Groundwater Scheme in Shropshire. These help maintain a minimum average flow at Bewdley gauging station. The Environment Agency and Natural Resources Wales manage the daily releases according to the Clywedog Reservoir Joint Authority Act (1963) and Shropshire Groundwater Scheme abstraction licence, in cooperation with water companies and the Canal & River Trust. This is known as River Severn regulation and is designed to provide a major source of water for public consumption, industry, electricity generation, navigation and agriculture, whilst maintaining an acceptable flow for the purposes of fisheries, conservation, recreation, effluent dilution and other in-river uses.

River Severn Drought Order

In normal and dry years the water available for River Severn regulation from Llyn Clywedog, Lake Vyrnwy and the Shropshire Groundwater Scheme is sufficient. In the event of a severe drought it is possible that these sources may become depleted and need temporary changes in how we operate the system to protect people and the environment.

It is expected that tributaries of the River Severn and neighbouring rivers would be experiencing significant drought stress and abstraction restrictions, whilst regulation would have largely protected the River Severn during the developing drought. The River Severn Drought Order is

[1] https://naturalresourceswales.gov.uk/permits-and-permissions/water-abstraction-and-impoundment/drought-permits-and-drought-orders/before-you-apply-for-a-drought-permit-or-drought-order/?lang=en and https://naturalresourceswales.gov.uk/permits-and-permissions/water-abstraction-and-impoundment/drought-permits-and-drought-orders/applying-for-a-drought-order-or-emergency-drought-order/?lang=en

designed to ration out the remaining regulation water used to support the River Severn, balancing human and environmental needs during a severe drought.

The River Severn Drought Order aims to reduce the risk of running out of regulation water, by maintaining lower flows along the River Severn the remaining water can be used for longer. If the regulation system were to run out of water, river levels and flows along the River Severn would drop suddenly and some sections may dry up. Water supplies would be threatened and significant environmental damage would be expected. The River Severn Drought Order is the Environment Agency and NRW's final drought management option; other measures would be in force, including abstraction restrictions and public appeals.

The River Severn Drought Order aims to ration out water by:

- capping the maximum release from Llyn Clywedog reservoir at 300 megalitres per day (Ml/d);
- reducing the prescribed flow at Bewdley from a single daily mean of 727 Ml/d and 850 Ml/d averaged over 5 days to a target of 730 Ml/d averaged over 5 days;
- reducing the prescribed flow at Bewdley below the target flow of 730 Ml/d averaged over 5 days if River Severn Regulation releases can no longer achieve it;
- imposing a 5% reduction on water company licensed abstractions from the River Severn;
- imposing a 300 Ml/d abstraction cap on the Gloucester Docks abstraction for the Gloucester & Sharpness Canal, when flows at Deerhurst or Haw Bridge gauge are below 1200 Ml/d;
- capping releases from Llyn Clywedog reservoir to 1.5% of remaining storage if storage in Llyn Clywedog reservoir falls below the 'emergency storage' trigger.

The River Severn Drought Order is triggered by the amount of water in Llyn Clywedog reservoir, and not by the amount of water flowing in the river. Llyn Clywedog reservoir was constructed solely to provide water for the Severn regulation system and represents the largest supply of water currently available to support the River Severn and is critical to managing the water efficiently. Storage levels in the reservoir are monitored against the control curves to track the available water resources and raise awareness of developing dry conditions.

Previous River Severn Drought Order applications

Variations of the River Severn Drought Order were operated in 1976, 1984 and 1989. No drought order applications have been made since these events; most notably the 1995-1996, 2022 or 2025 drought events did not trigger the drought order requirement.

Drought Scenarios

The resilience of the River Severn catchment under prolonged drought has been tested using the Aquator water resources model. Modelling indicated a River Severn Drought Order implementation would no longer be triggered by droughts of the same magnitude as 1976 because more water resources have been developed. In order to test the drought order, 1975-1976 drought conditions were prolonged and increased to create theoretical 'Acute' and 'Chronic' drought conditions. The Acute condition tested two dry winters/springs and an Acute drought summer situation, while the Chronic condition built on this to create a third dry winter/spring followed by a second Acute summer drought.

For each condition, two model scenarios were tested; a baseline 'Do Nothing' scenario and a 'Drought Order Only' scenario. The 'Do Nothing' scenario represented conditions under the Acute and Chronic conditions if normal Severn regulation continued, without the operation of a drought order. The 'Drought Order Only' scenario represented the Acute and Chronic conditions, all existing abstractions and discharges, and the operation of the River Severn Drought Order.

Summary of Environmental Effects

Water Resources (Hydrology)

River flows and water levels would initially be reduced by the River Severn Drought Order but should not reduce greatly below the natural drought flows and levels that would occur if no regulation support were available. The River Severn Drought Order modelling indicated no additional ecological flow target (Water Framework Directive standards) failures beyond what the natural drought was predicted to cause. The duration of failure may be slightly increased but all impacts would be temporary and unlikely to have a significant impact on the ecology.

If a drought continued for a long time (i.e. Acute condition), or a third dry winter occurred (i.e. Chronic condition), the modelling showed clear benefits associated with operation of the River Severn Drought Order. Prolonging storage in Llyn Clywedog would prolong compensation releases and reduce the risk of the upper section of the river drying up, which was a risk identified if the drought order were not operated. Water saved by operating the drought order was predicted to allow Llyn Clywedog to refill more quickly. This ensured storage was higher for the following year and potentially prevents the need for a second drought order application if another drought followed. This would have significant benefits to people and the environment.

The lower tidal River Severn above the Severn Estuary Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar Site was found to be most at risk to low flows and levels. The Canal and River Trust abstraction to the Gloucester and Sharpness Canal is now licensed and an operating agreement between the Environment Agency and the Canal & River Trust ensures the Severn Estuary is protected during normal to low flow conditions, however droughts are not covered.

Water Resources (Other Abstractors)

Before a River Severn Drought Order application is made, it is anticipated the majority of impacts on water abstractors along the River Severn would have already come into force as part of the Environment Agency's water resource and drought management procedures (i.e. they are not directly related to the drought order). Direct implications of the River Severn Drought Order for water companies with abstractions from the River Severn would include enforcement of 5 percent reductions to abstraction licences and potential for further reductions (up to 20 percent) that could be sought if storage at Llyn Clywedog crossed the 18 percent emergency storage curve. There would be a degree of flexibility around when restrictions could be relaxed temporarily and/or the drought order could be fully removed. However a drought order can legally remain in force for six months, or a year if extensions are sought.

Modelling indicated the River Severn Drought Order could operate for approximately 144 days from 25 August, for which the minimum 5 percent reduction would apply. The 18 percent emergency storage curve was predicted to be crossed for a total 22 days between 15 October and 6 November. Potential impacts on water company abstractions would alter according to current abstraction demands and whether or not the Environment Agency requested further abstraction reductions. Close discussions would therefore be held with the relevant water companies.

There is a risk of conflicting interests between some water company drought permits/orders (identified in their own Drought Plans) and the River Severn Drought Order. The River Severn Drought Order would seek to lower River Severn flows and lower abstraction pressures to enable regulation to last for longer to support people and the environment, while water companies with abstractions directly from the River Severn would seek to maintain or increase abstraction solely to support public water supplies. The Environment Agency and the relevant water companies would meet early to discuss any potential conflict. If no alternative could be found the water companies would be directed to apply to the Secretary of State for a drought order on the grounds of Imperative Reasons of Overriding Public Interest (IROPI).

Abstractions into the Montgomery Canal are licensed by Natural Resources Wales and are restricted under the River Severn Drought Order operation. Modelling suggested the River Severn Drought Order would be of benefit to the Montgomery Canal abstraction, as it would reduce the period of no abstraction enforced if Llyn Clywedog storage falls below 25 percent. Modelling suggested approximately 76 days of no permitted abstraction between 16 September and 30 November with the River Severn Drought Order in place, compared to 120 days between 2 September and 30 December if no drought order were operated.

The Gloucester & Sharpness Canal abstraction is known to have a potential impact on the lower tidal Severn and inflows to the Severn Estuary depending on tide heights and the volume of abstraction. Abstraction during drought periods is not covered by the 1998 Operating Agreement with the Environment Agency or their abstraction licence, and historic River Severn Drought Order applications did not include specific restrictions for this canal. Due to the Habitat Regulation Assessment findings, a restriction is being introduced under the River Severn Drought Order to mitigate potential risk to the National Site Network. The maximum amount of water that can be taken for the canal when the River Severn Drought Order is in place will be 300 Ml/d, to be enforced when flows at Deerhurst drop below 1200 Ml/d. The restriction aims to protect environmental needs whilst still allowing the Canal & River Trust enough water to meet its main obligations.

The Canal & River Trust's internal drought management flow trigger at Deerhurst was used to assess the potential impact of the River Severn Drought Order operation on navigation. The Acute 'Do Nothing' scenario identified 106 days of potential impact between 2 July and 1 November and the Chronic 'Do Nothing' scenario 101 days. When compared with the 'Drought Order Only' scenario, 38 of these days coincided with the activation of the River Severn Drought Order. Owing to the consistency compared to the 'Do Nothing' scenarios and period of River Severn Drought Order operation, no additional canal closures are predicted as a result of activating the drought order when compared to the Canal & River Trust’s 1150 Ml/d trigger to consider drought restrictions.

Testing the proposed new abstraction cap of 300 Ml/d concluded the Canal & River Trust’s abstraction from the River Severn was impacted for 38 days out of the year; all days which had already crossed the 1150 Ml/d Deerhurst trigger for considering drought restriction implementation and potential canal closure.

Bristol Water's public water supply abstraction is taken directly from the Gloucester & Sharpness Canal. Due to its proximity to the Severn Estuary there is a risk of saline intrusion into the canal. This is normally mitigated by the Operating Agreement rules, which are all linked to tide heights and flows at Deerhurst. Reports identified that during the 1976 drought, salinity was reaching critical levels just before rainfall returned. The theoretical Acute and Chronic conditions modelled for the River Severn Drought Order extended this drought period, increasing the risk of saline intrusion up the lower tidal Severn and therefore the risk of saline water entering the Gloucester & Sharpness Canal.

With careful water management and the continued interception of several tributaries, the Environment Agency believe a 300 Ml/d restriction from the River Severn, only when flows drop below 1200 Ml/d at Deerhurst, should still control salinity and allow the Canal & River Trust to supply Bristol Water with enough water.

Water Quality

Comparing the 'Drought Order Only' and 'Do Nothing' scenarios (under both Acute and Chronic conditions), the River Severn Drought Order modelling predicted no additional water quality WFD failures. Water quality was found to improve with the operation of the River Severn Drought Order because the higher minimum flows created greater dilution. Nutrients and phosphates were found to increase as a consequence of the natural drought; but the River Severn Drought Order had no negative impacts on concentrations of these parameters.

Ecology (macroinvertebrates and macrophytes)

Ecological impacts of the River Severn Drought Order were assessed with reference to potential effects upon river macroinvertebrate communities at various points along the river. Historical information from the 1975/76 drought and several subsequent drought periods provided indications of potential future impacts, while predictions of flow patterns allowed an assessment of severity of impact and how these may change if the drought order were applied. Close to the Llyn Clywedog and Lake Vyrnwy reservoirs, the drought order would require a compensation flow higher than the river flow which would be expected naturally under drought conditions and therefore low flow sensitive taxa would benefit. However, there would be potential detrimental impacts: the large volume of water released would necessitate a longer time to replenish the reservoir following the end of the drought, thereby reducing natural flow variability while the reservoir refills. Further downstream, releases under the drought order would reduce the negative impacts on the macroinvertebrate fauna, particularly because a larger proportion of the riverbed would remain immersed than predicted under natural drought conditions. Water quality has improved along much of the river since the 1975/6 drought, making this less likely to cause problems under future drought conditions.

Towards the lower reaches of the River Severn, predictions of ecological impacts are more difficult, as the data available are patchy. There is also too little information to predict the effect of a drought, or the mitigating effect of the drought order, on macrophytes.

Ecology (Fish of the Severn Corridor)

An assessment of potential impacts on fish was conducted by considering flow requirements of different species and examining hydrographs indicating predicted flows based on Acute and Chronic low flow conditions under the two drought order scenarios ('Drought Order Only' and 'Do Nothing'). Overall, it was concluded that operation of the River Severn Drought Order would be beneficial to the fish population in the upper River Severn although further downstream, and in particular near the estuary, the benefits would be greatly reduced.

Ecology (Invasive Non Native Species)

Specific within the area covered by the River Severn Drought Order, only American signal crayfish, giant hogweed, Japanese knotweed, Himalayan balsam and mink are likely to be problematic. Considering the individual reproduction and dispersion methods for each of these species did not identify an increased risk through the River Severn Drought Order implementation, no adverse impact was concluded.

Designated Sites connected to the River Severn

All the nationally and internationally designated sites connected to the River Severn by water pathways were assessed for potential impact from the River Severn Drought Order. Thirteen sites were taken through the Habitats Directive Assessment screening process because they could potentially be sensitive to lowered water levels and flows. Only the Severn Estuary was found to be at potential risk, all other sites were concluded as having no impact from the River Severn Drought Order.

Severn Estuary (National Site Network)

A Habitats Regulations Assessment was carried out for the River Severn Drought Order. The assessment concluded the River Severn Drought Order alone was unlikely to have a significant effect on the designated estuary feature, sub features or supporting habitats. The main area of risk was identified as the lower tidal Severn, just upstream of the designated Estuary site, extending upstream to where the River Severn splits at Gloucester. The assessment considered the operation of the Canal & River Trust’s maximum potential abstraction for the Gloucester & Sharpness Canal and was unable to conclude no likely significant effect on migratory fish with the greatest uncertainty remaining around what the maximum abstraction might be during a severe drought.

As a competent authority under the Habitats Directive we have to either mitigate against potential environmental harm or apply for the River Severn Drought Order on the grounds of Imperative Reasons of Overriding Public Interest. The most appropriate option to balance water needs and the requirements of the Habitats Directive was found to be limiting the abstraction to the Gloucester & Sharpness Canal. The Habitats Regulations Assessment concluded that a maximum abstraction of 300 Ml/d to the canal was unlikely to cause harm to the National Site Network designations. Applications for this Drought Order will therefore include an abstraction cap of 300 Ml/d on the Canal & River Trust, when flows at Deerhurst drop below 1200 Ml/d. If the Drought Order is granted, the conditions set would become legally enforceable. This action should successfully mitigate any potential harm to the National Site Network and satisfy the Habitat Directive requirements.

Water Framework Directive

The potential impacts of the River Severn Drought Order are considered to come under Article 4.6 of the Water Framework Directive (WFD), allowing for temporary deterioration as a *'result of circumstances of natural cause which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts.'* Modelling indicated flows and water quality would deteriorate below local WFD targets as part of the natural drought process, regardless of whether the River Severn Drought Order was operated or not. Data from historic drought events support this conclusion, with regulated flows under historical drought order operations having exceeded or equalled what would have naturally occurred at Bewdley and Haw Bridge. The River Severn Drought Order is not expected to delay the recovery of the environment following the drought event, having only a temporary impact on surface water flows. It is concluded there will be no significant impact on WFD targets.

Archaeology and Cultural Heritage

No impact was concluded on archaeology and cultural heritage from operating the River Severn Drought Order.

Navigation and Recreation

In 2018 and 2022, depletion of water levels in Llyn Clywedog had an impact on access to water for recreational use, when previously no information existed which related volumes and levels in Llyn Clywedog reservoir to impacting recreational use. Despite this, it can be assumed implementation of the River Severn Drought Order would have a positive impact on sailing and boating activities on Llyn Clywedog by conserving water resources and prolonging the sailing season compared to not operating the drought order. The post drought recovery time, including time for the reservoir to refill, would also be reduced by operating the drought order. This would subsequently reduce the duration of drought impact on the sailing club and fishing club and help to protect against a second year of impact.

In 2018, boats were removed early because draw down made access difficult but no other information was found to relate volumes and levels in Lake Vyrnwy reservoir to impact recreational use. The River Severn Drought Order does not seek to alter the maximum quantity of water released from the reservoir compared to normal operation, therefore no impact was concluded.

Navigation along the River Severn from the middle to lower catchment would be impacted by the lowered water levels experienced during a drought, making passage over weirs and through locks limited depending on the drought severity. During 1995 commercial vessels experienced considerable difficulty in navigating between Gloucester and Tewkesbury with a water depth of only approximately 1.44 m. During 2022 the Canal & River Trust reported difficulties with significant silt build up and the dredging boats becoming stuck for both the Montgomery canal and Gloucester Docks.

The degree of impact is likely to vary locally and already be an issue before being exacerbated by the River Severn Drought Order and in combination abstractions. Taking a worst case approach, navigation by the majority of vessels during droughts of the modelled magnitude could be largely prevented until high rainfall events return.

Angling will be impacted by the naturally falling water levels in the reservoir and watercourses regardless of whether the drought order is operated or not. Extremely low levels may have adverse effects on fish survival, particularly in the lower catchment where locks and weirs are extensive. Fish recruitment could be affected if the chronic condition is met and low levels continue through autumn 2026 and winter/spring 2027. Poor recruitment years are a naturally cyclical event, but missing year classes could affect future angling. If angling is considered to be leading to additional stress on fish it may be beneficial to suggest a temporary cessation of fishing activities. The duration of any suggestions is unlikely to be different whether the River Severn Drought Order is operated or not, therefore no additional impact is expected on angling.

Crynodeb Annhechnegol

Diben yr Adroddiad Asesu Amgylcheddol hwn

Digwyddiad prin yw sychder yn y Deyrnas Unedig ond pan fydd yn digwydd gall ei effaith fod yn sylweddol. Mae gan Asiantaeth yr Amgylchedd gyfrifoldeb dros liniaru effeithiau sychder ar bobl, busnesau a'r amgylchedd trwy sicrhau bod adnoddau dŵr yn Lloegr yn cael eu rheoli mewn modd synhwyrol. Mae Asiantaeth yr Amgylchedd hefyd yn arwain ar waith rheoli sychder ar gyfer Afon Hafren yng Nghymru, mewn ymgynghoriad â Cyfoeth Naturiol Cymru.

Mae'n rhaid i adroddiad asesu amgylcheddol gyd-fynd â cheisiadau am orchymyn sychder, sy'n rhoi asesiad o effeithiau amgylcheddol posibl y gorchymyn ar ei ben ei hun, neu ar y cyd â chynlluniau, trwyddedau/gorchmynion sychder a gweithrediadau tynnu dŵr hysbys eraill. Diffinnir gofynion adroddiad asesu amgylcheddol mewn cyfarwyddyd gan Defra ac Asiantaeth yr Amgylchedd, ac ar wefan Cyfoeth Naturiol Cymru[2]. Rhaid i'r adroddiad asesu amgylcheddol hwn gyd-fynd â chais am Orchymyn Sychder Afon Hafren.

Cefndir y Dalgylch

Afon Hafren yw'r afon hwyaf ym Mhrydain Fawr, gan lifo tua 354 km (220 o filltiroedd) o'i tharddle ym Mhumlumon i lawr i Aber Afon Hafren. Ac eithrio Afon Gwy, mae'r dalgylch yn cwmpasu tua 11,420 km2, ac mae'r aber dros bum milltir o led. Mae gan Afon Hafren 21 o isafonydd ac mae'n llifo trwy bedair sir, sef Powys, Swydd Amwythig, Swydd Gaerwrangon a Swydd Gaerloyw.

Ychwanegir at ddŵr Afon Hafren gan ddŵr sydd wedi'i storio yng nghronfeydd dŵr Llyn Clywedog a Llyn Efyrnwy ym Mhowys, a thyllau turio sy'n rhan o Gynllun Dŵr Daear Swydd Amwythig. Mae'r rhain yn helpu i gynnal lleiafswm llif cyfartalog ger gorsaf fesur Bewdley. Mae Asiantaeth yr Amgylchedd a Cyfoeth Naturiol Cymru yn rheoli'r gollyngiadau dyddiol yn ôl Deddf Cyd-awdurdod Cronfa Ddŵr Clywedog (1963) a thrwydded tynnu dŵr Cynllun Dŵr Daear Swydd Amwythig, mewn cydweithrediad â chwmnïau dŵr ac Ymddiriedolaeth y Camlesi a'r Afonydd (Glandŵr Cymru yng Nghymru). Gelwir hyn yn rheoleiddio afon Hafren a'i nod yw darparu ffynhonnell fawr o ddŵr ar gyfer ei ddefnyddio gan y cyhoedd a diwydiant, i gynhyrchu trydan a mordwyo arno, ac ar gyfer amaethyddiaeth, ar yr un pryd â chynnal llif derbyniol at ddibenion pysgodfeydd, cadwraeth, hamdden, gwanhau elifion a defnyddiau eraill o fewn yr afon.

Gorchymyn Sychder Afon Hafren

Yn ystod blynyddoedd arferol a sych, mae'r dŵr sydd ar gael o Lyn Clywedog, Llyn Efyrnwy a Chynllun Dŵr Daear Swydd Amwythig yn ddigon ar gyfer rheoleiddio afon Hafren. Pe bai sychder difrifol yn digwydd, mae'n bosibl y gallai'r ffynonellau hyn ddirywio, a byddai angen sicrhau newidiadau dros dro o ran y ffordd rydym yn gweithredu'r system, er mwyn diogelu pobl a'r amgylchedd.

[2] https://naturalresourceswales.gov.uk/permits-and-permissions/water-abstraction-and-impoundment/drought-permits-and-drought-orders/before-you-apply-for-a-drought-permit-or-drought-order/?lang=en and https://naturalresourceswales.gov.uk/permits-and-permissions/water-abstraction-and-impoundment/drought-permits-and-drought-orders/applying-for-a-drought-order-or-emergency-drought-order/?lang=en

Disgwylir y byddai isafonydd afon Hafren a'r afonydd gerllaw yn profi straen sychder sylweddol, ac y byddai cyfyngiadau ar dynnu dŵr oddi wrthynt ar waith, tra byddai rheoleiddio wedi gwarchod Afon Hafren i raddau helaeth yn ystod y sychder datblygol. Nod Gorchymyn Sychder Afon Hafren yw dogni'r dŵr rheoleiddio sy'n weddill a ddefnyddir i gynnal afon Hafren, gan gydbwyso anghenion dynol ac amgylcheddol yn ystod sychder difrifol.

Mae Gorchymyn Sychder Afon Hafren yn anelu at leihau'r risg y bydd dŵr rheoleiddio'n dod i ben, a thrwy gynnal llifoedd is ar hyd Afon Hafren, gellir defnyddio'r dŵr sy'n weddill am fwy o amser. Pe na bai dŵr ar gael ar gyfer y system reoleiddio o gwbl, byddai lefelau afonydd a llifoedd ar hyd Afon Hafren yn gostwng yn sydyn a gallai rhai rhannau sychu'n gyfan gwbl. Byddai bygythiad i gyflenwadau dŵr a disgwylid y byddai difrod amgylcheddol sylweddol o ganlyniad. Gorchymyn Sychder Afon Hafren yw opsiwn rheoli sychder terfynol Asiantaeth yr Amgylchedd a CNC, a byddai mesurau eraill mewn grym, gan gynnwys cyfyngiadau ar dynnu dŵr ac apeliadau at y cyhoedd.

Mae Gorchymyn Sychder Afon Hafren yn anelu at ddogni dŵr drwy wneud y canlynol:

- rhoi terfyn uchaf ar faint o ddŵr y gellir ei ryddhau o gronfa ddŵr Llyn Clywedog i 300 megalitr y dydd (Ml/d);
- lleihau'r llif penodedig yn Bewdley o gymedr dyddiol sengl o 727 Ml/d ac 850 Ml/d ar gyfartaledd dros 5 diwrnod i darged o 730 Ml/d ar gyfartaledd dros 5 diwrnod;
- lleihau'r llif penodedig yn Bewdley islaw'r llif targed o 730 Ml/d ar gyfartaledd dros 5 diwrnod os na all gollyngiadau Rheoleiddio Afon Hafren ei gyflawni mwyach;
- gosod gostyngiad o 5% ar faint o ddŵr y gall cwmnïau dŵr dynnu yn ôl eu trwyddedau o Afon Hafren;
- gosod cap tynnu dŵr o 300 Ml/d ar dynnu dŵr yn Nociau Caerloyw ar gyfer Camlas Caerloyw a Sharpness, pan fydd llifoedd ym mesurydd Deerhurst neu Bont Haw islaw 1200 Ml/d;
- gosod terfyn uchaf ar ollyngiadau o gronfa ddŵr Llyn Clywedog o 1.5% o'r dŵr wedi'i storio sy'n weddill os yw lefel y dŵr wedi'i storio yn Llyn Clywedog yn mynd o dan y trothwy 'storio argyfwng'.

Sbardunir Gorchymyn Sychder Afon Hafren gan y cyfaint o ddŵr sydd yng nghronfa ddŵr Llyn Clywedog, ac nid gan y swm o ddŵr sy'n llifo yn yr afon. Cafodd cronfa ddŵr Llyn Clywedog ei hadeiladu er mwyn darparu dŵr ar gyfer system reoleiddio afon Hafren yn unig, ac mae'n cynrychioli'r cyflenwad mwyaf o ddŵr sydd ar gael ar hyn o bryd ar gyfer cynnal Afon Hafren, ac mae'n hanfodol bwysig o safbwynt rheoli'r dŵr mewn modd effeithlon. Caiff y swm o ddŵr sydd wedi'i storio yn y gronfa ddŵr ei fonitro yn erbyn y cromliniau rheoli er mwyn olrhain yr adnoddau dŵr sydd ar gael a chodi ymwybyddiaeth o amodau sych datblygol.

Ceisiadau blaenorol am Orchymyn Sychder Afon Hafren

Gweithredwyd amrywiadau o Orchymyn Sychder Afon Hafren yn 1976, 1984 ac 1989. Ni wnaed ceisiadau am orchymyn sychder ers y digwyddiadau hyn ac, yn fwyaf nodedig, ni wnaeth y digwyddiadau sychder yn 1995-1996, 2022 na 2025 sbarduno'r gofyniad am orchymyn sychder.

Senarios Sychder

Mae gwytnwch dalgylch Afon Hafren o dan amodau sychder estynedig wedi'i brofi gan ddefnyddio model adnoddau dŵr Aquator. Dangosodd gwaith modelu na fyddai sychder o'r un difrifoldeb â'r un a ddigwyddodd yn 1976 yn ddigon i weithredu Gorchymyn Sychder Afon Hafren mwyach oherwydd bod mwy o adnoddau dŵr wedi'u datblygu. Er mwyn profi'r gorchymyn sychder, cafodd

amodau sychder 1975-1976 eu hymestyn a'u cynyddu er mwyn creu amodau sychder ‘acíwt’ a ‘chronig’ damcaniaethol. Profodd yr amodau acíwt ddau aeaf/gwanwyn sych a sefyllfa o sychder acíwt yn yr haf, ac adeiladodd yr amodau cronig ar hyn i greu trydydd gaeaf/gwanwyn sych a gafodd ei ddilyn gan ail sychder acíwt yn yr haf.

Ar gyfer y ddau fath o amodau, profwyd dwy senario model: senario sylfaen ‘Gwneud Dim Byd’ a senario ‘Gorchymyn Sychder yn Unig’. Roedd y senario ‘Gwneud Dim Byd’ yn cynrychioli'r amodau acíwt a chronig pe bai rheoleiddio afon Hafren yn parhau fel arfer, heb weithredu gorchymyn sychder. Roedd y senario ‘Gorchymyn Sychder yn Unig’ yn cynrychioli'r amodau acíwt a chronig, yr holl weithrediadau tynnu dŵr a gollyngiadau presennol, a gweithredu Gorchymyn Sychder Afon Hafren.

Crynodeb o Effeithiau Amgylcheddol

Adnoddau Dŵr (Hydroleg)

Byddai llifoedd afonydd a lefelau dŵr yn gostwng i ddechrau o ganlyniad i weithredu Gorchymyn Sychder Afon Hafren ond ni ddylent ostwng ymhell islaw'r llifoedd a lefelau sychder naturiol a fyddai'n digwydd pe na bai cefnogaeth o ran rheoleiddio ar gael. Dangosodd gwaith modelu ar gyfer Gorchymyn Sychder Afon Hafren na fyddai diffygion ychwanegol yn y llif darged ecolegol (safonau'r Gyfarwyddeb Fframwaith Dŵr) y tu hwnt i'r hyn y rhagfynegwyd y byddai sychder naturiol yn ei achosi. Efallai y byddai'r diffyg yn para ychydig yn hwy, ond byddai’r rhain i gyd yn effeithiau dros dro, ac ni fyddent yn debygol o gael effaith sylweddol ar yr ecoleg.

Pe bai sychder yn parhau am gyfnod hir (h.y. amodau acíwt), neu pe bai trydydd gaeaf sych yn digwydd (h.y. amodau cronig), dangosodd y gwaith modelu fanteision amlwg mewn perthynas â gweithredu Gorchymyn Sychder Afon Hafren. Byddai cadw'r dŵr yn Llyn Clywedog yn ymestyn gollyngiadau adfer ac yn lleihau'r posibilrwydd y gallai adran uwch yr afon sychu, a oedd yn risg a nodwyd pe na fyddai'r gorchymyn sychder yn cael ei weithredu. Rhagfynegwyd y byddai'r dŵr a arbedwyd drwy weithredu'r gorchymyn sychder yn galluogi Llyn Clywedog i ail-lenwi'n gynt. Roedd hyn yn sicrhau bod mwy o ddŵr wedi'i storio ar gyfer y flwyddyn ganlynol ac mae’n osgoi'r angen o bosib am wneud cais arall am orchymyn sychder pe bai cyfnod arall o sychder. Byddai hyn yn cyflwyno manteision sylweddol i bobl a'r amgylchedd.

Canfuwyd bod rhan isaf, lanwol Afon Hafren uwchben Ardal Cadwraeth Arbennig (ACA), Ardal Gwarchod Arbennig (AGA) a Safle Ramsar Aber Afon Hafren yn fwyaf agored i lifoedd a lefelau isel. Bellach, mae gan Ymddiriedolaeth y Camlesi a’r Afonydd drwydded i dynnu dŵr i Gamlas Caerloyw a Sharpness ac mae cytundeb gweithredu rhwng Asiantaeth yr Amgylchedd ac Ymddiriedolaeth y Camlesi a’r Afonydd yn sicrhau bod Aber Afon Hafren yn cael ei warchod yn wirfoddol yn ystod amodau llif arferol i isel, fodd bynnag nid yw cyfnodau o sychder yn cael eu cwmpasu.

Adnoddau Dŵr (Tynwyr Dŵr Eraill)

Cyn y gwneir cais am Orchymyn Sychder Afon Hafren, rhagwelir y byddai'r mwyafrif o effeithiau ar dynwyr dŵr ar hyd Afon Hafren eisoes wedi dod i rym fel rhan o weithdrefnau rheoli adnoddau dŵr a sychder Asiantaeth yr Amgylchedd (h.y. nid ydynt yn perthyn yn uniongyrchol i'r gorchymyn sychder). Byddai goblygiadau uniongyrchol Gorchymyn Sychder Afon Hafren ar gyfer cwmnïau dŵr sy'n tynnu dŵr o afon Hafren yn cynnwys gorfodi gostyngiadau o 5 y cant ar drwyddedau tynnu dŵr, a'r posibilrwydd y gellid ceisio gostyngiadau pellach (hyd at 20 y cant) pe bai'r lefel storio dŵr yn Llyn Clywedog yn mynd heibio i'r pwynt storio argyfwng o 18 y cant. Byddai rhywfaint o hyblygrwydd ynghylch pryd y gellid llacio cyfyngiadau dros dro a/neu y gellid diddymu'r gorchymyn sychder yn gyfan gwbl. Fodd bynnag, gall gorchymyn sychder barhau i fod mewn grym am hyd at chwe mis, neu flwyddyn os ceisir estyniadau.

Dangosodd gwaith modelu y gallai Gorchymyn Sychder Afon Hafren weithredu am tua 144 o ddyddiau o 25 Awst, y byddai'r gostyngiad lleiaf o 5 y cant ar drwyddedau tynnu dŵr yn gymwys ar

eu cyfer. Rhagfynegwyd y byddai'r pwynt storio argyfwng o 18 y cant yn cael ei groesi am gyfanswm o 22 o ddyddiau rhwng 15 Hydref a 6 Tachwedd. Byddai goblygiadau posibl ar weithrediadau tynnu dŵr cwmnïau dŵr yn newid yn ôl y gofynion tynnu dŵr cyfredol a ph'un a fyddai Asiantaeth yr Amgylchedd yn gofyn am ragor o ostyngiadau ar dynnu dŵr ai peidio. Byddai trafodaethau agos felly'n cael eu cynnal â'r cwmnïau dŵr perthnasol.

Ceir risg o wrthdaro buddiannau rhwng nifer o drwyddedau/gorchmynion sychder cwmnïau dŵr (a nodir yn eu cynlluniau sychder perthnasol) a Gorchymyn Sychder Afon Hafren. Byddai Gorchymyn Sychder Afon Hafren yn ceisio lleihau llifoedd afon Hafren a lleihau'r pwysau tynnu dŵr er mwyn galluogi gwaith rheoleiddio i barhau'n hwy i gefnogi pobl a'r amgylchedd, a byddai cwmnïau dŵr sy'n tynnu dŵr yn uniongyrchol o afon Hafren yn ceisio cynnal neu gynyddu gweithrediadau tynnu dŵr er mwyn cefnogi cyflenwadau dŵr cyhoeddus yn unig. Byddai Asiantaeth yr Amgylchedd a'r cwmnïau dŵr perthnasol yn cyfarfod yn gynnar i drafod unrhyw wrthdaro posibl. Os na ellid dod o hyd i ddewis arall, byddai'r cwmnïau dŵr yn cael eu cyfarwyddo i wneud cais i'r Ysgrifennydd Gwladol am orchymyn sychder ar sail rhesymau hanfodol, sef er budd cyhoeddus tra phwysig (IROPI).

Mae gweithrediadau tynnu dŵr i Gamlas Trefaldwyn wedi'u trwyddedu gan Cyfoeth Naturiol Cymru ac maent wedi'u cyfyngu o dan weithrediad Gorchymyn Sychder Afon Hafren. Roedd gwaith modelu'n awgrymu y byddai Gorchymyn Sychder Afon Hafren o fudd i dynnu dŵr i Gamlas Trefaldwyn, gan y byddai'n lleihau'r cyfnod a orfodir o beidio â thynnu dŵr pe bai storfa Llyn Clywedog yn gostwng o dan 25 y cant. Roedd gwaith modelu'n awgrymu tua 76 diwrnod lle na chaniateir tynnu dŵr rhwng 16 Medi a 30 Tachwedd gyda Gorchymyn Sychder Afon Hafren ar waith, o'i gymharu â 120 diwrnod rhwng 2 Medi a 30 Rhagfyr pe na bai gorchymyn sychder ar waith.

Mae'n hysbys bod gwaith tynnu dŵr ar gyfer Camlas Caerloyw a Sharpness yn cael effaith bosibl ar rannau llanwol is Afon Hafren, ac ar fewnlifau i Aber Afon Hafren, gan ddibynnu ar uchder y llanw a'r cyfaint o ddŵr a dynnir. Nid yw tynnu dŵr yn ystod cyfnodau o sychder wedi'i gwmpasu gan Gytundeb Gweithredu 1998 gydag Asiantaeth yr Amgylchedd na'u trwydded tynnu dŵr, ac nid oedd ceisiadau hanesyddol ar gyfer Gorchymyn Sychder Afon Hafren yn cynnwys cyfyngiadau penodol ar gyfer y gamlas hon. Oherwydd canfyddiadau'r Asesiad Rheoliadau Cynefinoedd, mae cyfyngiad yn cael ei gyflwyno o dan Orchymyn Sychder Afon Hafren i liniaru risg bosibl i'r Rhwydwaith Safleoedd Cenedlaethol. Uchafswm y dŵr y caniateir ei dynnu ar gyfer y gamlas pan fydd Gorchymyn Sychder Afon Hafren yn weithredol fydd 300 Ml/d, a gaiff ei orfodi pan fydd y llif yn Deerhurst islaw 1,200 Ml/d. Nod y cyfyngiad yw gwarchod anghenion amgylcheddol wrth barhau i adael digon o ddŵr i Ymddiriedolaeth y Camlesi a'r Afonydd (Glandŵr Cymru yng Nghymru) fodloni ei brif rwymedigaethau.

Cafodd trothwy llif rheoli sychder mewnol Ymddiriedolaeth y Camlesi a'r Afonydd yn Deerhurst ei ddefnyddio i asesu effaith bosibl gweithredu Gorchymyn Sychder Afon Hafren ar fordwyo. Nododd y senario acíwt 'Gwneud Dim Byd' fod 106 o ddyddiau o effaith bosibl rhwng 2 Gorffennaf a 1 Tachwedd, a bod 101 o ddyddiau felly ar gyfer y senario cronig 'Gwneud Dim Byd'. Wrth gymharu â'r senario 'Gorchymyn Sychder yn Unig', roedd 38 o'r dyddiau hyn yn cyd-ddigwydd ag actifadu Gorchymyn Sychder Afon Hafren. O ganlyniad i'r cysondeb o gymharu â'r senarios 'Gwneud Dim Byd' a chyfnod o weithredu Gorchymyn Sychder Afon Hafren, ni ragwelir achosion pellach o gau'r gamlas o ganlyniad i actifadu'r gorchymyn sychder o gymharu â sbardun 1,150 Ml/d Ymddiriedolaeth yr Afonydd a'r Camlesi ar gyfer ystyried cyfyngiadau sychder.

Daeth profion ar y terfyn arfaethedig newydd ar dynnu dŵr o 300 Ml/d i'r casgliad y byddai'n cael effaith ar weithgareddau tynnu dŵr Ymddiriedolaeth yr Afonydd a'r Camlesi o afon Hafren am 38 o ddyddiau o'r flwyddyn, sydd oll yn ddyddiau pan oedd y sbardun yn Deerhurst o 1150 Ml/d ar gyfer ystyried gweithredu cyfyngiadau sychder, a chau'r gamlas o bosib, eisoes wedi'i groesi.

Mae'r dŵr a dynnir gan Bristol Water ar gyfer cyflenwad dŵr cyhoeddus yn cael ei gymryd yn uniongyrchol o Gamlas Caerloyw a Sharpness. Oherwydd bod y gwaith hwn yn agos at aber afon Hafren, mae perygl o ymwthiad halwynog i'r gamlas. Caiff hyn ei liniaru fel arfer gan reolau'r

Cytundeb Gweithredu, sydd i gyd yn gysylltiedig ag uchderau a llifoedd y llanw yn Deerhurst. Yn ystod sychder 1976, nododd adroddiadau fod halwynedd yn cyrraedd lefelau critigol ychydig cyn i'r glaw ddychwelyd. Ymestynnodd yr amodau acíwt a chronig damcaniaethol a gafodd eu modelu ar gyfer Gorchymyn Sychder Afon Hafren y cyfnod sychder hwn, gan gynyddu'r risg o ymwthiad halwynog i fyny rhan lanwol is afon Hafren, ac felly'r risg y gallai dŵr halwynog fynd i mewn i Gamlas Caerloyw a Sharpness.

Drwy reoli dŵr yn ofalus a thrwy barhau i ailgyfeirio sawl isafon, mae Asiantaeth yr Amgylchedd yn credu y dylai cyfyngiad o 300 Ml/d ar dynnu dŵr o afon Hafren, pan fo'r llif yn Deerhurst yn gostwng islaw 1,200 Ml/d yn unig, olygu y gallai Ymddiriedolaeth y Camlesi a'r Afonydd gyflenwi digon o ddŵr i Bristol Water o hyd.

Ansawdd Dŵr

O gymharu'r senarios 'Gorchymyn Sychder yn Unig' a 'Gwneud Dim Byd' (o dan amodau acíwt ac amodau cronig), rhagfynegodd gwaith modelu ar Orchymyn Sychder Afon Hafren na fyddai methiannau ychwanegol o safbwynt safonau ansawdd dŵr y Gyfarwyddeb Fframwaith Dŵr. Canfuwyd y byddai ansawdd dŵr yn gwella wrth weithredu Gorchymyn Sychder Afon Hafren oherwydd y byddai'r llifoedd lleiaf uwch yn creu mwy o wanhad. Canfuwyd y byddai maethynnau a ffosffadau'n cynyddu o ganlyniad i'r sychder naturiol, ond ni chafodd Gorchymyn Sychder Afon Hafren effaith negyddol o gwbl ar grynodiadau'r paramedrau hyn.

Ecoleg (Macroinfertebratau a Macroffytau)

Aseswyd effeithiau ecolegol Gorchymyn Sychder Afon Hafren gan gyfeirio at effeithiau posibl ar gymunedau o macroinfertebratau afonol ar bwyntiau amrywiol ar hyd yr afon. Darparodd gwybodaeth hanesyddol o'r sychder yn 1975/76, a nifer o gyfnodau o sychder dilynol, arwyddion o effeithiau posibl yn y dyfodol, tra hwylusodd rhagfynegiadau o batrymau llif asesiad o ddifrifoldeb yr effaith a sut y gallai'r rhain newid pe bai'r gorchymyn sychder yn cael ei weithredu. Gerllaw cronfeydd dŵr Llyn Clywedog a Llyn Efyrnwy, byddai'r gorchymyn sychder yn gofyn am lif adfer sy'n uwch na'r llif afon a ddisgwylid yn naturiol o dan amodau sychder, ac felly byddai tacsonau sy'n sensitif i lif isel yn elwa. Fodd bynnag, byddai effeithiau andwyol posibl: byddai angen mwy o amser i ail-lenwi'r gronfa ddŵr o ganlyniad i ryddhau swm mawr o ddŵr yn dilyn diwedd y sychder, gan felly leihau amrywioldeb naturiol y llif tra bo'r gronfa ddŵr yn ail-lenwi. Ymhellach i lawr yr afon, byddai gollyngiadau o dan y gorchymyn sychder yn lleihau'r effeithiau negyddol ar ffawna'r macroinfertebratau, yn arbennig oherwydd y byddai cyfran uwch o wely'r afon yn parhau i fod o dan y dŵr nag a ragwelir o dan amodau sychder naturiol. Mae ansawdd dŵr wedi gwella ar hyd llawer o'r afon ers sychder 1975/6, gan leihau'r posibilrwydd y bydd hyn yn achosi problemau o dan amodau sychder yn y dyfodol.

Tuag at rannau is Afon Hafren, mae rhagfynegi effeithiau ecolegol yn anos gan fod y data sydd ar gael yn fylchog. Nid oes digon o wybodaeth ychwaith i ragfynegi effaith sychder ar facroffytau, nac effaith liniarol y gorchymyn sychder arnynt.

Ecoleg (Pysgod Coridor Afon Hafren)

Cynhaliwyd asesiad o effeithiau posibl ar bysgod drwy ystyried gofynion llif rhywogaethau gwahanol ac archwilio hydrograffiau sy'n dangos llifoedd a ragfynegir yn seiliedig ar amodau llif isel acíwt a chronig o dan y ddwy senario ar gyfer gorchymyn sychder (sef 'Gorchymyn Sychder yn Unig' a 'Gwneud Dim Byd'). Ar y cyfan, daethpwyd i'r casgliad y byddai gweithredu Gorchymyn Sychder Afon Hafren yn fuddiol i'r boblogaeth pysgod yn Afon Hafren uchaf er y byddai'r manteision yn llai o lawer ymhellach i lawr yr afon, ac yn arbennig ger yr aber.

Ecoleg (Rhywogaethau Estron Goresgynnol)

Yn benodol o fewn yr ardal a gwmpesir gan Orchymyn Sychder Afon Hafren, dim ond cimychiaid afon arwyddol, efwr enfawr, clymog Japan, jac y neidiwr a mincod sy'n debygol o achosi problemau. O ystyried na wnaeth y dulliau atgenhedlu a gwasgaru unigol ar gyfer pob un o'r rhywogaethau hyn nodi risg gynyddol trwy weithrediad Gorchymyn Sychder Afon Hafren, ni chasglwyd bod unrhyw effaith andwyol.

Safleoedd Dynodedig sydd wedi'u cysylltu ag afon Hafren

Cafodd pob un o'r safleoedd dynodedig cenedlaethol a rhyngwladol sydd wedi'u cysylltu ag afon Hafren gan lwybrau dŵr eu hasesu o safbwynt effaith bosib Gorchymyn Sychder Afon Hafren arnynt. Rhoddwyd 13 o safleoedd drwy broses sgrinio'r Asesiad Cyfarwyddeb Cynefinoedd oherwydd y posibilrwydd y gallent fod yn sensitif i lefelau is o ddŵr a llifoedd. Dim ond aber afon Hafren y canfuwyd ei fod mewn perygl o bosibl, a chasglwyd na fyddai Gorchymyn Sychder Afon Hafren yn cael unrhyw effaith ar unrhyw un o'r safleoedd eraill.

Aber afon Hafren (Rhwydwaith Safleoedd Cenedlaethol)

Cynhaliwyd Asesiad Rheoliadau Cynefinoedd ar gyfer Gorchymyn Sychder Afon Hafren. Daeth yr asesiad i'r casgliad nad oedd Gorchymyn Sychder Afon Hafren ar ei ben ei hun yn debygol o gael effaith sylweddol ar nodwedd ddynodedig, is-nodweddion neu gynefinoedd cynhaliol yr aber. Nodwyd mai rhan lanwol is afon Hafren sydd â'r risg fwyaf, ychydig i fyny'r afon o'r safle aber dynodedig, mor bell i fyny'r afon â'r man ble mae afon Hafren yn ymrannu yng Nghaerloyw. Ystyriodd yr asesiad weithrediad gwaith tynnu dŵr mwyaf posibl Ymddiriedolaeth y Camlesi a'r Afonydd ar gyfer Camlas Caerloyw a Sharpness ac nid oedd yn gallu casglu na fyddai effaith sylweddol ar bysgod mudol, ac roedd yr ansicrwydd mwyaf yn parhau ynghylch beth allai'r gyfradd tynnu dŵr fwyaf fod yn ystod sychder difrifol.

Fel awdurdod cymwys o dan y Gyfarwyddeb Cynefinoedd, mae'n rhaid i ni naill ai liniaru yn erbyn niwed amgylcheddol posibl, neu wneud cais am Orchymyn Sychder Afon Hafren ar sail rhesymau hanfodol, sef er budd cyhoeddus tra phwysig. Canfuwyd mai'r opsiwn mwyaf priodol i gydbwyso anghenion dŵr yn erbyn gofynion y Gyfarwyddeb Cynefinoedd oedd cyfyngu ar faint o ddŵr a dynnir ar gyfer Camlas Caerloyw a Sharpness. Daeth yr Asesiad Rheoliadau Cynefinoedd i'r casgliad nad oedd uchafswm cyfradd tynnu dŵr o 300 Ml/d i'r gamlas yn debygol o achosi niwed i ddynodiadau Rhwydwaith Safleoedd Cenedlaethol. Felly, bydd ceisiadau ar gyfer y gorchymyn sychder hwn yn cynnwys terfyn ar faint o ddŵr y gall Ymddiriedolaeth y Camlesi a'r Afonydd ei dynnu o 300 Ml/d, pan fo'r llif yn Deerhurst yn gostwng islaw 1200 Ml/d. Os caniateir y Gorchymyn Sychder, byddai modd gorfodi'r amodau a osodir ganddo yn gyfreithiol. Dylai'r cam gweithredu hwn liniaru unrhyw niwed i'r Rhwydwaith Safleoedd Cenedlaethol yn llwyddiannus, a bodloni gofynion y Gyfarwyddeb Cynefinoedd.

Cyfarwyddeb Fframwaith Dŵr

Ystyrir bod effeithiau posibl Gorchymyn Sychder Afon Hafren yn dod o dan Erthygl 4.6 y Gyfarwyddeb Fframwaith Dŵr, sy'n darparu am ddirywiad dros dro o 'ganlyniad i amgylchiadau a achosir yn naturiol sy'n eithriadol, neu na ellid eu rhagweld yn rhesymol, yn enwedig llifogydd eithafol a chyfnodau estynedig o sychder.' Dangosodd gwaith modelu y byddai llifoedd ac ansawdd dŵr yn dirywio islaw targedau'r Gyfarwyddeb Fframwaith Dŵr fel rhan o'r broses sychder naturiol, ni waeth pe cawsai Gorchymyn Sychder Afon Hafren ei weithredu ai peidio. Mae data ar gyfer digwyddiadau sychder hanesyddol yn cefnogi'r casgliad hwn, lle ceir achosion lle mae llifoedd rheoledig o dan weithrediadau gorchmynion sychder hanesyddol wedi bod uwchlaw neu'n gyfartal â'r hyn y byddai wedi digwydd yn naturiol yn Bewdley a Haw Bridge. Ni ddisgwylir y bydd Gorchymyn Sychder Afon Hafren yn oedi adferiad yr amgylchedd yn sgil y digwyddiad sychder, gan mai ond effaith dros dro y bydd yn ei chael ar lifoedd dŵr wyneb. Casglwyd na fyddai unrhyw effaith sylweddol ar dargedau'r Gyfarwyddeb Fframwaith Dŵr.

Archaeoleg a Threftadaeth Ddiwylliannol

Casglwyd na fyddai effaith ar archaeoleg a threftadaeth ddiwylliannol yn sgil gweithredu Gorchymyn Sychder Afon Hafren.

Mordwyo a Hamdden

Yn 2018 a 2022, cafodd dirywiad yn lefelau dŵr effaith ar y dŵr a oedd ar gael ar gyfer defnydd hamdden, ac nid oedd gwybodaeth ar gael yn flaenorol am y berthynas rhwng cyfeintiau a lefelau yng nghronfa ddŵr Llyn Clywedog ac effeithiau ar ddefnydd hamdden. Er gwaethaf hyn, gellir tybio y byddai gweithredu Gorchymyn Sychder Afon Hafren yn cael effaith gadarnhaol ar weithgareddau hwylio a chychod ar Lyn Clywedog trwy gadw adnoddau dŵr ac ymestyn y tymor hwylio o gymharu â pheidio â gweithredu'r gorchymyn sychder. Hefyd byddai'r amser adfer ar ôl sychder, gan gynnwys amser ar gyfer ail-lenwi'r gronfa ddŵr, yn cael ei leihau trwy weithredu'r gorchymyn sychder. Byddai hyn yn lleihau hyd effaith y sychder ar y clwb hwylio yn y pen draw ac yn helpu i amddiffyn yn erbyn ail flwyddyn o effaith.

Yn 2018, cafodd cychod eu tynnu o Lyn Efyrnwy yn gynnar oherwydd bod y maint o ddŵr a oedd wedi'i dynnu'n gwneud mynediad yn anodd, ond ni chanfuwyd unrhyw wybodaeth arall i nodi perthynas rhwng cyfeintiau a lefelau yn Llyn Efyrnwy ac effeithiau ar ddefnydd hamdden. Nid yw Gorchymyn Sychder Afon Hafren yn ceisio addasu uchafswm y swm o ddŵr sy'n cael ei ryddhau o'r gronfa o gymharu â gweithrediad arferol, felly ni chasglwyd unrhyw effaith.

Byddai'r lefelau dŵr is a brofir yn ystod sychder yn cael effaith ar fordwyo ar hyd afon Hafren o'r dalgylch canol i'r un isaf, gan gyfyngu ar y posibilrwydd o fynd dros goredau a thrwy lifddorau yn dibynnu ar ddifrifoldeb y sychder. Yn ystod 1995, profodd cychod masnachol anawsterau sylweddol wrth fordwyo rhwng Caerloyw a Tewkesbury gyda dyfnder dŵr o oddeutu 1.44 metr yn unig. Yn ystod 2022 adroddodd Ymddiriedolaeth y Camlesi a'r Afonydd anawsterau gyda silt sylweddol yn cronni a bod y cychod carthu yn mynd yn sownd yng nghamlas Trefaldwyn a Dociau Caerloyw.

Mae graddfa'r effaith yn debygol o amrywio'n lleol a bod yn broblem eisoes cyn cael ei gwaethygu gan Orchymyn Sychder Afon Hafren ac mewn cyfuniad â gweithrediadau tynnu dŵr. Gan fabwysiadu ymagwedd achos gwaethaf, gallai mordwyo gan y mwyafrif o gychod yn ystod sychderau o'r maint a fodelwyd gael ei atal i raddau mawr nes bod digwyddiadau glaw uchel yn dychwelyd.

Caiff pysgota ei effeithio gan y lefelau dŵr sy'n syrthio'n naturiol yn y gronfa ddŵr a chyrsiau dŵr, pa un a weithredir y gorchymyn sychder ai peidio. Gallai lefelau eithafol o isel gael effeithiau andwyol ar oroesiad pysgod, yn arbennig yn y dalgylch is, lle ceir llawer o lifddorau a choredau. Gellid effeithio ar recriwtio pysgod os yw'r cyflwr cronig yn cael ei gyrraedd a bod lefelau isel yn parhau drwy hydref 2026 a gaeaf/gwanwyn 2027. Mae blynyddoedd recriwtio gwael yn ddigwyddiad sy'n naturiol gylchol, ond gallai dosbarthiadau blwyddyn coll effeithio ar bysgota yn y dyfodol. Os ystyrir bod pysgota'n arwain at bwysau ychwanegol ar bysgod, efallai y byddai'n fuddiol awgrymu rhoi'r gorau i weithgareddau pysgota am gyfnod. Nid yw hyd unrhyw awgrymiadau yn annhebygol o fod yn wahanol p'un a yw Gorchymyn Sychder Afon Hafren yn cael ei weithredu ai peidio, felly ni ddisgwylir unrhyw effaith ychwanegol ar bysgota.

1. Introduction

The Environment Agency is an Executive Non-departmental Public Body responsible to the Secretary of State for Environment, Food and Rural Affairs. Our principal aims are to protect and improve the environment, and to promote sustainable development in England. We play a central role in delivering the environmental priorities of central government.

Natural Resources Wales are the principal adviser to the Welsh Government on the environment in Wales, enabling the sustainable development of Wales' natural resources for the benefit of people, the economy and wildlife.

1.1. Introduction

The Environment Agency West Midlands Area has identified the option to apply for a Drought Order on the River Severn to support the Severn regulation system (details in section 2.2) during severe drought events. The River Severn Drought Order aims to maintain supported water resources along the River Severn for longer at lower quantities, rather than risking running out of supported water and causing significant and sudden river level/flow declines.

The River Severn Drought Order is triggered by storage levels at Llyn Clywedog (shown in Figure 4) reservoir in Wales (not by river thresholds) and has the potential to alter river flows in Wales and England, from Llyn Clywedog reservoir down to the Severn Estuary (shown in Figure 5, section 4.1).

The West Midlands Area Drought Plan is available on request from the Environment Agency National Customer Contact Centre: https://www.gov.uk/government/publications/drought-management-for-england.

1.2. Drought Order Requirements

Drought permits and drought orders are drought management actions that, if granted, can allow more flexibility to manage water resources and the effects of drought on public water supply and the environment for up to 6 months, although extensions for a further 6 months can be sought.

Drought Permit applications in England are made directly to the Environment Agency, however we cannot grant ourselves a Drought Permit. The Environment Agency would make a River Severn Drought Order application directly to the Secretary of State, and Natural Resources Wales would make an identical application to the Welsh Government.

The drought order application must satisfy that either:

- a serious deficiency of supplies of water in any area, exists or is threatened[3];

or

- such a deficiency in the flow or level of water in any inland waterway to pose a serious threat to any flora or fauna which are dependent on those waters[4], exists or is threatened;

and that

- the reason for the deficiency is an exceptional shortage of rain[5].

[3] Section 73(1)(a) of the WRA 1991 as amended by the Environment Act 1995.
[4] Section 73(1)(b) of the WRA 1991 as amended by the Environment Act 1995.
[5] Section 79A(1) of the WRA 1991 as amended by the Environment Act 1995.

All drought permit and drought order applications must be accompanied by an environmental assessment report, which provides a detailed and accurate description of the proposal, details of the baseline environment, likely positive and negative impacts from the drought order, a monitoring programme and any mitigation or alternative options. Where adverse effects are likely, the water undertaker must demonstrate that all alternative solutions have been utilised (e.g. publicity campaigns, flow restrictions etc.) or that the scheme is necessary for reasons of overriding public interest.

1.3. Strategic Environment Assessment (SEA) Requirements

The SEA Directive applies to all statutory plans or programmes. Environment Agency drought plans are not required under any legislative, regulatory or administrative provision; therefore the plans are not subject to the SEA Directive due to their voluntary status. Despite this, the principles behind SEA have been considered and applied during the environmental assessment of the River Severn Drought Order (refer to section 9 and 10).

1.4. Habitats Directive (HD) Requirements

The Habitats Directive (Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Flora and Fauna) protects habitats and species of European nature conservation importance. Together with the Birds Directive (Directive 2009/147/EC on the protection of wild birds), the Habitats Directive established a network of internationally important sites designated for their ecological status.

The Environment Agency and Natural Resources Wales are both a ‘competent authority’ under Regulation 7(1) of the Conservation of Habitats and Species Regulations 2010 (SI No. 2010/490) commonly referred to as the Habitats Regulations. Natural Resources Wales also has the dual role of being a statutory consultee under the Habitats Regulations (similar to Natural England).

Under Regulation 9(5) it states that “a competent authority must have regard to the requirements of the Habitats Directive when exercising any of its functions”, which includes activities authorised by a RSDO. It is therefore necessary for the Environment Agency to undertake a Habitats Regulations Assessment (HRA) for this RSDO. The HRA tests whether the impacts identified as arising from a permit, project or plan are likely to have a significant effect on European sites.

Where a plan or project is likely to have a significant effect on the interest features of a European Site, either alone or in combination with other plans or projects, an appropriate assessment is required. Under these circumstances, an environmental assessment report prepared in support of a drought order application should include an appropriate assessment to determine whether or not the proposal will adversely affect the integrity of the site, or features of the site outside of the designated site boundary (e.g. functionally linked species such as diadromous fish). Should the environmental assessment report conclude that the proposal will adversely affect the site, then a drought order will only be granted where there are no alternative solutions and for reasons of overriding public interest. In such cases, compensatory measures must then be implemented to protect the integrity of the site. It is also noted under Planning Policy Statement number 9 that Ramsar designated sites should be treated under the Habitats Regulations as being equivalent to European Sites.

A HRA Appropriate Assessment has been produced for the Severn Estuary National Site Network site, and other potentially impacted Habitat Directive sites were appropriately screened. The full report is in ANNEX 1, conclusions are contained within section 11 of this environmental assessment report.

1.5. Objectives and Scope of this Environmental Assessment Report

This environmental assessment report was produced in accordance with Defra and Environment Agency guidance to support a potential Environment Agency application for the surface water options of the River Severn Drought Order.

This environmental assessment report has been produced in consultation with Natural England, Natural Resources Wales, Severn Trent Water Ltd and South Staffordshire Water Ltd. The Canal & River Trust (CRT) have also been consulted in regards to the Gloucester & Sharpness Canal operations in the lower tidal River Severn.

The purpose of this environmental assessment report is to explain the River Severn Drought Order, present information on the current environment within the area of impact, model the potential impacts of the River Severn Drought Order and present an environmental monitoring plan. Where potential negative impacts have been identified, potentially available mitigation options have been highlighted. Mitigation options for the impacts associated have been discussed with the River Severn Drought Management Group and are summarised in this environmental assessment report.

2. Background Context

2.1. River Severn Catchment Summary

The River Severn is the longest river in Great Britain, travelling approximately 354 km (220 miles) from its source in Plynlimon down to the Severn Estuary. Excluding the River Wye, the catchment covers approximately 11,420 km^2 with an estuary over five miles wide. The Severn has twenty one tributaries and flows through four counties, Powys, Shropshire, Worcestershire and Gloucestershire.

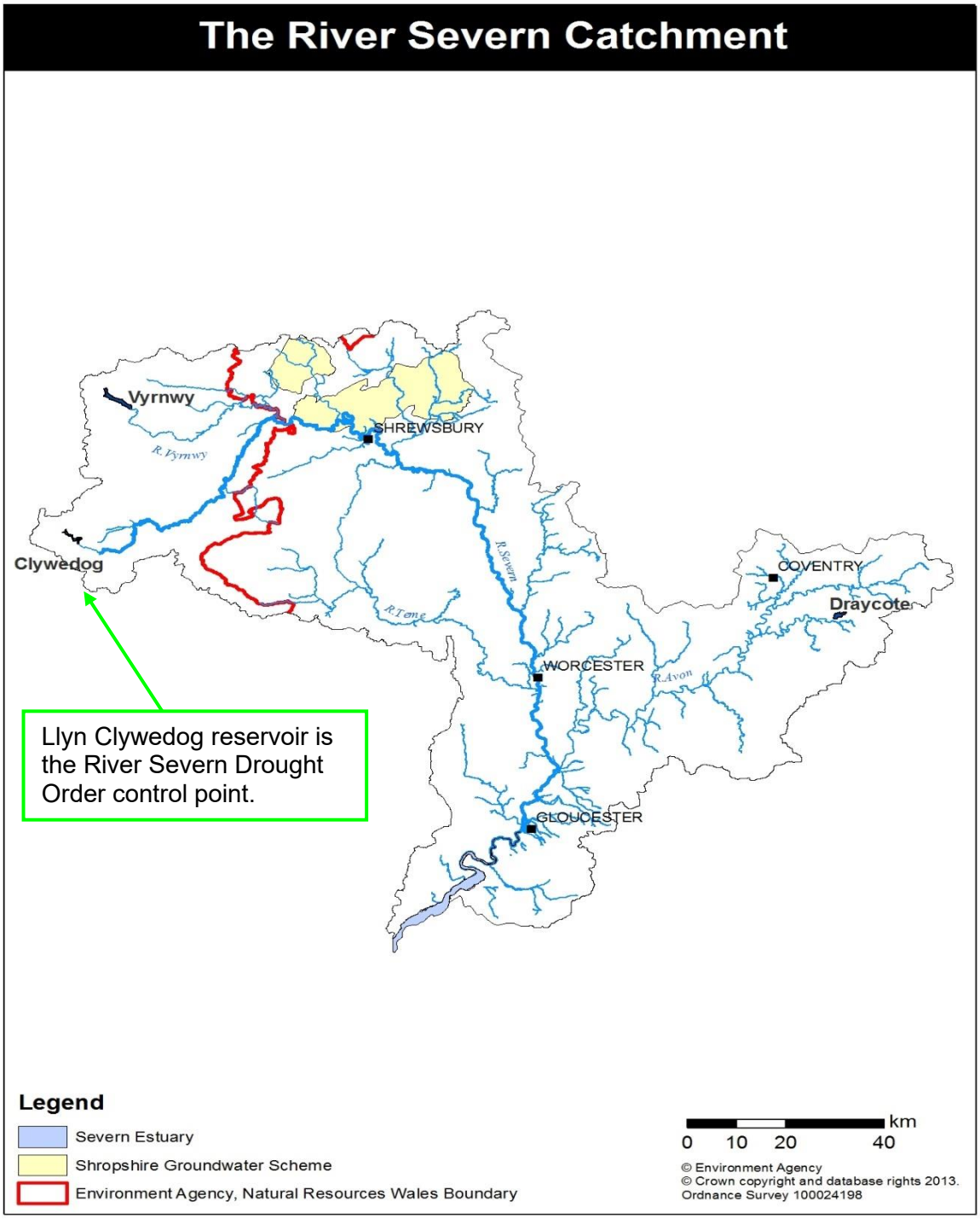

Figure 1: River Severn Catchment

The River Severn provides a major source of water for public consumption, industry, electricity generation, navigation and agriculture and is recognised for its environmental importance, providing habitats and a migratory corridor for many nationally and internationally important species (refer to Appendix A for designated sites). The catchment is largely rural, with the exception of a number of towns which lie along the banks of the River Severn, such as Llanidloes, Newtown, Welshpool, Shrewsbury, Bewdley and the City of Worcester.

The river is navigable from Stourport to Gloucester via the main channel and through links to the inland waterway system and provides an important recreational asset. In addition, Ironbridge Gorge is a World Heritage Site and recognised as the birthplace of industry.

The River Severn is tidal below Maisemore Weir, near Gloucester. The Severn Estuary exhibits an immense tidal range (second largest in the world), which impacts on the physical environment and on biological diversity and productivity. Sediment flows and fluxes are of particular importance for estuarine processes and ecology and the channel morphology is constantly changing. Four major rivers (Severn, Wye, Usk and Bristol-Avon) feed suspended sediments into the estuary, adding to the fine sediments already scoured from the seabed. The combination of sediments creates high turbidity and therefore restricts light and productivity within the ecosystem. Only a limited range of fauna and flora can survive this environment, resulting in low biodiversity within the Severn Estuary.

The Severn Estuary is designated as a Site of Special Scientific Interest (SSSI), a Special Protection Area (SPA), a Special Area of Conservation (SAC) and is included on the list of wetlands of international importance under the Ramsar Convention (Ramsar Site).

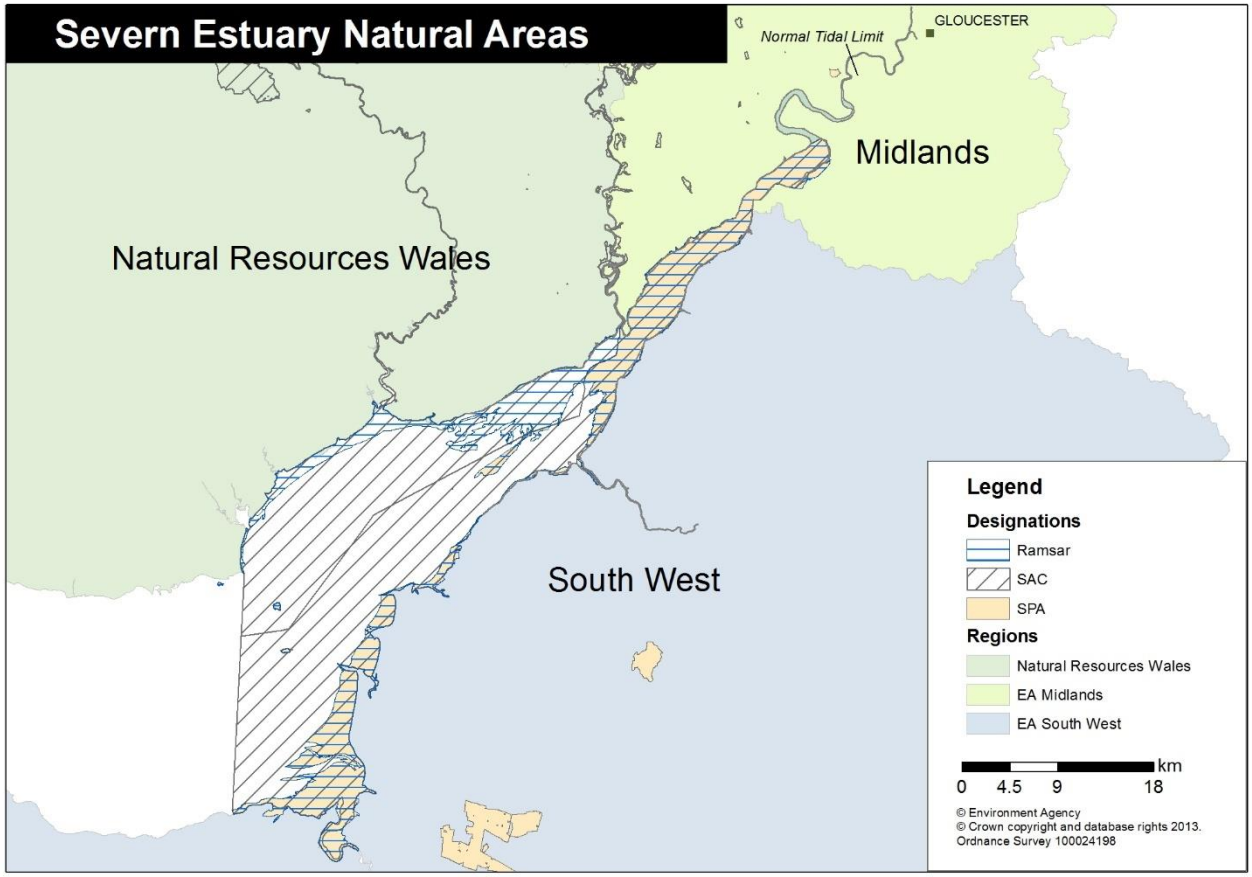

Figure 2: Severn Estuary National Site Network site

The area of intertidal mudflats, sand banks, rocky platforms and salt marsh is one of the largest and most important in Britain and supports internationally important populations of waterfowl, invertebrate populations of considerable interest and large populations of migratory fish including Atlantic salmon, sea trout, allis and twaite shad, eel and sea and river lamprey.

The River Severn provides a source of drinking water to over 6 million people across the Midlands as well as meeting demands for a range of agriculture, industry and navigation purposes.

The River Severn is regulated with flows supported by releases from Llyn Clywedog and Lake Vyrnwy reservoirs and from the SGS. The regulation system is designed to meet demands for public water supply, agriculture, industry and navigation as well as maintaining flow levels sufficient to support biodiversity and conservation interests. In practice, this means that baseflow is higher than it would be naturally in the River Severn.

The Llyn Clywedog reservoir Joint Authority Act (1963) requires that river flow is maintained at a daily flow of 727 Ml/d and the Shropshire Groundwater Scheme licence requires a flow of 850 Ml/d (over a five day average) at Bewdley, in order to provide adequate freshwater flow in the estuary and to meet other demands. The Environment Agency is responsible for managing this requirement, in consultation with Natural Resources Wales. Llyn Clywedog reservoir provides the primary resource for regulation with release volumes up to 500 Ml/d. The SGS can provide up to 165 Ml/d net at Bewdley, the rest is lost on route to other abstractors and natural evaporation processes. The water bank from Lake Vyrnwy reservoir provides sustainable releases up to 100 Ml/d, higher releases can be made but the available water would soon be used up if they continued for too long and we also need to consider the sensitive environment of the River Vyrnwy.

2.2. River Severn Regulation System

The River Severn supports a series of public water supply abstractions (some with large licensed volumes, not all of which are returned to the system), significant navigation abstractions and large discharges. Following the drought of 1959 and increasing abstraction demands a survey of water resources identified the need for a new reservoir to meet future demand and protect against drought impacts on the River Severn.

The main stakeholders, the affected water companies and the Canal & River Trust (was British Waterways), joined together and developed the Llyn Clywedog reservoir Joint Authority Act (1963). This involved the construction of a new reservoir solely for regulating (artificially supporting water volumes in) the River Severn. A minimum daily flow target of 727 Ml/d was set at Bewdley gauging station in England, designed to support abstraction and environmental need. In 1979 Severn Trent Water Authority exercised powers under the Water Resources Act 1963 to increase the regulated flow at Bewdley from a daily 727 Ml/d target to an 850 Ml/d mean over 5 consecutive days, contained in the Shropshire Groundwater Scheme licence; both prescribed flows are in force. This was to provide better reliability of flows in the lower reaches of the river where abstractions were increasing rapidly, with the 5 day mean incorporating travel time resilience from Llyn Clywedog.

The River Severn regulation system is designed to meet the water resource demands of abstractors on the river, while maintaining an acceptable environmental flow for the purposes of fisheries, conservation, recreation, effluent dilution and other in-river uses. Table 2 contains the statutory and non statutory flow targets driving regulation.

Table 2: Summary of Principal Flow Issues

Location	Flow driver/target	Statutory
Upper Reaches	Fisheries at Newtown are considered to be adversely affected by early season low flows before regulation releases are required. This has led to an additional flow control point at Dolwen. The current estimate is for a maintained flow of 70 Ml/d which would be supported by releases from Llyn Clywedog. This factor has not been accommodated within the drought management provisions currently being assessed.	No
Middle Reaches	**Maintenance of Prescribed Flow at Bewdley flow gauge: 850 Ml/d 5 day mean and daily mean 727 Ml/d**	**Yes**
Lower Reaches/ Upper Estuary	Maintain freshwater inflows to the Severn Estuary National Site Network designated site (Habitats Directive driver). 1992 research recommended maintaining a Mean Residual Flow of 1200-1500 Ml/d during neap tides and 1800-2400 Ml/d during spring tides – Regulation 'freshet' releases were tested but terminated in 2006, concluded as an inefficient use of resources with no reported benefits.	No

The River Severn regulation system maintains higher flows during dry conditions than would naturally be experienced, even with abstraction accounted for, by releasing water into the river and its tributaries as baseflows decrease and fail to meet the prescribed flow at Bewdley. The Severn regulation system protects the River Severn from the majority of low flow stress experienced in non-regulated catchments.

2.2.1. River Severn Regulation

There are three storage components to the Severn regulation system, illustrated in

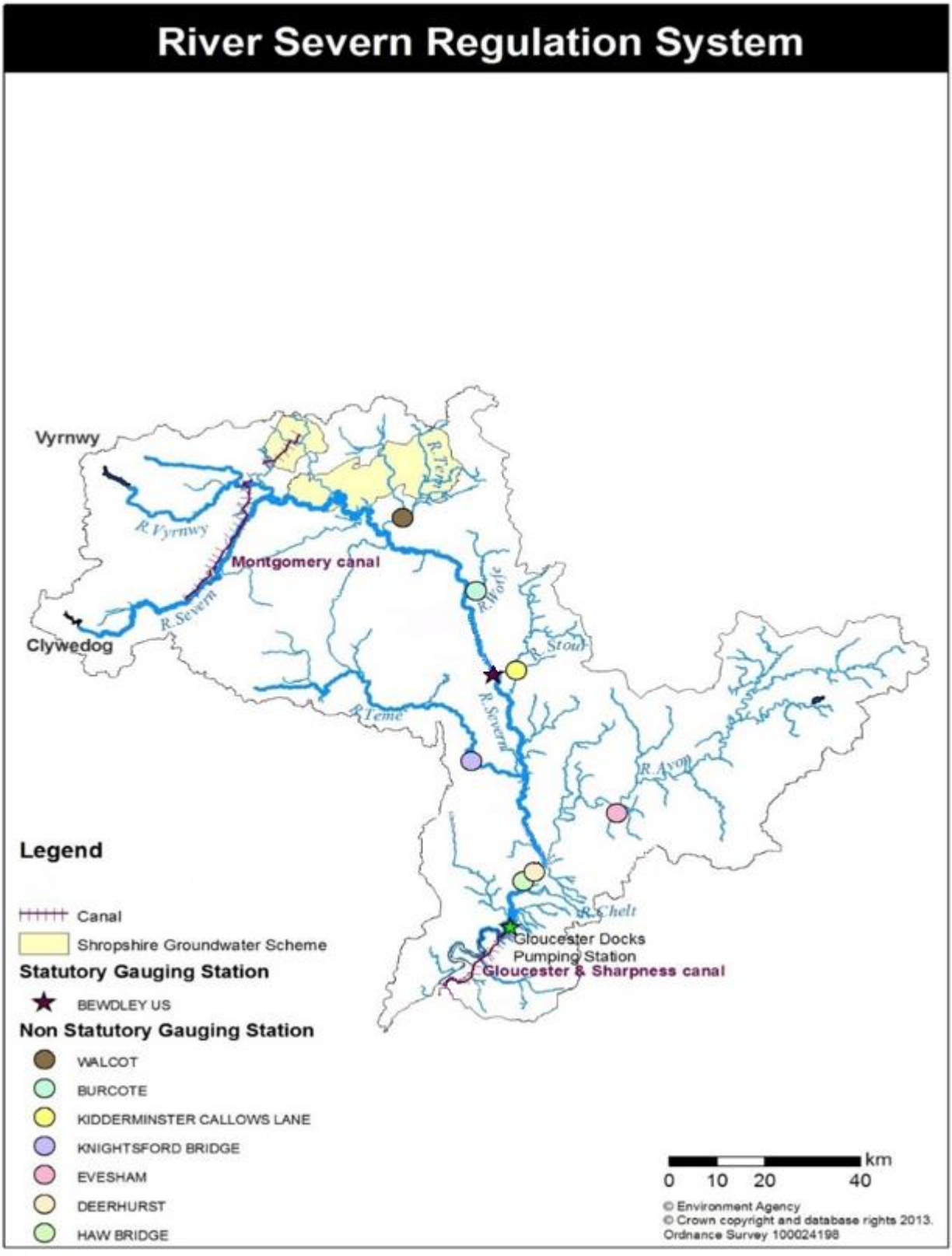

Figure 3;

- The full resource allocation from Llyn Clywedog Reservoir;
- Limited resources from the Lake Vyrnwy reservoir water bank; and the
- Shropshire Groundwater Scheme (SGS).

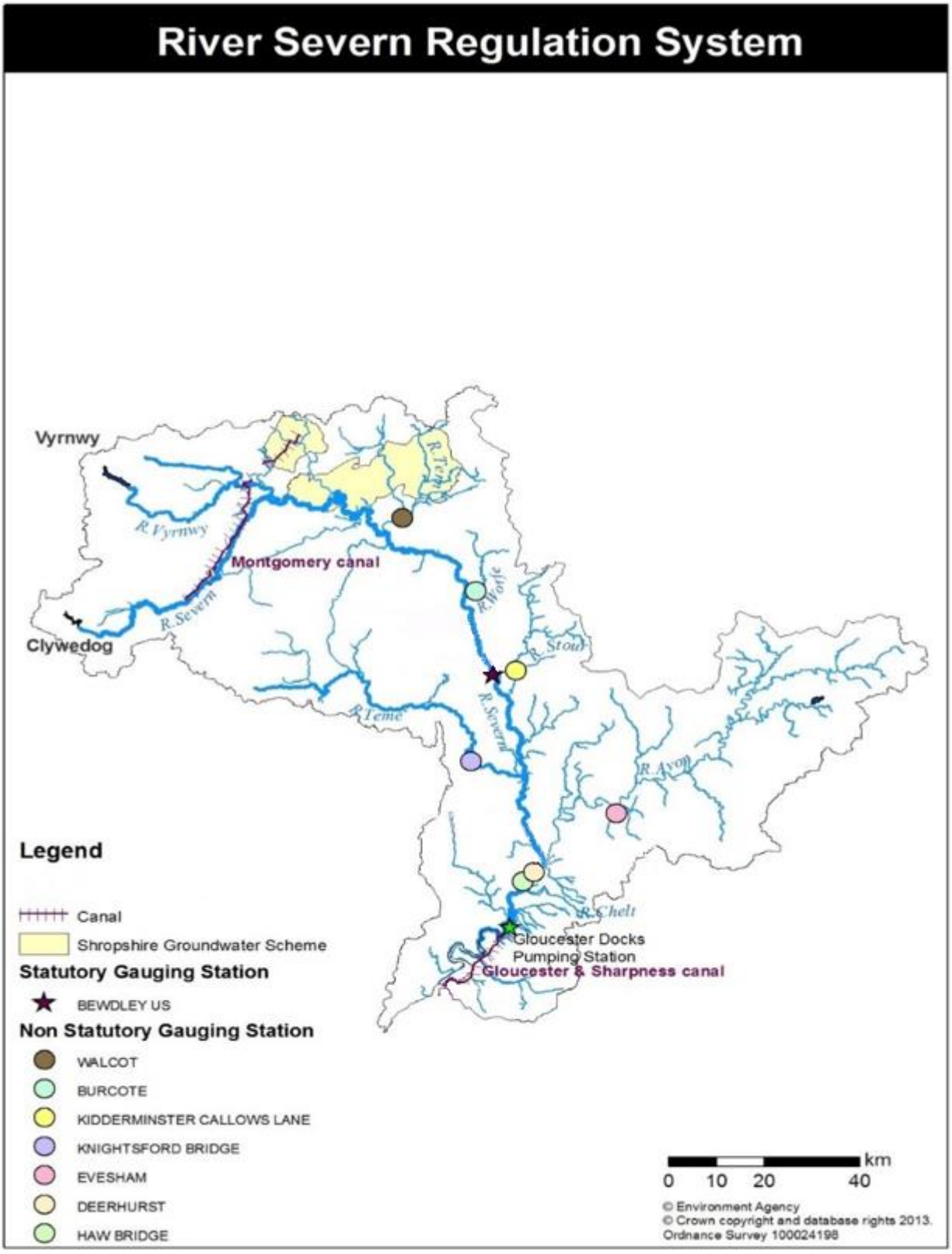

Figure 3: River Severn Regulation System

2.2.2. Llyn Clywedog

The drought year 1949 was used to design Llyn Clywedog, a reservoir with a storage capacity of 49,535 million litres solely for River Severn regulation purposes. Release volumes range from a minimum of 18.2 Ml/d to a sustainable maximum 500 Ml/d[6] in order to maintain the prescribed flow at Bewdley.

Llyn Clywedog was designed to cope with a lack of runoff during one single summer, based on 50 years data prior to construction. The drought of 1976 considerably exceeded its original design with up to 1% full storage lost each day in July/August 1976. This operational observation provided the basis for the 100 day regulation rule[7] used to restrict major abstractors during drought years.

2.2.3. Lake Vyrnwy

Lake Vyrnwy has a capacity of 62,335 million litres and was constructed with the principal objective of providing a water supply to Liverpool. A small proportion of the volume can be used to supplement regulation of the River Severn when required.

The maximum regulation discharge from Lake Vyrnwy is 405 Ml/d but a more sustainable release is considered to be 70 Ml/d. Normal compensation[8] flow is 41.876 Ml/d with a reduced daily compensation discharge of 21.876 Ml/d on any day when the flow at the Afon Cownwy gauge is above 20 Ml/d (at 09.00 hours)[9]. If able to operate at this reduced daily compensation discharge, the stored compensation water is accumulated as a theoretical 'water bank' for the Environment Agency to use in River Severn regulation. An additional 725 Ml is added to the bank on the 1st of every month from March to October inclusive, but at most times of the year all spill from the reservoir is removed from the bank.

The Vyrnwy water bank is reserved solely for the use of Severn regulation and cannot be used without prior agreement for any other purposes. United Utilities control a much larger portion of water within Lake Vyrnwy, for which it has identified a drought permit option; to reduce the compensation releases to the Afon Vyrnwy from 41.876 Ml/d to 21.876 Ml/d although this option has been removed from their Draft Drought Plan 2027.

2.2.4. Shropshire Groundwater Scheme *(SGS)*

The SGS was given formal approval for development in 1981. It comprises six development areas being constructed in eight phases and provides a means of abstracting groundwater from underlying sandstone aquifers, which can be used for augmentation of the River Severn.

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[6] Releases greater than 500 Ml/d can be made (e.g. during flood drawdown) but historic droughts identified capping releases at 500 Ml/d, approximately 1% storage, per day was the highest sustainable release recommended before depleting storage too quickly.

[7] For each day regulation continues after day 100 an abstractor with this condition on their licence will have 1/100th of their 100 day quantity (i.e. the quantity they would be restricted to under Maximum Regulation licence conditions) available for abstraction. In addition they would also have any allocation carried over from the 100 day period and each day could also bank any unused quantity from their daily allocation.

[8] Compensation requirements and/or operations are currently under review following completion of the Afon Cownwy and Marchnant capital projects to provide flow downstream of the intakes.

[9] The Lake Vyrnwy catchment artificially incorporates 75% of the flow from the Cownwy tributary, which is diverted to flow into Lake Vyrnwy reservoir rather than naturally joining the Afon Vyrnwy downstream. 25% of the flow remains to flow down the Afon Cownwy downstream of the diversion.

The Permo-Triassic Sandstone in which the SGS has been developed, is one of the most important principal aquifers in the United Kingdom, second only to the Chalk. This favours its use for large scale strategic resource development, as the effects of seasonal abstraction and recharge patterns are more evenly distributed over longer periods within the environment.

The primary role of the SGS is to provide a phased level of support (according to regulation risk and SGS operational curves) to help conserve Llyn Clywedog storage during dry years. The SGS draws resources from significant groundwater aquifers, which show a delayed response to drought impacts and provide a reliable extra source when surface water resources are limited. The boreholes are deep enough to have withstood all recent drought events.

The first five phases of the SGS are currently operational with no plan to develop further phases in the short term. The combined output from Phases 1, 2, 3, 4 and 5 provides a gross flow of 220 Ml/d and a net of approximately 165 Ml/d (active phases at the time of modelling were 1-4[10]). The additional development of phases 6, 7 and 8 would be required to achieve the combined scheme's maximum licensed yield of 330 Ml/d; the net combined volume would be approximately 225 Ml/d.

2.2.5. Water Supply

Llyn Clywedog and Lake Vyrnwy reservoirs provide water by gravity with a minimal carbon footprint. The SGS must be continuously pumped, and due to the limitation of its maximum discharge rate (i.e. the scheme cannot physically provide greater than 220 Ml/d), the SGS must be used over an extended period to produce a sufficient volume to supplement and help conserve the reservoir resources. The operation of the different resources within the Severn regulation system is appropriately managed according to cost (financial and environmental) and the risk of developing drought.

The need for regulation varies from day to day depending upon rainfall and abstraction demands, the specific use of the SGS varies according to the assessed pre-season risk[11] of the reservoir. The water level in Llyn Clywedog is monitored and plotted on a graph with operational curves developed by the Environment Agency in agreement with all relevant water companies (Figure 4, section 3.2).

Further details on the Severn regulation system operations in accordance with the Llyn Clywedog reservoir Joint Authority Act 1963 (as amended in 1979) and Shropshire Groundwater Scheme licence are contained in the current version of the Operating Rules for the River Severn Resource/Supply System.

The Severn regulation system maintains higher flows during dry conditions than would naturally be experienced, by releasing water stored during high rainfall/flow events into the river and its tributaries as baseflows decrease and are insufficient to meet the prescribed flow at Bewdley.

2.3. Previous River Severn Drought Order Applications

Variations of the River Severn Drought Order were operated in 1976, 1984 and 1989:

- **1975-1976 two separate drought order applications**

  29 July: Lower Bewdley prescribed flow reduced from 727 Ml/d to 545 Ml/d and removed the compensation release obligation (18 Ml/d) from Llyn Clywedog for 6 months. Granted 6 August and operated.

[10] Phase 5 of SGS was commissioned in 2014, providing an additional gross yield of 50 Ml/d.
[11] Regulation Risk is determined according to current conditions and whether a high regulation season is likely. High regulation can empty Llyn Clywedog in a single season, therefore the SGS would be used early on to prolong surface water sources.

20 August: Abandon prescribed flow at Bewdley and move to releasing 2% of remaining storage from Llyn Clywedog per day subject to Bewdley not exceeding 545 Ml/d. Granted 3 September but never operated, significant rainfall returned.

- **1984 one drought order application**

  1 August: Cap Llyn Clywedog releases to 2% of storage (no reference to prescribed flow reduction at Bewdley, flow records do not consistently fall below 850 Ml/d). Granted 18 August and operated.

- **1989 one drought order application**

  31 August details agreed, application made on 11 September. Lower Bewdley prescribed flow reduced from 850 Ml/d to 730 Ml/d over a 5 day mean. Granted 30 September.

In more than 30 years, and most notably during the 1995-96, 2022 and 2025 drought events, the River Severn Drought Order has not been required. This reflects the current robustness of the system and ongoing development of further resources in the Shropshire Groundwater Scheme.

3. River Severn Drought Order Rationale and Proposals

3.1. River Severn Drought Order Proposal

The Environment Agency has developed procedures for the River Severn Drought Order process (summarised in Table 4), driven by the control curves at Llyn Clywedog reservoir (shown in Figure 4

The River Severn Drought Order proposal includes:

- capping the maximum release from Llyn Clywedog reservoir at 300 megalitres per day (Ml/d);
- reducing the prescribed flow at Bewdley from a single daily mean of 727 Ml/d and 850 Ml/d averaged over 5 days to a target of 730 Ml/d averaged over 5 days;
- reducing the prescribed flow at Bewdley below the target flow of 730 Ml/d averaged over 5 days if River Severn Regulation releases can no longer achieve it;
- imposing a 5% reduction on water company licensed abstractions on the River Severn;
- imposing a 300 Ml/d abstraction cap on the Gloucester Docks abstraction for the Gloucester & Sharpness Canal, when flows at Deerhurst or Haw Bridge gauge are below 1200 Ml/d.
- capping releases from Llyn Clywedog reservoir to 1.5% of remaining storage if storage in Llyn Clywedog reservoir falls below the ‘emergency storage’ trigger.

The Clywedog maximum release cap of 300 Ml/d has been set to ensure that Llyn Clywedog would not empty during a repeat of 1976 drought conditions. If Llyn Clywedog reservoir is allowed to empty in a drought, flows and water levels along the whole River Severn would be severely reduced. This would have a significant impact on the environment and people that rely on water from the River Severn. Modelling work in 2006 found a 300 Ml/d cap could have provided approximately 30 days more water storage at the end of the 1976 drought, providing ‘back up’ resources should a drought of greater severity/duration be experienced. There is a risk that capping the maximum release from Llyn Clywedog to 300 Ml/d could make the new target flow at Bewdley of 730 Ml/d difficult to achieve during critical periods (e.g. extreme temperatures and high abstraction demands), as there may not be enough water remaining in Lake Vyrnwy water bank or SGS to compensate. However, the benefits to the system during an extended drought outweigh the temporary risks.

Lowering the prescribed flow at Bewdley aims to balance the existing environmental needs against the need to preserve water to safeguard both people and the environment if the drought continues. The change in prescribed flow at Bewdley equates to a proposed 120 Ml/d reduction in the 5 day mean, and refers to the ‘actual’ flows after all abstractions and discharges have been accounted for (not natural). The target of 730 Ml/d is based on an assessment made in 1960 following the 1959 drought (Environment Agency, pers. comm). A paper published by the National Rivers Authority[12] indicated that, while 850 Ml/d would be preferable, 730 Ml/d could be accepted as a minimum flow in the middle of the river to protect fish.

A reduction on water company abstraction licences aims to reduce the pressure on remaining water resources in the Severn Regulation system whilst balancing the need to protect abstraction for public water supply. An initial 5% reduction should be achievable for water companies without threatening people's drinking water supply, while still being large enough to benefit the

[12] River Severn Control Rules Review Position Statement, NRA, 1994.

environment and other water users. For licences with a 100 day condition, the 5% reduction will be applied to the remaining available licence during the first 100 days of regulation and pro-rata thereafter. For licences without a 100 day clause, the 5% will be applied to the daily licensed volume. It is proposed that restrictions will be lifted on non-regulation days. Higher reductions may also be set if the drought continues, up to 20% if storage in Llyn Clywedog falls below the 'emergency storage' curve. How the abstractors achieve the reductions will be for their own consideration.

The Environment Agency and the relevant water companies[13] recognise the potential conflict between the water company drought permits/orders and the River Severn Drought Order and close discussions would need to be held to manage this situation, should it arise. It is important to note the River Severn Drought Order seeks to prolong water to achieve multiple benefits, including the prolonged support of water supply abstractions. Conflicting drought permit/orders may be counterproductive in the longer term.

Imposing restrictions on the Canal & River Trust under the River Severn Drought Order aims to ensure abstractions are operated responsibly during severe drought to benefit both people and the environment. The current operating rules for the Severn Regulation system contain agreed restrictions for the Montgomery Canal abstractions from the River Severn dating back to 1988. These are now incorporated into the abstraction licence granted by NRW.

The Gloucester & Sharpness Canal has not been restricted during River Severn Drought Order operations before. In order to satisfy the Conservation of Habitats and Species Regulations 2010 in protecting the Severn Estuary National Site Network under in combination operations, a restriction has now been included as part of the River Severn Drought Order application conditions. The restriction conditions and quantities have been based on the best available information at the time, aiming to balance the Canal & River Trust's obligations with other water user's needs and the environment. During River Severn Drought Order implementation, when flows at Deerhurst drop below 1200 Ml/d the Gloucester & Sharpness Canal abstraction from the River Severn will be capped at 300 Ml/d. The Habitats Regulation Assessment (ANNEX 1) concluded this abstraction cap would ensure no significant effect on the National Site Network.

The Canal & River Trust has raised concerns that 300 Ml/d could pose a risk to their operation of the Gloucester & Sharpness Canal and the Bristol Water abstraction it supports.

Before the River Severn Drought Order is implemented, S57 spray irrigation restrictions will have been assessed and where of benefit, have been enforced. Although this is not a direct consequence of the drought order itself, it is part of the sequence for managing water use during a drought situation. It would impact on the agricultural industry, mainly on the existing Licences of Right[14] which normally avoid restrictions.

If all the above drought management strategies cannot prevent storage in Clywedog declining below the ‘emergency storage’ trigger then critical levels will have been reached and regulation is moving into system failure. At this stage it is no longer possible to maintain a prescribed flow at Bewdley as water resources are becoming exhausted. Llyn Clywedog provides the largest source of regulation water. The emergency strategy at this stage is to cap remaining releases from Llyn Clywedog to 1.5% of remaining storage each day, rationing out the remaining water to provide some regulation support until dead storage is reached and releases are no longer possible. The majority of regulation releases at this stage are likely to be from SGS, and any remaining water in Lake Vyrnwy water bank.

[13] Severn Trent Water Ltd and South Staffordshire Water Ltd.
[14] Licences of Right are abstraction licences that pre-date the current legislation, containing no restrictions (i.e. Hands off Flows) to their rights to abstract water.

3.2. The River Severn Drought Order Control Curves

The River Severn Drought Order is entirely triggered by storage in Llyn Clywedog reservoir, and not by river flows. Storage levels in the reservoir are plotted against the control curves in Figure 4 to track the available water resources and raise awareness of developing dry conditions.

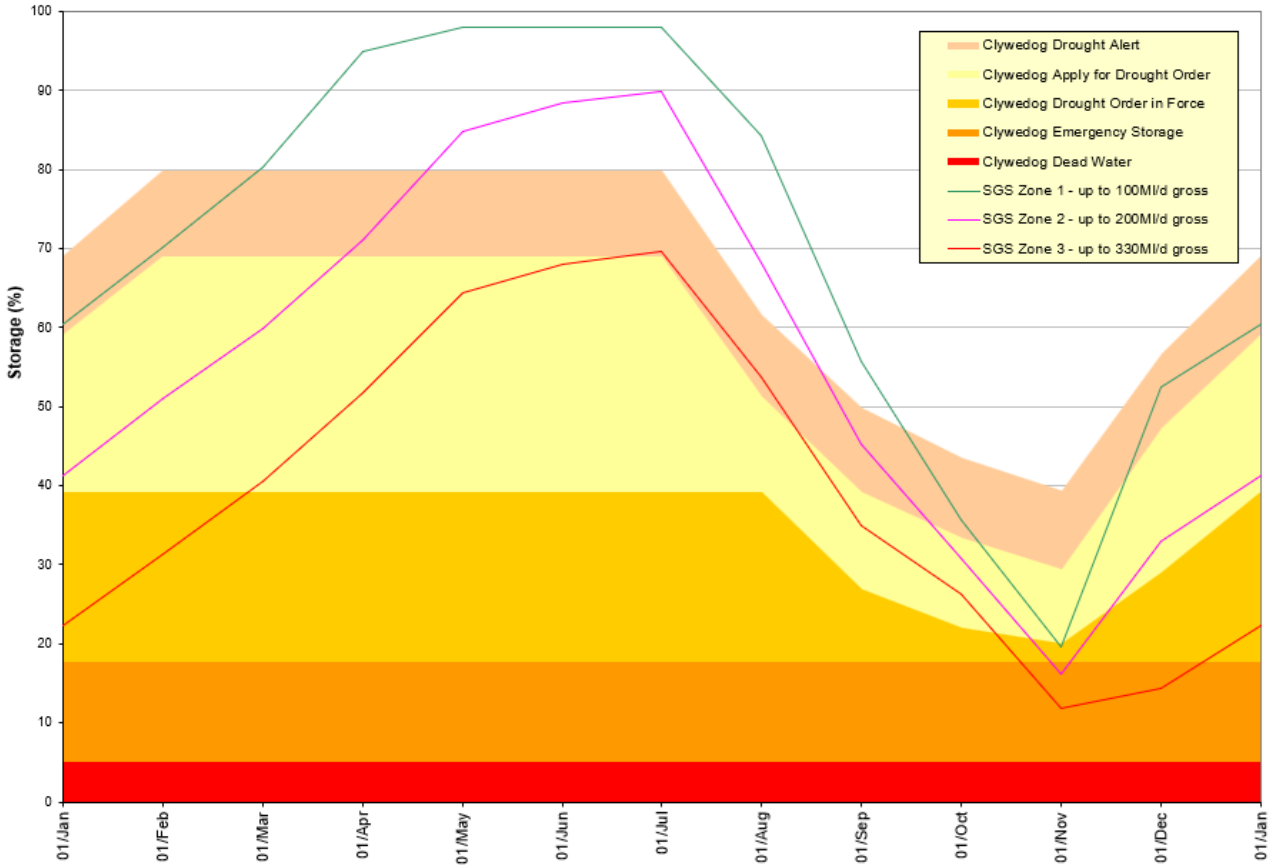

Figure 4: River Severn Drought Order and Shropshire Groundwater Scheme Curves

** Note, the curves provide an operational guide but can be overridden as required.*

The River Severn Drought Order control curves (excluding SGS) were last updated in 2006[15] using the Ressim water resources modelling software. Using 2006 abstraction demands, Ressim identified 1976 as the only year between 1920 and 1996 where modelled storage in Llyn Clywedog fell below the 'apply' trigger curve. Modelling work in 2010, using the water resources Aquator model found 1976 conditions no longer triggered the need for the Severn Drought Order; this could be attributable to additional SGS development improving the robustness of the Severn regulation system.

[15] Report on generation of draft trigger curves for Clywedog Reservoir (Environment Agency, February 2006).

3.3. The Environment Agency River Severn Drought Order Process

Table 4 shows the associated actions the Environment Agency would take as storage within Llyn Clywedog reservoir dropped below the specific control curves.

Table 4: The River Severn Drought Order Process

Alert Curve Figure 4	**Drought order preparation:** · The Environment Agency will form the River Severn Drought Management Group[16]. Mitigation options to be discussed and feasibility identified. · The Environment Agency prepares the drought order application in consultation with Natural Resources Wales and discussion with other groups (including water companies, the Canal & River Trust, Natural England, National Farmers Union (NFU), Country Landowners Association, Farmers Union of Wales (FUW), Defra and Welsh Government) and considers: • The requirement/nature of a Section 57 irrigation licence restriction; • Whether to include emergency storage drought order conditions as part of the application. • Whether the drought order needs to include varying the Shropshire Groundwater Scheme (SGS) Licence. · The Environment Agency circulates and discusses reservoir refill prospects. **Communications:** · The Environment Agency organises a meeting[17] with the River Severn Drought Management Group (plus appropriate stakeholders/partners) to discuss the developing drought situation and implications on the Severn and wider catchments. Further meetings may be required. · The Environment Agency will engage with Natural England and Natural Resources Wales, in particular reference to management of the River Severn Estuary. · The Environment Agency and Natural Resources Wales will meet with the NFU, and FUW and Country Landowners Association as required, to discuss the possible need and implications of S57 Spray irrigation restrictions and how best to manage their implementation. · The Environment Agency and Natural Resources Wales intensify their public water conservation appeals in the media. The communication plan will be followed in liaison with water companies, to ensure a consistent message is delivered.

[16] The River Severn Drought Management Group should consist of representatives from: Environment Agency, Natural Resources Wales, Severn Trent Water, South Staffordshire Water, Bristol Water, United Utilities and the Canal and River Trust. The group is flexible and representatives from Natural England should also be considered.
[17] At this meeting the group will decide the frequency of further meetings and consider liaising with other groups including NFU, Natural England, Consumer Council for Water and Welsh Government.

Application Curve Figure 4	**Drought order application:** · The Environment Agency formally applies for a drought order to the Secretary of State for environment, food and rural affairs (Defra) in England, and Natural Resources Wales formally applies for the same drought order to the Welsh Government for Wales. **Communications:** · The Environment Agency will seek opportunities for a Lake Vyrnwy overdraft with United Utilities[18]. · The Environment Agency will organise a meeting of the River Severn Drought Management Group to discuss: • Voluntary reductions in abstraction that could be implemented immediately. • Abstraction reductions that will be applied once the drought order is granted. • Using mitigation options in section 14 as appropriate. · The Environment Agency will inform other external groups of the application and what it means for the River Severn and how it may affect them. · The Environment Agency and Natural Resources Wales will decide what S57 restrictions are appropriate and begin to consider the process of implementation. · The Environment Agency and Natural Resources Wales will decide whether temporary restrictions on fishing activities are appropriate and begin the process of implementation. · The Environment Agency will continue public appeals for water conservation in accordance with the West Midlands Drought Plan.
Enforce Curve Figure 4	**Drought order conditions become live, if not already implemented:** · Section 57 restrictions on surface water irrigation licences in force where appropriate. · Max releases at Llyn Clywedog capped to 300 Ml/d. · Prescribed flow at Bewdley reduced to 730 Ml/d 5 day mean or below 730 Ml/d if regulation releases can no longer achieve it. · 5% daily licence reduction in water company licensed abstractions from the River Severn enforced. • For licences with a 100 day condition, the 5% reduction will be applied to the remaining available licence during the first 100 days of regulation and pro-rata thereafter. • For licences without the 100 day condition, the 5% reduction will be applied to the daily licensed volume. • It is proposed that restrictions will be lifted on non-regulation days. · Canal & River Trust abstraction reductions to be enforced; • Gloucester & Sharpness Canal abstraction cap of 300 Ml/d when flows at Deerhurst drop below 1200 M/d. **Additional non-drought order actions to be taken:**

[18] The feasibility of an overdraft from Lake Vyrnwy will depend on whether there is sufficient excess storage in Lake Vyrnwy, and if United Utilities were able to spare the water at low risk to their own supply network.

	· If agreement in place - water company bankside storage used for short term reductions in water company abstraction to alleviate low flows in the lower River Severn (subject to need). **Timing of drought order conditions:** · It is anticipated that it will take at least 28 days for the drought order to be granted, assuming a public hearing is not required. This lead-time is built into the curves for the majority of scenarios, however exceptional droughts may exceed the control curve design capacity. **Communications:** · The Environment Agency and Natural Resources Wales will organise a joint meeting with external groups[19] to discuss the drought situation and drought order conditions. Further meetings may be required. · The meeting should look ahead to possible implementation of emergency storage conditions and amendments to the drought order if not included in original application. · The Environment Agency and Natural Resources Wales will continue public appeals for water conservation in accordance with the Midlands Drought Plan.
Emergency Storage curve Figure 4	By this stage in a drought event, unavoidable region and/or country wide drought impacts are expected to be occurring due to the natural shortage of rainfall. Storage in Llyn Clywedog is now critical and River Severn regulation will be moving into system failure as water resources are no longer sufficient to maintain a prescribed flow at Bewdley. Poor water quality at this stage needs to be considered. **Options considered to enhance drought order conditions: (will depend on the extent and timing of drought).** · Releases from Llyn Clywedog reservoir capped to 1.5% of remaining useable storage each day. · At this stage it is no longer possible to maintain a prescribed flow at Bewdley as water resources are becoming exhausted. · Consider reductions in daily licensed quantities of water company abstraction licences of greater than 5% (reductions up to 20% to be considered). **Communications:** · The Environment Agency organises a meeting with the River Severn Drought Management Group to discuss the drought situation and enhanced drought order conditions. Further meetings, with other groups may be required within this drought zone. · Ongoing engagement with Natural England and Natural Resources Wales (plus other appropriate external groups). · The Environment Agency and Natural Resources Wales will continue public appeals for water conservation in accordance with the West Midlands Drought Plan.

[19] This meeting could include: Severn Trent Water, South Staffordshire Water, Bristol Water, United Utilities, Canal & River Trust, Natural England, Natural Resources Wales, Farmers Unions, Water UK, Defra, Welsh Government, CC Water.

Dead Water Curve Figure 4	**Llyn Clywedog Reservoir** Best efforts will be made to prevent storage falling below 5% capacity, into the 'Dead Water' zone. Water physically cannot be released from Llyn Clywedog below this point and all releases (including compensation flow) will potentially stop, putting the immediate watercourse at great risk of drying up. Water quality at this stage needs to be a serious consideration.
Drought Order Cessation · Consider withdrawing drought order application if storage rises above drought alert curve. · Consider relaxing drought order conditions once storage rises 10% above enforce curve. (Note: Drought order powers are in place for six months after date granted. Conditions could be implemented again without another application if storage subsequently drops below enforce curve). · Consider relaxing emergency storage drought order once storage rises 5% above emergency storage.	

Note: Drought order powers can be extended within the last 28 days of the agreement. The Environment Agency will discuss with the River Severn Drought Management Group if it intends to apply for an extension to the River Severn Drought Order.

4. Approach to Assessment of Impacts

To assess the potential positive and negative impacts from operating a River Severn Drought Order, the geographical areas and species of likely impact were identified, likely flow scenarios were generated, and then appropriate assessment methods were used for each component (e.g. water resources, water quality, ecology).

This section outlines the high level generic assessment approaches and introduces the theoretical drought scenarios applied for impact assessment. Details of the assessment of water resources (section 5.2); water quality (section 6.3) and ecological impacts (sections 7.3, 7.4 and 9.2) can be found in the relevant sections.

4.1. Area of Potential Impact

Figure 5 displays the area which could potentially be impacted (positively or negatively) by the River Severn Drought Order. All impact assessments have focused on these areas, connected conservation sites (refer to Appendix A) have been individually screened and taken through the Habitat Regulation Assessment where appropriate.

The River Severn Drought Order impacts directly ('Primary Path') upon Llyn Clywedog reservoir in Wales, and directly downstream along the River Severn into the Severn Estuary at Bristol. Several connected tributaries are sensitive to alterations because of migratory species trying to reach spawning grounds; these have been identified as 'Secondary Paths.' Due to the role of Lake Vyrnwy in the regulation system, altering releases from Llyn Clywedog will also have direct impact on Lake Vyrnwy, and the reach of the Afon Vyrnwy from the reservoir downstream has therefore also been marked as a 'Primary Path'.

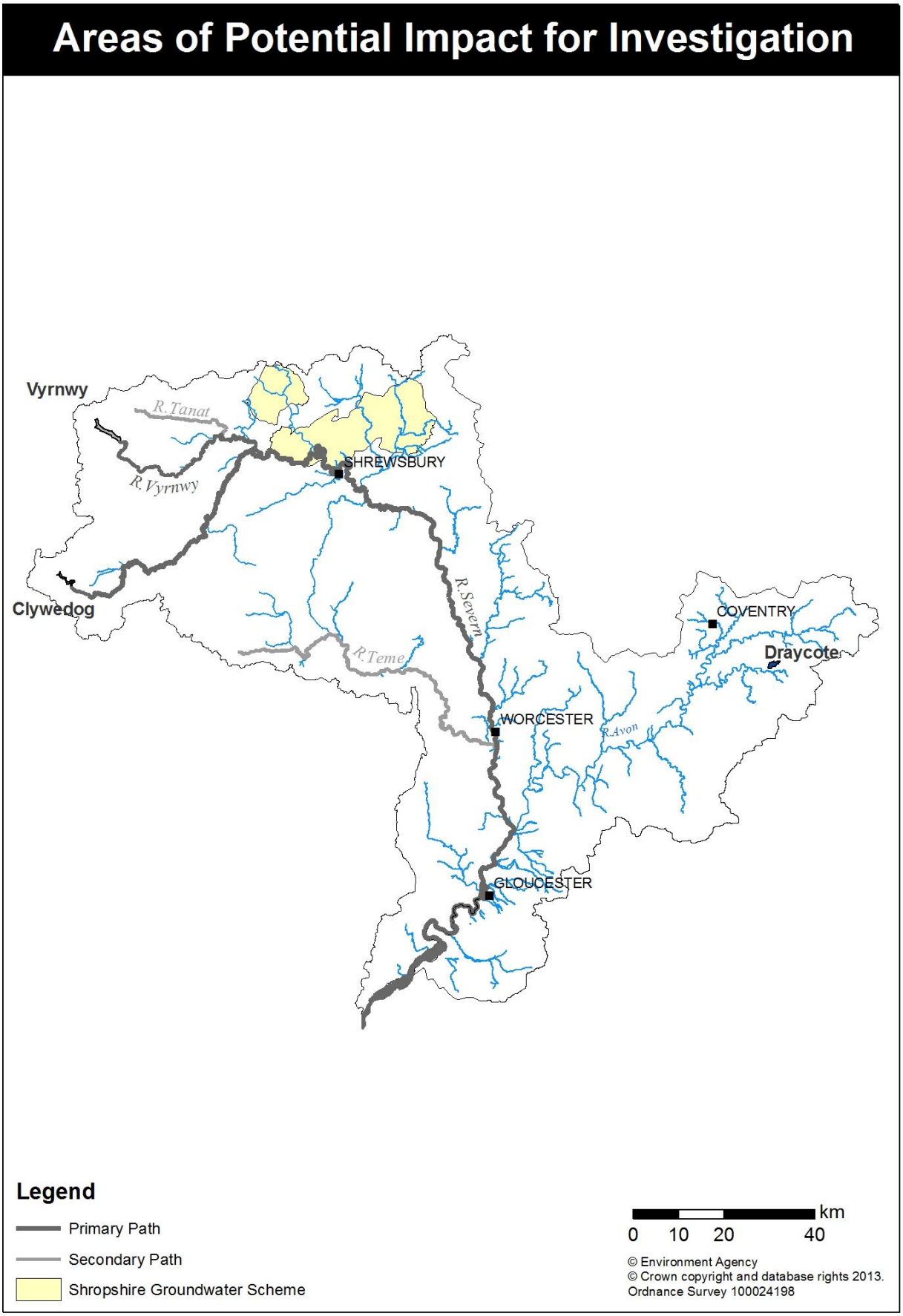

Figure 5: Areas of potential impact from the River Severn Drought Order

4.2. Ecological Sensitivity

The impact a River Severn Drought Order could have on the ecology of the aquatic environment will vary significantly according to the time of year it is needed, and the existing antecedent conditions. Specific flow conditions have been modelled to help assess some of the likely worse case situations; however it is important to recognise the exact timing and scale of flow deterioration cannot be guaranteed. To help assess future droughts as they occur, Table 7 identifies the critical ecological periods, highlighting when the river environment is most vulnerable to flow stress.

Table 7: Critical Periods of Ecological Sensitivity

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Macroinvertebrates		x	x	x	x	x	x	x	x	x	x	x	x
Macrophytes						x	x	x	x	x			
Resident fish species of note													
Brown trout (Salmo trutta morpha fario)	Adults	x	x	x	x	x	x	x	x	x	x	x	x
	Spawning	x									x	x	x
	Egg incubation	x	x	x								x	x
	Fry			x	x	x	x	x	x	x	x	x	x
	Parr	x	x	x	x	x	x	x	x	x	x	x	x
Bullhead (Cottus gobio)	Spawning			x	x	x	x						
	Egg incubation			x	x	x	x	x					
Chub (Leuciscus cephalus)	Spawning				x	x	x	x					
	Egg incubation				x	x	x	x					
Perch (Perca fluviatilis)	Spawning			x	x	x	x						
	Egg incubation				x	x	x	x					
Barbel (Barbus barbus)	Spawning					x	x	x					
	Egg incubation					x	x	x	x				
Grayling	Spawning			x	x	x							
	Egg incubation			x	x	x	x						
	Adults	x	x	x	x	x	x	x	x	x	x	x	x
Pike (Esox lucius)	Spawning		x	x	x	x							
	Egg incubation		x	x	x	x	x						
Dace (Leuciscus leuciscus)	Spawning			x	x	x							
	Egg incubation			x	x	x	x						

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Roach (Rutilus rutilus)	Spawning				x	x	x						
	Egg incubation					x	x	x					
Common bream (Abramis brama)	Spawning					x	x	x					
	Egg incubation					x	x	x					
Migratory Fish of note													
Atlantic salmon (Salmo salar)	U/S migration	x	x	x	x	x	x	x	x	x	x	x	x
	Spawning										x	x	x
	Egg incubation	x	x	x								x	x
	Fry	x	x	x	x	x	x	x	x	x	x	x	x
	Parr	x	x	x	x	x	x	x	x	x	x	x	x
	Smolt D/S migration				x	x	x	x					
Sea trout (Salmo trutta morpha trutta)	Upstream migration				x	x	x	x	x	x			
European eel (Anguila anguila)	Elver U/S migration		x	x	x	x	x	x					
	Silver eel D/S migration									x	x	x	x
Severn Estuary Annex II migratory species (SAC status)													
Twaite shad (Alosa fallax)	Upstream migration				x	x	x						
	Downstream migration						*	*	*	*			
	Spawning					x	x						
River lamprey (Lampetra fluviatilis)	Adult U/S migration	x	x	x						x	x	x	x
	Juvenile D/S migration	x	x								x	x	x
	Spawning		x	x	x	x							
Sea lamprey (Petromyzon marinus)	Adult U/S migration				x	x	x	x					
	Juvenile D/S migration	x	x								x	x	x
	Spawning					x	x	x					

*Twaite shad are not necessarily vulnerable to low flows whilst in freshwater, therefore their downstream migration may not be impacted. However, the cycle has been included in Table 7 for future consideration.

As the table shows, macroinvertebrates can be at risk all year according to the species and degree of low flows that occurs. Similarly, some fish species could be at risk all year, as low flows could limit their movements, food availability and possibly increase the risk of predation. However some species may only be vulnerable at certain times of year, usually relating to breeding cycles and migration patterns.

This information has been used in the impact assessments for ecology, to investigate the potential impacts the River Severn Drought Order could have as a result of changes in water levels and flows.

4.3. Assessment Points

Eight assessment points (APs) were selected along the main River Severn (Figure 6) to represent and assess the impacts on flows at key points along the river system;

- Vyrnwy (Vyrnwy Weir)
- Clywedog (Bryntail)
- Buildwas
- Bewdley
- Saxons Lode
- Deerhurst/Haw Bridge
- U/S Sharpness
- Lower Parting

The first six sites were located at gauging stations to enable modelled data to be compared against actual recorded flows and existing Environmental Flow Indictors[20] (taken from the Environment Agency's current Catchment Abstractions Management Strategies (CAMS), please refer to Appendix C for more detail).

Deerhurst and Haw Bridge represent the furthest downstream continuous flow gauges, but for this investigation it was decided to have two APs further downstream in order to more accurately assess the inflows to the Severn Estuary. U/S Sharpness and Lower Parting were selected to assess flows up and downstream of the potentially large abstraction to the Gloucester & Sharpness Canal, with Lower Parting representing inflows to the Severn Estuary. Modelled data (using Low Flows Enterprise[21]) was used to represent expected normal and/or natural conditions for comparison against the modelled drought flows. This does represent a change away from the techniques used to assess all the upstream assessment points.

In order to gather and represent ecological and WFD information for the whole River Severn, sample sites close to the assessment points were used to incorporate the longest records possible for analysis. Information on these locations and how they have been paired with the River Severn Drought Order assessment points is contained in Appendix K and section 7.

For macroinvertebrate assessment, two control points were also used to represent unsupported (i.e. more natural) watercourses for comparison. Tenbury on the River Teme and Llanyblodwel on the River Tanat were selected to provide a benchmark for comparing the impacts from low flows/droughts on macroinvertebrates living in non regulated (i.e. unsupported) rivers. This is

[20] Environmental Flow Indicators are used to indicate where abstraction pressure may start to cause an undesirable effect on river habitats and species. For more information refer to Appendix C.

[21] Low Flows Enterprise (subsequently superseded by Qube) is an established rainfall runoff model capable of modelling natural and influenced FDCs for surface water.

important to illustrate the different scale of drought magnitude that an unsupported river would experience when compared to the supported flows of the River Severn.

Figure 6: Main River Severn Flow Assessment Points

4.4. Modelled Drought Conditions

Studying historic droughts on the River Severn provided a foundation for assessing the potential impacts of a River Severn Drought Order. The last operation was in 1989, when the river environment, permitted activities, monitoring and population size were all very different to present. The capacity of the Severn regulation system has also been increased since the last drought order application. Initial water resource modelling found that even 1976 drought conditions would no longer trigger the operation of the River Severn Drought Order. Therefore the full impacts on the current system could not be tested based on data from historical droughts.

In order to fully test the potential worst case impacts of the River Severn Drought Order, two theoretical drought events were created using the 1975 and 1976 conditions as a starting point. Natural flows[22] and reservoir inflows[23] were then altered to extend and repeat the drought summer of 1976.

The drought conditions and subsequent scenarios produced all resulted in a River Severn Drought Order application during August. The main impacts on flow and therefore ecology were experienced until natural rainfall returned in November, the drought order did however remain in force beyond the natural flow recovery and over the winter until Llyn Clywedog refilled. Modelling did test the drought order over the winter months, however a separate winter only application has not been prepared because the modelling concluded no physical benefits would be achieved (refer to section **Error! Reference source not found.** for more detail).

4.4.1. Acute Drought Condition

The Acute drought condition represents a severe summer drought event following two dry winters/springs (i.e. below average recharge). The Acute drought uses all the rainfall and flow conditions from 1975 up to and including August 1976. For September and October the existing river flow recessions (falling flows and levels) were allowed to continue as if little to no rain had been received, extending the duration of the drought away from the real event and therefore increasing the severity enough to trigger the River Severn Drought Order operation. Real rainfall and natural flows were used from November 1976 onwards, testing the potential recovery from the River Severn Drought Order under realistic conditions.

[22] Natural flows refer to the volume of water moving down a river in the absence of any man made influences such as abstractions (removing water) and discharges (returning water).
[23] Reservoir inflows refer to the amount of water entering a reservoir and therefore increasing the storage levels, known as refill.

4.4.2. Chronic Drought Condition

The Chronic drought condition was created to test the long-term performance of the River Severn Drought Order, over three dry winter/springs and two drought summers.

The same theoretical Acute scenario was used up to mid-September, triggering the River Severn Drought Order initially but then a return of some rainfall was modelled before any flow benefits were recognised. To produce the subsequent year's summer drought, real natural flows from mid-September 1975 to the end of May 1976 were used with a 10% reduction. The Acute scenario flows were then repeated from June onwards.

4.5. Drought Scenarios

Within both the Acute and Chronic drought conditions, two separate scenarios were created to assess the potential benefits and impacts of the River Severn Drought Order;

- Do Nothing (Baseline)
- Drought Order Only

It is important to emphasise that the drought scenarios described above and assessed in this report are theoretical. They were developed as a means of assessing the potential worse case environmental impacts associated with managing water resources during a severe drought, providing a guide on flow trends and likely periods of operation. Models cannot predict to a high level of accuracy exactly what each drought will look like (e.g. timing and duration) until the antecedent conditions are known.

4.5.1. Do Nothing (Baseline)

The 'Do Nothing' (Baseline) scenario represents the River Severn regulation system continuing to operate at 'normal' parameters throughout both the Acute and Chronic drought conditions. This represents the conditions that would be expected if no River Severn Drought Order were operated i.e. if Llyn Clywedog continued to provide the primary resource support and Bewdley prescribed flows were maintained at 850 Ml/d, until resources became exhausted.

The 'Do Nothing' scenario was used as the baseline comparison instead of a natural flow series for this investigation on the basis that it represented a more realistic comparison of likely flows during a severe drought event if no drought management actions were taken to conserve storage in Llyn Clywedog. It should also be noted that the water resource model used (Aquator) could not isolate natural flows away from discharges and some abstractions, making it difficult to accurately separate and naturalise the flow series for a theoretical event.

As the River Severn is a regulated river, natural flow regimes can no longer be expected along the main river (due to large water abstractions, transfers, weirs, Severn regulation etc), although flow targets derived from expected natural flows exist to protect the environment. The Severn Corridor Catchment Abstraction Management Strategy (CAMS) identified that current and fully licensed management of water resources along the River Severn is acceptable with respect to Environmental Flow Indicators (EFI) (for a brief introduction to EFIs refer to Appendix C). The Review Of Consents (RoC) stage 3 (2009) conducted a Habitats Directive Appropriate Assessment into the current flow regime entering the Severn Estuary, marking the furthest downstream point that Severn regulation is designed to protect. Investigations concluded the

current licensing policy and operation of the Severn regulation system protect and maintain adequate flows in accordance with WFD transitional waterbody flow targets. The Appropriate Assessment concluded that the current flow regime was having no significant impact on the Severn Estuary features, with the exception of severe drought conditions, which were not assessed.

The assessment described in this report built on the foundations of the RoC, CAMS and WFD assessments of the River Severn using the 'Do Nothing' scenario as a baseline. Historic drought data and report accounts were used to build on this previous work and assess the potential impacts from severe drought.

4.5.2. Drought Order Only (River Severn Drought Order)

The 'Drought Order Only' scenario represents conditions that would be expected if the River Severn Drought Order were granted and operated to full effect. No other drought permits or drought orders were activated during these runs, but all existing abstractions and discharges were represented. The Gloucester & Sharpness Canal abstraction near the Severn Estuary was represented with an average monthly abstraction profile, with a peak abstraction of 300 Ml/d in September (refer to section 5.3.3.2 for further detail). This scenario therefore does not allow the River Severn Drought Order to be assessed entirely in isolation, but involves a degree of in-combination effects that represent a more realistic representation of expected flows on the River Severn.

4.6. Impact Assessment Methods

For each element of investigation (e.g. water quality, macroinvertebrates etc) different methods were used to assess and try to quantify the potential impacts from operating the River Severn Drought Order when compared to the baseline 'Do Nothing' scenarios. The details of each method are contained within the relevant chapters of this report, and within the relevant appendices.

The River Severn Drought Order impacts can be categorised into positive or negative impacts on individual species and water user interests, although it's important to note the impact can change from negative to positive and vice versa according to which period of the drought is being assessed. The size and diversity of the River Severn catchment, the conflicting interests between water users, the different methods used to assess individual elements and the limitations encountered when trying to predict drought flows and ecological responses, made drawing conclusions consistently together a complex process.

All assessments where the environmental impacts are predicted before the magnitude and extent of an event or incident is known can be open to debate, and a number of different methods can be used. Some environmental impact assessments use a scale from High/Critical to Neutral/Negligible, while others use terminology such as 'significant' or 'likely' effects. It was not feasible to apply a quantifiable methodology for determining the overall magnitude of impact at each assessment point and receptor for this report. There were too many variables, and because impacts changed as the drought developed, trying to apply a conclusive magnitude could have hidden the true nature of each impact. To keep the overall assessment understandable to all and applicable to a catchment of this size, we opted to use a basic scale of risk to summarise the potential impacts and leave the detailed assessments within the relevant chapters.

4.6.1. Summary of Potential Risk Methodology

Individual assessments have been conducted for water resources, water quality, ecology, designated sites, archaeological and cultural heritage and navigation and recreation. Section 13 uses categories of risk to summarise the 'overall conclusion' for each assessment point. The classification uses a principle 'one out, all out' which means that the poorest individual result drives the overall classification (similar to Water Framework Directive). Therefore, where one or more of the individual assessments concluded a potential negative impact, the assessment point risk has been assigned to reflect this.

The scale of risk used to summarise the potential impacts concluded at each of the assessment points consists of;

- Low Risk/Benefit
- Medium Risk
- High Risk
- Potential Indirect Risk

The 'Low Risk/Benefit' category is used to describe where individual assessments concluded there would either be a benefit from operating the River Severn Drought Order, or where any impacts were temporary and/or too small to be considered a threat or investigated further. The 'Medium Risk' category describes where one or more of the individual assessments highlighted there could be some negative impacts during the drought event, but they would be temporary and not concluded as significant or greatly detrimental. The 'High Risk' category describes where significant impacts such as complete loss of flow or complete barriers to fish movements were concluded in the individual assessments. This category has also been used where a large amount of uncertainty in the results or abstraction operations remains.

A further category was used for the watercourses identified in section 4.1 as being indirectly (Secondary Path) at risk from changes to the River Severn. These sites were treated differently because the risk only related to migratory species trying to reach their spawning grounds, rather than the impact affecting the immediate environment.

5. River Severn Catchment Water Resources

5.1. Baseline Environment

The Water Resource environment of the River Severn incorporates the full hydrological cycle, from the precipitation inputs to the flows out to sea via the Severn Estuary. Surface and ground water sources are encompassed, including the abstractions and discharges which interact with the natural movement of water through the River Severn catchment.

5.1.1. Geology

The upper reaches of the Severn catchment from Plynlimon in Wales to just downstream of Shrewsbury, consist predominantly of Palaeozoic strata comprising Ordovician and Silurian aged mudstones and shale's within interbedded sandstones, conglomerates and limestones. Pre-Cambrian and Cambrian aged igneous rocks such as lavas and intrusive basic rocks outcrop on the northern catchment boundary and are some of the oldest rocks in the world. A small area of limestone, Millstone Grit and Coal Measures, of Carboniferous age, separates Permian sandstones forming a flat plain to the east of Oswestry. Alluvium and river terrace gravels overlie much of the Palaeozoic strata. Elsewhere the solid strata are mainly overlain by unconsolidated Quaternary glacial and post-glacial sands, gravel and clays.

The geology of **the middle reaches** of the catchment (Shrewsbury to Worcester) is dominated by the Permo-Triassic sandstone and mudstone formations. In the northern part of the area these form the North Shropshire Plain although, throughout this area, Quaternary clays generally obscure them. Lying to the south and west of these formations are Carboniferous Coal Measures strata upon which Telford and the beginnings of the Industrial Revolution, in and around the Ironbridge Gorge, were based.

The course of the River Severn in **the lower reaches** (Worcester to Gloucester) is influenced by erosion-resistant Palaeozoic rocks which form the Welsh border hills to the west of the catchment and the Malvern Hills, and the escarpment of the Cotswolds ridge that forms the SE boundary of the catchment comprised of Jurassic oolitic limestones. Between the Welsh Borders/Malvern Hills and the Cotswolds escarpment, the Severn Vale comprises a low lying plain of Triassic mudstones covered by a broad flat river terraces and modern-day flood plain alluvial deposits extending from Gloucester out to the extensive tidal flats of the mouth of the Severn Estuary.

It is considered that current drought management provisions designed to stabilize river flow under severe drought conditions would not affect the geology within the study area. No further assessment will be undertaken.

5.1.2. Geomorphology

The topography of the River Severn catchment has been strongly influenced by the underlying solid geology. Generally the older hard rocks in the upper part of the catchment forms high topographic elevations whilst the younger less resilient rocks form topographic lows.

The upper Severn and its main tributaries exhibit classic river geomorphologic development from the source to the downstream end of this part of the catchment. The river starts on an upland plateau before dropping through steep sided gorges, eventually flowing through an embanked

floodplain that supports agricultural land. On reaching the floodplain the Severn and its tributaries flow along a medium gradient course, through flat-bottomed valleys comprised mainly of alluvial soils. As a result, erosion and deposition rates are high and give rise to the formation of features such as meanders and oxbow lakes, some of which are of national importance with respect to geomorphology. The reach of the River Severn between Dolwen and Penstroewd has been proposed as a geomorphologic SSSI of high conservation value since it represents one of the most unstable sections of natural gravel-bed channel in England and Wales. This section of the river exhibits a wide range of erosional and depositional features and is an important site for studying the development of sedimentary structures such as bars, islands and braided channels.

The middle Severn can be divided into two areas north and south, separated by the Ironbridge Gorge. The northern section of the middle Severn consists of the flat Shropshire Plain and provides a fairly typical example of the middle course of a river being bordered, characteristically, by a wide floodplain and meanders and in parts forming cliffs on the outside of meanders. The Ironbridge Gorge was formed at the end of the Ice Age when the course of the River Severn was re-directed with the retreat of the glaciers. The gorge remains unstable due to its steep slopes, which have not reached their final angle of repose. The important industrial heritage of the site has exacerbated the problem of instability since the riverbank consists largely of made ground, particularly in the Jackfields area. The southern part comprises the more undulating landscape of the Severn valley. However, many of the tributaries further south in the catchment are small, fast flowing and more characteristic of upland rivers.

The lower Severn is generally low lying and flat, the Severn Vale is situated within an extensive agricultural plain and constitutes the major landscape feature within the lower catchment. Many small streams and rivers meander across the floodplain to join the River Severn.

5.1.3. Rainfall

Within the Severn catchment, rainfall generally decreases from north to south and from west to east. Superimposed upon this pattern is a marked increase in rainfall totals with altitude. Annual rainfall totals average up to 2400 mm on the high ground around the headwaters of the Severn, decreasing to below 700 mm on the North Shropshire Plain and to less than 600 mm around the head of the Severn Estuary. When compared to population density, the highest water demand is located in the areas receiving lower rainfall. Annual variability can be large with a standard deviation of 100 mm being common for mean annual totals of 600 to 700 mm.

The Environment Agency and Natural Resources Wales use Long Term Average (LTA) rainfall figures based on a 30 year period (currently 1991-2020 for EA and 1981-2010 for NRW) to assess whether a shortage or abundance of rainfall has been received over a catchment each month. This helps predict the onset of drought (or flood) conditions and enables planning to help prepare and mitigate against the worst impacts. The Severn catchment is split into six rainfall catchment areas for reporting, shown in the wider context of the West Midlands Area in 7:

- Welsh Uplands;
- Shropshire Plains;
- Mid Severn/Teme;
- Avon;
- Lower Severn; and
- Lower Wye.

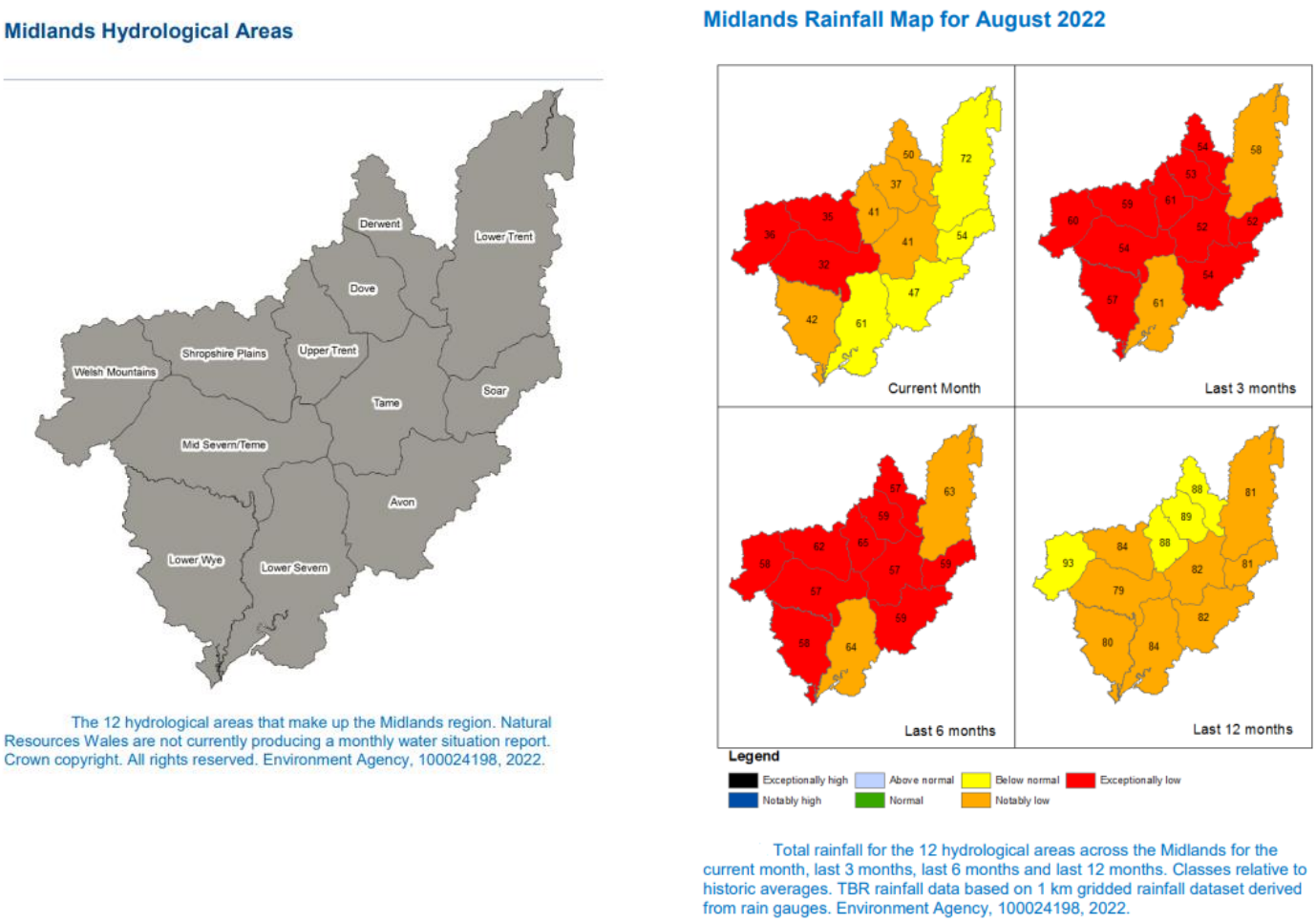

Figure 7: Rainfall Catchments impacting upon the West Midlands Area

Figure 7 is taken from the August 2022 Midlands Water Situation Report, produced by the Environment Agency.

Winter rainfall and associated run off normally generates sufficient flow to meet the seasonal abstraction and environmental demands placed on the River Severn. However, during most summers flows have to be augmented by releasing water from the River Severn regulation system in order to meet the Bewdley flow target (section 2.2 for detail). The combination of complex abstractions and Severn regulation makes the River Severn a heavily influenced and artificial watercourse.

5.1.4. Flow Regimes

Flows downstream of both Llyn Clywedog and Lake Vyrnwy are subject to large and often sudden variations, as water releases are altered to satisfy downstream need. Both sites conform to minimum flow requirements to protect the environment as much as possible; there is a requirement to maintain 18.2 Ml/d downstream of Llyn Clywedog and 41.876 Ml/d downstream of Lake Vyrnwy (although if flows exceed 20 Ml/d at Cownwy Weir (Afon Cownwy) then releases directly from Lake Vyrnwy can be reduced to 21.876 Ml/d[24]).

The River Severn regulation system increases flows significantly above what would naturally occur. Regulation releases are evident as steps in the flow duration curves at gauging locations

[24] Compensation requirements and/or operations are currently under review following completion of the Afon Cownwy and Marchnant capital projects to provide flow downstream of the intakes..

some distance downstream of the major reservoirs. These steps have largely been smoothed out of the hydrographs by Bewdley as a result of abstraction. Low flows remain elevated above what would naturally occur. This artificial elevation in flows, particularly low flows, illustrates what the Severn regulation system is designed to achieve; balancing abstraction needs with environmental protection.

5.1.4.1. Assessment Points: Hydrology current environment

More detail is contained in Appendix D, including the gauging station specifications and underlying geology.

Clywedog (Bryntail)
The catchment is 49km^2 with steep topography and high rainfall making it naturally flashy. Flows at Bryntail are constantly impacted by regulation, Hydropower, flood and other releases from the reservoir, making it a heavily artificial flow site. Appendix D contains the naturalised and gauged flow duration curves and illustrates how the high to mean flows are reduced and then returned to the system in a stepped approach from mid to low flows. The flow regime is affected and natural flow variation lost, but Q95 (flow exceeded for 95% of time) and lower flows (often dry weather/drought related) are protected and raised above what would naturally occur. Subsequently, the environment and ecology is prevented from experiencing drought conditions, as the compensation flow of 18.2 Ml/d is maintained.

Vyrnwy (Vyrnwy Weir)
The natural catchment area (excluding the Cownwy and Marchnant indirect catchments[25]) is 94.3km^2 with steep topography and high rainfall also making it naturally flashy. Flows at Vyrnwy Weir are particularly dominated by controlled releases from the reservoir during low flows, making it an artificial flow site. Appendix D contains the naturalised and gauged flow duration curves, and also illustrates how the high to mean flows are reduced. However, unlike Llyn Clywedog, due to the large abstractions from Lake Vyrnwy, the mid to lower flows do not display the same stepped return of flows to the system, as the majority of this water is transferred directly out of the catchment. The benefits from the compensation flow are displayed in the more infrequent percentiles; Q95 flows are protected and raised above what would naturally occur.

Buildwas
Buildwas is just upstream of Ironbridge gorge in Shropshire, with a catchment of 3723.7km^2. The flow regime at Buildwas remains close to natural behaviour under normal conditions, until Q80 onwards when regulation releases can be seen to elevate flows above what could naturally be expected. The site is therefore behaving relatively naturally with flow variation and volumes until dry/summer periods, illustrating how the stepped nature of flows immediately downstream of the reservoirs is gradually smoothed out as it travels downstream.

Once baseflows naturally begin declining, the regulation releases artificially prevent flows at this site from ever dropping to what would have naturally occurred. In effect, when tributaries of the River Severn are beginning to display natural summer/low flow effects, flows at Buildwas are artificially protected (increased) under normal regulation operation. This can be confusing when trying to understand the impacts of drought on the flow dependant environment, as the lowest flows are less likely to occur at the peak of a dry period because the highest regulation releases will be made during these times.

Bewdley
Flows to the 4334km^2 catchment are largely artificial. Bewdley is used as the flow trigger site where the five day rolling mean of 850 Ml/d and daily 727Ml/d (minimum flow target) is maintained for Severn regulation. Significant public water supply and power generation abstractions take place upstream, removing significant portions of the regulation releases which take between three

[25] Recent capital projects have been completed to allow 25% of the upstream flow to continue to flow downstream of the intakes with 75% diverted into Lake Vyrnwy

and four days travel time from Clywedog reservoir. Although flows are artificial, they do mirror the naturalised FDC (Appendix D). The gauged FDC (1990-2007) shows the EFI is normally achieved (minor deviations due to stepped representation of the EFI) and from Q97 regulation releases elevate flows above what would naturally occur.

Saxons Lode

The catchment is 6860.6km^2 and incorporates inflows from the River Teme and River Stour (large effluent returns), displaying a slower hydrograph with broad flood peaks. Flows at Saxons Lode can be affected by high tides travelling up the estuary, and operation of tidal gates on the Avon at Tewkesbury. Low flows remain artificially supported by regulation, although to a lesser degree as major abstractions have already removed the majority of additional supported water. Appendix D shows the effect is to return flows from Q95 back towards the natural flow, rather than notably elevating it. The graph also shows the current flow regime (gauged FDC) satisfies the EFI at all times.

Deerhurst/Haw Bridge

The catchment at Deerhurst is 9866.3km^2; flows at both sites are affected by tides. The sites are often used interchangeably, as Haw Bridge provides a much longer record and includes important historic drought events while Deerhurst was designed to cope with tidal movements. Deerhurst and Haw Bridge are the furthest downstream continuous flow gauging stations on the River Severn.

Flows are substantially modified by this point, with further public water supply abstractions and effluent returns (additional effluent received from the Avon and Thames). Low flows are artificially supported by regulation but to a lesser degree than Bewdley and Saxons Lode. Appendix D shows how flows from around Q96 onwards are elevated back to what would naturally have occurred. The current flow regime (gauged FDC) meets the EFI requirements at all times and therefore demonstrates that inflows to the Severn Estuary are still protected at this location.

U/S Sharpness and Lower Parting

U/S Sharpness and Lower Parting were selected to assess inflows to the Severn Estuary more accurately and investigate the potentially large abstraction to the Gloucester & Sharpness Canal. The River Severn abstraction is taken at Gloucester Docks, from the East channel where the river splits. Abstraction was previously exempt from abstraction licensing under the Water Resources Act 1991, and could range from 0-691 Ml/d from the River Severn at Gloucester; this exemption was removed in January 2018 by the Water Resources (Transitional Provisions) Regulations 2017, such that the Canal & River Trust now requires an abstraction licence. The channel bifurcation (channel split) itself raises additional modelling and impact assessment challenges; Monitoring between 1990-2004 indicates an approximate flow split of 40% down the East channel and 60% down the West channel. The complex interaction and variability of abstraction coupled with a lack of actual flow data downstream of the canal abstraction make it very difficult to assess with confidence what the true impact on the lower River Severn would be.

Appendix D shows modelled natural and influenced (incorporates abstractions and discharges) rainfall runoff modelled (Low Flows Enterprise) data just downstream of Lower Parting. The EFI used is in accordance with the WFD guidance for transitional waterbody's and conforms with the Stage 3 RoC. Due to the large tidal range of the Estuary (second largest in the world), flow requirements are less sensitive than represented by a normal watercourse so will not match those plotted at Deerhurst.

The flow duration curve suggests flows consistently remain below what would have naturally occurred, meeting only at the severest drought. This could involve errors relating to how the regulation system and Gloucester & Sharpness Canal abstraction is represented within Low Flows Enterprise. However the FDCs do suggest the EFI requirements are met at all times, with only Q99-Q100 showing marginal results. Appendix D therefore indicates normal flow operation protects the lower River Severn and subsequently inflows to the Severn Estuary. Greater confidence could be achieved by investigating how the Gloucester & Sharpness Canal abstraction

has been represented (likely to be average pre-New Authorisation abstraction, not accounting for severe droughts) inside Low Flows Enterprise, to verify the results being shown.

5.1.5. Major Abstractions

A number of critical water supply, industrial and waterways abstractions from the River Severn are licensed on the basis of regulation releases being made to support them. This legal agreement dates back to the Clywedog Joint Authority Act of 1963, with regulation operations now the responsibility of the Environment Agency in consultation with Natural Resources Wales. It is the reservoir and supported abstractions which will be referred to as 'major abstractions' for the purposes of this report.

5.1.5.1. Public Water Supplies

The River Severn provides drinking water to over 6 million people via a number of licensed Public Water Supply (PWS) abstraction points. Water is abstracted by five water companies to enable the provision of water supplies to households and industry in the region:

- United Utilities
- Hafren Dyfrdwy
- Severn Trent Water
- South Staffordshire Water
- Bristol Water

Dŵr Cymru Welsh Water also have unsupported abstractions within the River Severn catchment, however they are located in the upper reaches of the tributary River Teme. Figure 5 identifies the River Teme as a Secondary Pathway for impacts, however the potential impact relates specifically to migratory fish.

Figure 8 includes the location of these abstractions and Table 8 indicates both the licensed daily abstraction rates for the larger consumptive licences.

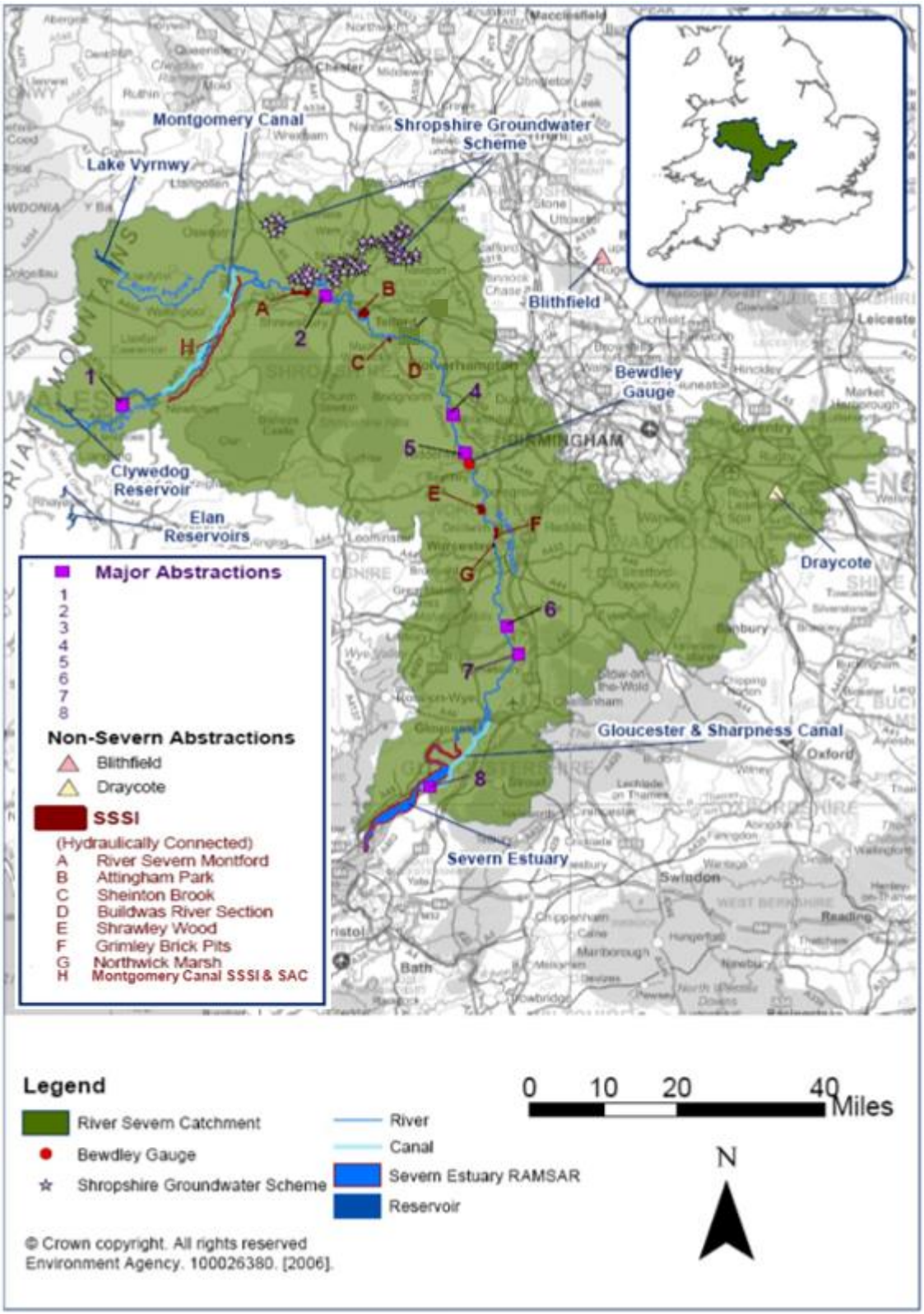

Figure 8: Major Abstractions from the River Severn

Table 8: Public Water Supply Licensed Daily and 100 day Quantities

Abstraction	Water Company	Daily licensed volume (Ml/d)	100 day licence volume (Ml)
WA/054/0001/0109	Hafren Dyfrdwy	24	N/A
18/54/01/0157	United Utilities	252.8	N/A
18/54/02/0168	STWL	38.6	N/A
18/54/02/0163 18/54/02/0584	SSW & STWL	280	21,200
18/54/02/0110	STWL	211	9100
MD/054/0002/031	STWL	79	N/A
18/54/08/0101	STWL	167	16,500
18/54/08/0165	STWL	120	N/A
18/54/20/0138	Bristol Water	245	21,000

Note

- Total combined abstraction from 18/54/02/0163 and 18/54/02/0110 is capped at 431 Ml/d.
- Max daily aggregate total for 18/54/02/0584 and 18/54/02/0163 is 280 Ml/d when the flow in the River Severn at Bewdley is equal to or less than 1,000,000 Megalitres per day (for Public Water Supply).
  From April to October inclusive, the aggregate quantity of water authorised to be abstracted under this licence and licence serial number 18/54/02/0163 for the purpose of public water supply shall not exceed 320,000 cubic metres per day, except when Emergency conditions apply.
  When Emergency conditions apply, the aggregate quantity of water authorised to be abstracted under this licence and licence serial number 18/54/02/0163 for the purpose of public water supply shall not exceed 375,000 cubic metres per day.
- The aggregate quantity of water authorised to be abstracted under this licence and licence serial numbers 18/54/02/0163 and 18/54/02/0110 for the purpose of public water supply shall not exceed 431 Megalitres per day, except when Emergency Conditions apply.
  When Emergency conditions apply, the aggregate quantity of water authorised to be abstracted under this licence and licence serial numbers 18/54/02/0163 and 18/54/02/0110 for the purpose of public water supply shall not exceed 586 Megalitres per day.

In addition to the above surface water sources there are numerous groundwater abstractions made for PWS within the Severn catchment. Little abstracted groundwater is directly exported out of the Severn catchment and most of the water is returned to the river network as treated effluent via various sewage treatment works (STWs), although the location of the water return can affect local flows.

During periods of low flow, when the river is supported by regulation releases of water the permitted licensed abstraction rates are reduced for many of the PWS abstractions. Many licences also have a maximum volume of water that can be abstracted during the first 100 days of regulation and pro-rata thereafter. This is undertaken to reduce the stress on the river system. The daily and 100 day licence volumes are shown in Table 8. In reality the actual volumes of water abstracted from the river vary depending on demand.

A significant proportion of the water abstracted from the River Severn is transferred outside the catchment with no return. This includes all of the water abstracted from 18/54/01/0157 (transferred to Liverpool) and 18/54/20/0138 (transferred to Bristol Water) as well as significant proportions of the abstractions from 18/54/02/0163, 18/54/02/0584 (>80% exported) and 18/54/02/0110. Some of the water supplied within the catchment is also subject to consumption and will effectively be lost.

5.1.5.2. Industrial Water Supplies

The only major abstraction from the River Severn for industrial use was at the Ironbridge power station in Shropshire (Figure 8), previously operated by E.ON UK. This power station has now been decommissioned and the licence for 110 Ml/d abstraction traded to another abstractor.

5.1.5.3. Canal Abstractions

Canal abstractions are now licensed by the Environment Agency and Natural Resources Wales.

A number of canals feed into and draw water from the River Severn. In the majority of cases the importance of these in terms of water resources is how they deplete flows from the point of abstraction until discharges are returned to the main channel some distance downstream. The most notable examples include the Montgomery Canal in Powys and the Gloucester & Sharpness Canal in Gloucestershire.

The Canal & River Trust abstraction for the Montgomery Canal is operated according to abstraction licence granted by Natural Resources Wales.
The Gloucester & Sharpness Canal is the largest potential abstraction between Deerhurst and the Severn Estuary and is known to have a significant impact on the distribution of water in the lower reaches of the River Severn around the tidal limit (hereafter referred to as the lower tidal Severn). Water is abstracted from the East channel of the River Severn at Gloucester; to supplement the canal at times when demands are not satisfied by several intercepted tributaries (i.e. River Frome, River Cam, Daniels Brook and Sud Brook). The Canal & River Trust licence allows abstraction of up to 398 Ml/d. In addition, Bristol Water abstract up to 245 Ml/d directly from the canal under licence 18/54/20/0138. Water from the canal, minus losses due to leakage and/or consumptive use, finds its way back to the estuary via the lockage at Sharpness, lockage at Gloucester, and leakage/seepage from the canal.

If high abstraction rates into the canal coincide with low flows in the River Severn, dissolved oxygen concentration could decrease rapidly and other water quality impacts along the tidally influenced reaches of the river can be exacerbated, particularly when combined with spring tides. As a result of this (and other factors less relevant to this study) an Operating Agreement (1998) was set between the Canal & River Trust and the Environment Agency stating that;

“No pumping for 3 hours after high water springs in March, April and May when flows are less than 2400 Ml/d at Deerhurst and when tides > 8.5m at Sharpness.”

This measure helps to critically increase the flow in the river during spring tide conditions and thereby helps reduce the adverse impacts previously reported. The stage 3 RoC and more recent Severn Corridor CAMS assessments both concluded that Severn Estuary inflows were adequate under current operations (i.e. Seven regulation and the Operating Agreement) to protect the site designations. The Operating Agreement does however contain a clause for drought conditions, recognising the more extreme scarcity of resources and difficulties that would be faced in balancing navigation, abstraction and environmental needs.

Clause 7 of the Operating Agreement means the Canal & River Trust could not be held liable for the failure to observe any of its obligations under the agreement during a drought. This is particularly significant to this investigation because it potentially allows the maximum daily licensed volume of 398 Ml/d to be abstracted at Gloucester.

5.1.5.4. Spray Irrigation

There are a large number of licences for spray irrigation within the Severn catchment, permitting over 24500 Ml of abstraction from ground and surface water sources within a calendar year. For the purposes of this assessment it has been assumed that the full amount (i.e. both groundwater and surface water abstractions) would be abstracted annually and would directly and instantaneously impact the surface water system of the Severn catchment. In reality the distribution of these abstractions is varied, both spatially and temporally.

5.2. Assessment of Impact on the Current Environment: Hydrology

The assessment aimed to determine the impact of the River Severn Drought Order on river flows during the Acute and Chronic drought conditions described in section 4.4. Simulations were conducted for the two scenarios described in section 4.5 ('Do Nothing' and 'Drought Order Only') to allow the changes in river flow under each scenario to be assessed. The aim of the assessment was to identify whether the River Severn Drought Order was a beneficial drought management option or not, and to identify any adverse impacts that could occur.

5.2.1. Aquator Modelling

The drought order was modelled in a water resource simulation programme called Aquator, version 3. Water Resources West and the Severn Modelling Sub-group are signed up to collaboratively deliver improved baseline and modelling capability on the River Severn. The ambition is for outputs from these groups to be used to improve drought modelling and impact assessment work in the future.

The Aquator model used covers the River Severn and Wye, routing an 88 year record of inflow sequences through the rivers and water supply network in accordance with existing licence constraints, to where it is needed based on demand profiles. The model contains public water supply and large private abstractions, discharges and the Environment Agency's Severn regulation system. VBA code directs the model to maintain the prescribed flow at Bewdley by use of releases from Llyn Clywedog, Lake Vyrnwy water bank and the SGS (active phases at the time of modelling were 1-4[26]).

In order to assess impacts, the Environment Agency modified the Severn & Wye PR09 Aquator model to include the Gloucester & Sharpness Canal abstraction. An average abstraction profile was manually imported into Aquator to model the potential impacts of the Gloucester & Sharpness Canal. Maximum abstraction from the Severn into the canal was modelled at 300 Ml/d (based on observed data),

5.2.2. Hydrological Assessment Methods

A number of methods were used to present and interpret the modelled flow data at each of the eight assessment points. Hydrographs were produced for each scenario to assess the daily changes in flow and drought (critical low flow) duration. Flow duration curves (FDCs) were produced for comparison between the Aquator modelled flows, actual observed (gauged data) flow records, and CAMS Environmental Flow Indicators (Refer to Appendix C for an explanation of EFIs).

Flow duration curves are useful for illustrating the duration and magnitude of low flow/drought events (i.e. the rarity); however caution is needed when comparing different time periods as the results may be skewed. The observed FDCs (based on gauged data) were all based around the CAMS period 1990 to 2007 (18 years). The modelled data is based on a theoretical three year period (based on but not equivalent to flows observed in 1975 to 1977). The latter is a much shorter record and largely biased towards low flows, which needs to be understood when interpreting the results. Therefore, consideration of adverse impacts was largely based on the mid to low flows from each FDC, excluding the normal to higher flows which will have been skewed by the short time period used.

[26] Phase 5 of SGS was commissioned in 2014, providing an additional gross yield of 50 Ml/d.

These modelling and assessment approaches provided the best certainty possible at the time of analysis, using the best available information and most up to date Aquator model and inflows.

5.2.3. Impact on Flows; Acute Drought Condition

Only the summary and conclusions are presented in this section, for the complete Hydrological assessment refer to Appendix D (Appendix E.1 to E.5 contain the supporting hydrographs, flow duration curves and a breakdown of the key regulation volumes and critical dates for the Acute scenario testing). It is important to emphasise the drought order scenarios being assessed are theoretical worse case situations. They were developed to assess the likely flow trends and identify the potential periods of drought order operation.

Figure 9 presents data from the furthest downstream River Severn assessment point, Lower Parting, and therefore includes cumulative impacts (from upstream) of all abstractions, plans and drought permits/orders. The hydrograph demonstrates the overall flow trend predicted along the majority of the River Severn; an initial flow depletion was predicted as the drought order was activated (compared to the 'Do Nothing' baseline), followed by a higher maintained flow than would be possible without operation of the drought order if the dry conditions continued.

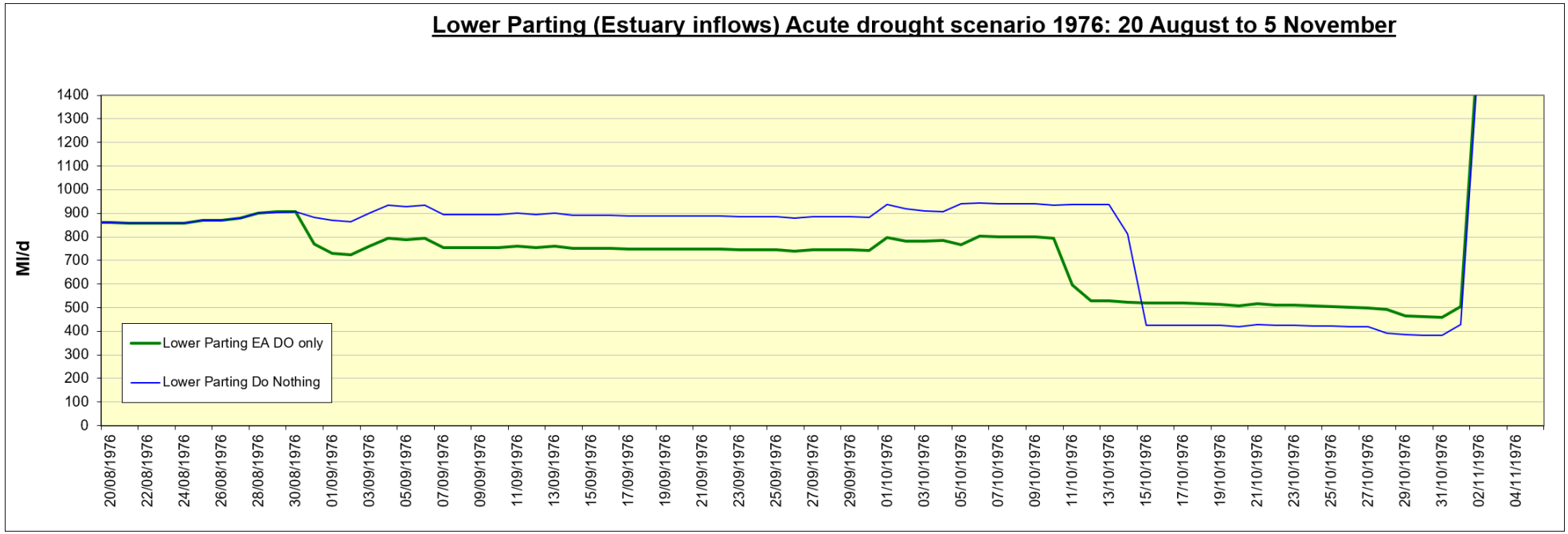

Figure 9: Lower Parting (Estuary inflows) Acute drought scenario 1976; 20 August to 5 November.

Figure 9*: shows all the modelled impacts on flows at Lower parting, downstream of all the regulation inputs (Clywedog, Vyrnwy and SGS) and major abstractions, including the Gloucester & Sharpness Canal. The graph highlights the specific period of interest, when the Environment Agency drought order was modelled as being active.*

Table 9 contains a summary of the modelled flow values under each scenario, the modelled drought Q30* values need to be viewed with additional caution due to the short (3 year) record of data used.

Table 9: Summary of Modelled Flow percentiles

Flow value	Acute Do Nothing Ml/d	Acute EA DO in isolation Ml/d	Current flow Ml/d (G=Gauged, M=modelled**)	Naturalised flow Ml/d (D=decomposition, M=modelled**)
	(1975-1977)	(1975-1977)	(1990-2007)	(1990-2007)
Bryntail				
Q30*	163	163	176 G	216 D
Q95	18	18	18 G	19 D
Q99	9	18	18 G	-6 D
Q99.9	9	18	-	-59 D
Vyrnwy Weir				
Q30*	45	45	131 G	426 D
Q95	25	25	25 G	30 D
Q99	25	25	24 G	0 D
Q99.9	25	25	-	0 D
Buildwas				
Q30*	4978	4978	5511 G	5646 D
Q95	1068	934	1030 G	742 D
Q99	551	635	919 G	527 D
Q99.9	513	586	-	527 D
Bewdley				
Q30*	4988	4982	5470 G	6211 D
Q95	901	762	881 G	930 D
Q99	375	458	791 G	715 D
Q99.9	337	411	-	458 D
Saxons Lode				
Q30*	7551	7551	7992 G	8523 D
Q95	946	817	1327 G	1350 D
Q99	440	526	1167 G	1131 D
Q99.9	400	475	-	536 D
Deerhurst				
Q30*	9501	9501	7992 G	8523 D
Q95	946	817	1327 G	1350 D
Q99	440	526	1167 G	1131 D
Q99.9	400	475	-	536 D
U/S Sharpness				
Q30*	1170	1033	-	-
Q95	648	732	-	-
Q99	616	706	-	-
Q99.9	609	684	-	-
Lower Parting				

Q30*	983	893	9772 M	10213 M
Q95	370	735	1910 M	2056 M
Q99	319	729	1509 M	1564 M
Q99.9	304	528	1096 M	1123 M

*Modelled drought Q30 values need to be viewed with caution due to the short (3 year) record of data used.
**Modelled data using Low Flows Enterprise, a rainfall runoff model producing flow duration curves for a drainage basin (not time series data).*
Negative values within the calculated naturalised dataset are known errors associated with data quality.

5.2.3.1. Summary

The Acute drought condition represented a dry summer and winter (1975) preceding a summer drought (theoretical 1976) event. The modelled drought broke in November with the return of high rainfall. It is important to note the November rainfall created significant flow recovery; if the drought period were prolonged the duration of flow reduction would also have increased until regulation failure (all three sources exhausted) was reached. Similarly, if rainfall was to return earlier then regulation failure would be avoided and flow benefits of the River Severn Drought Order may not be observed (refer to the Chronic scenario).

The most difficult stretch to assess with confidence was the lower tidal Severn, from the channel bifurcation down to the Severn Estuary. Owing to the proximity to the National Site Network and its importance for migratory fish and navigation, any impacts here could have the greatest significance to the catchment as a whole. Post drought reports from 1976 and 1989 indicated that large abstractions to the canal were taken during the peak of the droughts. In 1989 flows down the West channel dried up and were almost completely removed from the East channel, allowing only a few centimetres to pass over the Llanthony Weir. An Operating Agreement was created in 1998 to help safeguard the Severn Estuary, and assessments have shown that under routine flow regimes there is sufficient flow reaching the Estuary. The difficulty is managing a severe drought, which falls outside normal operation and would require close liaison and management between interested parties.

5.2.3.2. Do Nothing (Baseline)

An annual total of 166 regulation days and 70,220 Ml combined releases were modelled during the Acute 'Do Nothing' scenario, with 152 days of continuous regulation; Llyn Clywedog provided 66% (46374 Ml), SGS 25% (17744 Ml) and Lake Vyrnwy 9% (6102 Ml) of the total resource.

SGS provided steady and continuous support, limited to a net of approximately 140 Ml/d. Once Llyn Clywedog became exhausted only the Lake Vyrnwy water bank contained large enough volumes to replace the 500+ Ml/d that regulation required to support the prescribed flow at Bewdley. However, the Lake Vyrnwy water bank is a short term resource when large releases are required and can only provide a temporary replacement to Llyn Clywedog. Modelling showed that during high regulation requirements, if Llyn Clywedog was exhausted and significant rainfall did not arrive, the regulation system would begin to fail and flows decline. The speed and degree of failure and resultant flow crashes would vary according to the climatic conditions, abstraction demand and how much resource remained individually within the Lake Vyrnwy water bank and SGS licence.

'Do Nothing' modelled regulation failure to begin on 29 September, 16 days after Clywedog reached dead water. Once the Lake Vyrnwy water bank became exhausted, SGS also began to reach its 'individual' licence limits. In reality, SGS could be operated differently to utilise the group

licence surplus (7756 Ml) more effectively, and/or the Environment Agency could consider applying the SGS Drought Order. It is important to note the additional daily quantities from SGS would be too small to prevent the eventual regulation failure, but early optimisation of the scheme could help delay a River Severn Drought Order application.

Significant flow impacts were observed at Bryntail, Bewdley, Saxons Lode, Deerhurst and the lower River Severn (most notably Lower Parting, downstream of the Gloucester & Sharpness Canal abstraction). It can therefore be assumed a drought of this magnitude would put the most flow stress on the Upper Severn (dependant on reservoir operation), and from around Bewdley downstream. Flows around Bewdley were most likely to be affected at and downstream of the major abstraction points.

Bryntail identified significant flow impact; although the EFI (derived from natural flow) was not failed the local habitat and ecosystems would have adapted to rely on this residual flow. As Clywedog reaches dead water the 18.2 Ml/d compensation flow requirement can no longer be made between 27 September and 1 November, a total of 35 days. The model did not show flows drying up entirely at Bryntail, however in reality this is likely to occur immediately downstream of the dam under such a severe drought (i.e. little/no baseflow expected). It was unclear where flows would begin to buffer from tributary inputs, but with such a severe drought affecting the whole catchment it could be some distance downstream before significant flow returned.

Another consideration at Bryntail and downstream is the longer term effect on flow variation. Under ‘Do Nothing’, including the 35 days of little/no flow, there was a total of 306 continuous days (almost a full year) when only the compensation flow was released. The minimum compensation flow occurred because the reservoir would be intercepting all upstream runoff to refill, a vital process to prepare for the year ahead. The model showed September right through to the following July as being affected, in reality this period will vary according to how much and how quickly recharge is received.

From Bewdley, it can be expected the whole River Severn downstream would be affected to varying degrees by the natural drought event. As a result of the regulation system failing, flows were shown to fall approximately 500 Ml/d over 2 days. Flows crashed between 12 and 14 October, with depressions lasting between 19 and 22 days before natural recharge was modelled in early November. Bewdley predicted a daily minimum flow of 336 Ml/d, 182 Ml/d lower than ever recorded, Saxons Lode predicted a daily minimum 399 Ml/d, 316 Ml/d below existing records and Deerhurst predicted a daily minimum 577 Ml/d, 398 Ml/d below existing records.

The minimum daily flow prediction at U/S Sharpness was 609 Ml/d and 382 Ml/d at Lower Parting, downstream of the Gloucester & Sharpness Canal abstraction. The variability of abstraction quantities and limited data make it difficult to assess whether flows could be reduced significantly further still. The lower section of the River Severn, around Lower Parting, was shown to be most at risk to likely significant effects from an Acute drought magnitude.

In reality, it is unclear what the minimum flows would be if the regulation system did fail. Aquator (version 3) has known problems with naturalised flows, and discharges are currently built into the background flows and cannot be altered. Therefore exact flow predictions need to be assessed with caution. However, the flow response is the important result for future planning. Should Llyn Clywedog fail, the remaining regulation support is short term and unlikely to cope. Minimum flows will depend on climatic conditions and abstraction demands at the time of failure, but the River Severn flows can be expected to rapidly decline to baseflow rates until rainfall returns.

The degree of adverse impact resulting from significant flow impacts will depend on the duration of the event and demand management at the time. It is important to note that whilst satisfactory naturalised flows could not be extracted from Aquator at this time, once the flows crash they are effectively representing the baseflow expected in the absence of regulation support, flows maintained above this level are therefore in the best interest of supporting the environment.

5.2.3.3. Drought Order Only (River Severn Drought Order)

An annual total of 166 regulation days and 64,557 Ml combined releases were modelled during the Acute River Severn Drought Order scenario, with 153 days of continuous regulation; Clywedog provided 63% (40748 Ml), SGS 27% (17708 Ml) and Lake Vyrnwy 9% (6102 Ml) of the total resource.

Operating the River Severn Drought Order under the Acute condition caused the regulation system to begin failing 2-3 days earlier than the 'Do Nothing' scenario. The drought order lowered the prescribed flow at Bewdley from 850 Ml/d to 730 Ml/d (over a 5 day mean), which only reduced regulation pressure on Llyn Clywedog by 120 Ml/d. Capping the releases at Clywedog at 300 Ml/d is necessary but created a regulation deficit to achieve 730 Ml/d at Bewdley, which Vyrnwy water bank and SGS supplemented earlier than under the 'Do Nothing' scenario. The available resource remained the same so inevitably the regulation system began to fail slightly earlier as a result of Clywedog's reduced contribution.

The River Severn Drought Order prevented Clywedog from reaching dead water, which had various benefits to the whole Severn catchment. Avoiding dead water enabled the 18.2 Ml/d compensation flow to Bryntail to be made throughout, preventing 35 days of little/no flows for this section of watercourse. Due to the 11% storage saving, Clywedog refilled faster over the winter (exceeds 90% in April 1977) and therefore flow variation was returned in mid June, 49 days earlier than under 'Do Nothing

Downstream, flows were reduced for between 45-48 days before the obvious flow benefits were observed. During this period, flows were reduced from 'Do Nothing' by 139-142 Ml/d, equating to 13-15% flow reductions. Bryntail showed a significant improvement as discussed. Vyrnwy showed no change and Buildwas continued to show no significant flow impacts against the EFI. At Bewdley, no significant deterioration in flows beyond the unavoidable drought impacts were observed. Both Saxons Lode and Deerhurst showed the initial flow reductions caused a small increase in the duration of Medium Risk EFI failure, related to the 140 Ml/d reduction in flows. At Lower Parting the EFI failure was assessed as High Risk and more prolonged than upstream, however operating the Severn 'Drought Order Only' created a minor increase in duration of this failure. It is difficult to assess whether the initial flow reductions (prior to any regulation failure) would be significant to the environment, and needs to be balanced against the subsequent flow gains it achieved.

Once the regulation system began to fail, the River Severn Drought Order showed clear benefits. Protecting the storage in Llyn Clywedog over the previous 45-48 days enabled small but continuous releases between 91-63 Ml/d (reduced per day according to remaining storage) to be made throughout the critical flow depression period. Under 'Do Nothing' only small SGS releases were possible at this point. The regulation support Llyn Clywedog continued to provide was short term, but the Acute condition increased minimum flows by 72-75 Ml, and produced an average flow gain of 89-90 Ml/d.

Modelling supported the aim of the River Severn Drought Order. By operating the drought order and regulating to a lower flow target at Bewdley, Llyn Clywedog avoided reaching dead water and compensation flows at Bryntail were protected. The drought order did not prevent regulation system failure from occurring when the drought persisted, but did enable Clywedog to continue providing regulation support at a reduced rate throughout the Acute drought. Subsequently higher flows were maintained during the worst period of the drought. Longer term, the River Severn Drought Order enabled the reservoir to refill faster, reducing the impacts on flow variation in the upper catchment and preparing the system for a subsequent drought/regulation season.

5.2.4. Impact on Water Levels; Acute Drought Condition

The impact of modelled flow reductions was investigated by using rating curves to convert the flow data into water levels. Rating curves identify the relationship between water level and flow; this requires continuous monitoring to establish a reliable equation. The assessment point at Lower Parting did not have a rating curve or enough recent gauged data to produce one for this investigation; it has therefore been flagged for the appropriate future monitoring.

In context to Severn regulation, a reduction of flow at Bewdley from 850 Ml/d to 730 Ml/d would reduce the water level from 6.81 meters to 6.36 meters. This 0.45m reduction represents a 7% change in total water level for this specific location. How it would impact the whole River Severn will depend on the channel dimensions and morphology at each location.

To investigate the modelled drought conditions, Q95, Q99 and Q99.9 flows (low to drought flows only) were compared against the 'Do Nothing' baseline scenario to identify the impact. Table 10 summarises the results and provides the naturalised and gauged water levels for comparison. Green boxes show where no change against the 'Do Nothing' baseline was identified, yellow boxes identified a reduction in levels and blue boxes an increase in water levels against the baseline.

The results showed the River Severn Drought Order was of benefit to water levels during the extreme low flow period.

In the upper catchment, at the Clywedog and Vyrnwy assessment points, the drought order either made no difference to water levels or increased them, reflecting how the drought order would enable the compensation flows to continue throughout a severe drought.

At the remaining four assessment points the water level at the equivalent Q95 flow was found to be lowest when operating the River Severn Drought Order. The decrease ranged from 0.93 meters at Buildwas to 0.12 meters at Deerhurst. The range of impact reflects the difference in channel dimensions that can be expected along a river of this size. At Buildwas the river channel becomes narrow and deep as it travels through the Ironbridge Gorge, comparing the water levels against the expected natural suggests even with the drought order in operation water levels could be 1.41 meters higher than naturally expected. However at Deerhurst, where the channel is much wider, a smaller impact on water levels was identified.

Looking at water levels at the equivalent Q99 and Q99.9 flows highlighted how the River Severn Drought Order would provide the benefit from prolonging Severn regulation releases during the extreme period of drought. Water levels were increased by between 0.12 meters at Deerhurst to 0.68 meters at Saxons Lode, Bewdley and Buildwas. . With the exception of Deerhurst, the benefit was often around 0.1 meters less, identifying the extra pressure that could result from the water companies operating their drought orders at the same time.

Table 10: Summary of Water Level data under the Acute scenario

	Acute Do Nothing (meters)	Acute EA DO in isolation (meters)	EA Naturalised 1990-2008 (meters)	Gauging Station observed 1990-2008 (meters)
Bryntail				
Q95	0.87	0.87	0.88	0.87
Q99	0.63	0.87 (+0.24)	0	0.86
Q99.9	0.61	0.87 (+0.26)	0	-
Vyrnwy Weir				
Q95	0.94	0.94	1.02	0.95
Q99	0.94	0.94	0	0.92
Q99.9	0.94	0.94	0	-
Buildwas				
Q95	10.70	9.77 (-0.93)	8.36	10.44
Q99	6.84	7.52 (+0.68)	6.63	9.66
Q99.9	6.51	7.13 (+0.62)	6.63	-
Bewdley				
Q95	6.98	6.48 (+0.50)	7.08	6.91
Q99	4.31	4.99 (+0.68)	6.29	6.59
Q99.9	3.97	4.60 (+0.63)	4.99	-
Saxons Lode				
Q95	8.86	7.94 (-0.92)	11.58	11.43
Q99	5.09	5.77 (+0.68)	10.13	10.37
Q99.9	4.76	5.37 (+0.61)	5.85	-
Deerhurst				
Q95	5.96	5.84 (-0.12)	6.45	6.37
Q99	5.31	5.45 (+0.14)	6.07	6.16
Q99.9	5.23	5.37 (+0.14)	5.48	-

Water level changes could not be assessed at this time for Lower Parting. The river is generally wide in the lower sections, which would buffer smaller changes in flow. However the channel split at Gloucester and the amount of abstraction for the Gloucester & Sharpness Canal would also vary the impact in the lower tidal Severn.

To improve this analysis cross section survey work is needed to enable water levels and flows to be related to wetted perimeter and habitat characteristics. This will support a more detailed ecological assessment of water and flow changes in the future.

5.2.5. Impact on Flows; Chronic Drought Condition

The previous Acute drought condition attempted to model a prolonged one season drought, identifying the risk that significant rainfall could arrive earlier than modelled and prevent the flow benefits occurring. This raised the question of “what value would the River Severn Drought Order be if rainfall returned before regulation failure was reached? The Chronic condition was built to investigate this question. By introducing rainfall earlier in the existing Acute condition the flow benefits were removed in the first dry summer, the dry period was then extended over the critical winter recharge season to produce a more long term drought.

Only the summary and conclusions are presented in this section, for the complete Hydrological assessment refer to Appendix D (Appendix F.1 to F.5 contain the supporting hydrographs, flow duration curves and a breakdown of the key regulation volumes and critical dates for the Chronic drought condition testing). It is important to emphasise the drought order scenarios being assessed are theoretical worse case situations. They were developed to assess the likely flow trends and identify the potential periods of drought order operation.

Figure 10 presents data from the Lower Parting assessment point, which includes the cumulative impacts of all abstractions, plans and other drought permits/orders. The main focus of interpretation and graphing is the modelled 1977 year, the impacts and flow behaviour for the Chronic 1976 drought were very similar to the Acute drought condition, but with shorter duration low flow periods and no flow benefits being observed (to simulate the return of significant rainfall). Once again, the hydrograph demonstrates the overall flow trend observed along the majority of the River Severn, illustrating the initial flow depletion as the drought order is activated (compared to the 'Do Nothing' baseline), followed by a higher maintained flow than would be possible without the drought order. More crucially with the Chronic drought condition testing, by saving water from the previous year's drought order activation, flow could be maintained significantly higher during the chronic drought summer than if no drought order had been activated.

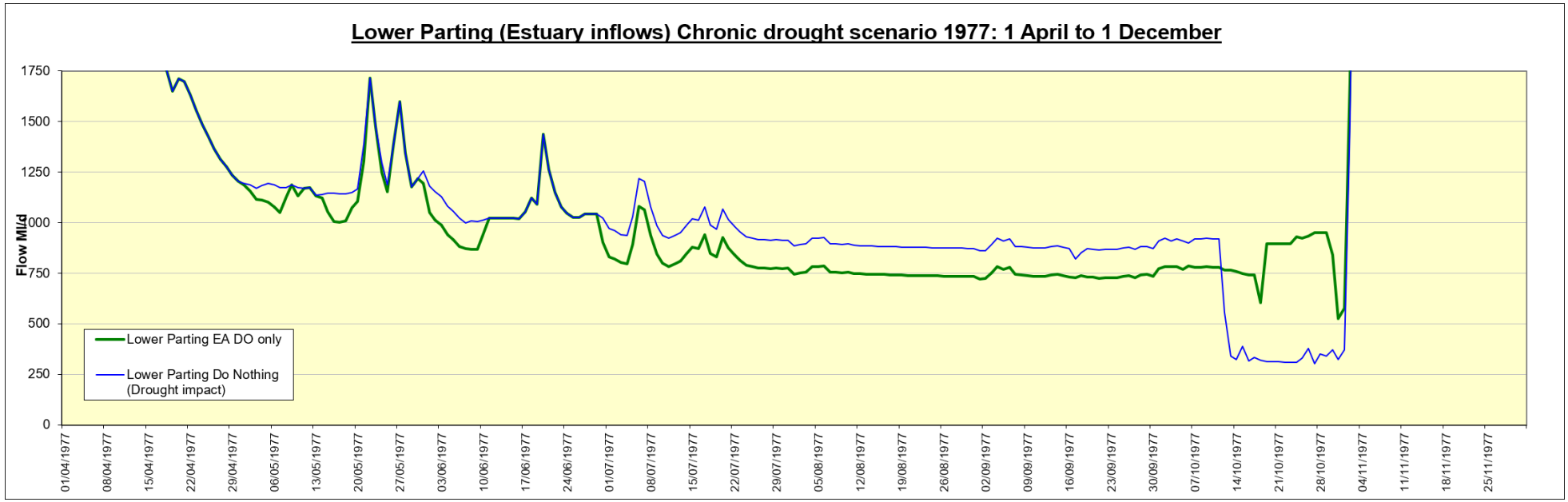

Figure 10: Lower Parting (Estuary inflows) Chronic Drought scenario 1977; 1 April to 1 December

Figure 10 *shows all the modelled impacts on flows at Lower parting, downstream of all the regulation inputs (Clywedog, Vyrnwy and SGS) and major abstractions, including the Gloucester & Sharpness Canal abstraction. The graph highlights the specific period of interest, when the Environment Agency drought order was modelled as being active.*

Within the Chronic modelling there were anomalies relating to when the Severn Drought Order was activated by Aquator, the results were therefore analysed in terms of general flow behaviour and trends, using judgement to suggest how the results might have differed if the drought order were operated more realistically. The 'Do Nothing' baseline was unaffected by this issue, as no drought orders or permits were operated. EFI testing was conducted but not analysed in detail as the duration of low flows under the Severn Drought Order operation were incorrect due to the modelling anomaly.

Table 11 contains some flow values for comparison, the drought scenario Q30 values need to be viewed with additional caution due to the short (3 year) record of data used.

Table 11: Summary of Modelled Chronic Flow percentiles

Flow value	Acute Do Nothing Ml/d	Acute EA DO in isolation Ml/d	Current flow Ml/d (G=Gauged, M=modelled*)	Naturalised flow Ml/d (D=decomposition, M=modelled*)
	(1975-1977)	(1975-1977)	(1990-2007)	(1990-2007)
Bryntail				
Q30*	174	175	176 G	216 D
Q95	18	18	18 G	19 D
Q99	10	18	18 G	-6 D
Q99.9	9	18	-	-59 D
Vyrnwy Weir				
Q30*	45	45	131 G	426 D
Q95	25	25	25 G	30 D
Q99	20	25	24 G	-3 D
Q99.9	18	18	-	-228 D
Buildwas				
Q30*	3345	3345	5511 G	5646 D
Q95	1067	934	1030 G	741 D
Q99	471	910	919 G	527 D
Q99.9	459	691	-	527 D
Bewdley				
Q30*	3250	3250	5470 G	6211 D
Q95	895	762	881 G	930 D
Q99	304	745	791 G	715 D
Q99.9	289	521	-	458 D
Saxons Lode				
Q30*	3938	3938	7991 G	8523 D
Q95	939	804	1327 G	1350 D
Q99	344	791	1167 G	1131 D
Q99.9	328	551	-	536 D
Deerhurst				
Q30*	4418	4418	9054 G	10079 D
Q95	1108	979	1571 G	1680 D
Q99	520	966	1317 G	1224 D
Q99.9	505	727	-	730 D

Flow value	Acute Do Nothing Ml/d	Acute EA DO in isolation Ml/d	Current flow Ml/d (G=Gauged, M=modelled*)	Naturalised flow Ml/d (D=decomposition, M=modelled*)
	(1975-1977)	(1975-1977)	(1990-2007)	(1990-2007)
U/S Sharpness				
Q30*	1209	1117	-	-
Q95	578	1005	-	-
Q99	547	1000	-	-
Q99.9	532	755	-	-
Lower Parting				
Q30*	983	893	9772 M	10213 M
Q95	370	735	1910 M	2056 M
Q99	319	729	1509 M	1564 M
Q99.9	304	528	1096 M	1123 M

*Modelled drought Q30 values need to be viewed with caution due to the short (3 year) record of data used.
**Modelled data using Low Flows Enterprise, a rainfall runoff model producing flow duration curves for a drainage basin (not time series data).*
Negative values within the calculated naturalised dataset are known errors associated with data quality.

5.2.5.1. Summary

The Chronic drought scenario represented a dry summer and winter (1975) preceding a drought summer (1976), which triggered a River Severn Drought Order implementation but significant rainfall returned before true flow benefits were achieved. A second drought summer followed (1977). The main focus of the Chronic scenario is the second drought year (1977), and what impact applying a River Severn Drought Order in the first year without achieving flow benefits could have on a consecutive drought year.

The greatest uncertainty remains around the Gloucester & Sharpness Canal abstraction and its impact on the lower River Severn during a severe drought. The River Severn splits between U/S Sharpness and Lower Parting, with monitoring (between 1977-2007) indicating approximately 40% of flow goes down the East channel and 60% down the West channel. Low flows occurring due to the drought would become further divided (as the channel split) and flow velocity decreased encouraging siltation and saline intrusion. The degree of flow loss and subsequent impacts is unclear without more data/monitoring, however this stretch of the River Severn could potentially be at high risk during a severe drought and likely significant effects have been concluded as a precautionary measure.

5.2.5.2. Do Nothing (Baseline)

The Chronic scenario once again proved the importance of Llyn Clywedog as the primary source of Severn regulation water. Modelling showed that if Clywedog became exhausted, Lake Vyrnwy water bank could only offer a short term replacement for the large volumes of regulation water required. The SGS did not have enough capacity to replace the reservoir volumes. It also appears likely during such a drought, that Lake Vyrnwy storage would also become critically low and could pose another resource issue that would need careful management with the appropriate water company. The key message is that if Llyn Clywedog becomes exhausted the whole regulation system is likely to fail. Forward planning is needed during any event, considering the impact on the subsequent year if resources are drawn down too low.

The modelled 1976 drought event did not appear to have any significant flow impacts under 'Do Nothing', owing to the continued high releases made as part of normal regulation. This outcome would be unpredictable, if rainfall had not arrived, events would have followed the Acute condition, however on this occasion recharge was received and therefore no adverse flow impacts were observed along the Severn corridor. Significant flow impacts were observed during the modelled 1977 drought ('Do Nothing') at Bryntail, Bewdley, Saxons Lode and Deerhurst, the same locations identified in the Acute condition.

Bryntail was potentially at high risk of significant flow impact, as the 18.2 Ml/d compensation flow failed for 42 days between 18 September and 10 October. Modelling indicated a minimum flow of 9 Ml/d, however with no releases being made from the reservoir, the area immediately downstream of the dam is likely to become dry, extending downstream until significant natural baseflow returned.

During the modelled 1977 Vyrnwy Weir showed over 20 days (7 to 26 October) of irregular compensation flow failures, all below the minimum 25 Ml/d compensation flow. A minimum 17.46 Ml/d occurred on 25 October. It's unclear whether this is modelling error, although storage was at 14% and 7 continuous days recorded compensation flow failure.

From Bewdley, it can be expected the whole River Severn downstream would be affected to varying degrees by the naturally developing drought. If the regulation system failed, flows were found to fall up to 600 Ml over 2 days. Flows crashed between 8 and 11 October 1977, with depressions lasting between 21 and 24 days before natural recharge occurred in early November. Bewdley predicted a minimum flow of 289 Ml/d, 229 Ml/d lower than ever recorded, Saxons Lode predicted a minimum 323 Ml/d, 392 Ml/d below existing records and Deerhurst predicted a minimum 499 Ml/d, 476 Ml/d below existing records. Greater uncertainty surrounded the lower River Severn as discussed; assuming a maximum 300 Ml/d abstraction to the Gloucester & Sharpness Canal, a minimum daily flow of 532 Ml/d at U/S Sharpness and 304 Ml/d at Lower Parting was modelled. The magnitude of predicted flow impact is certainly significant; the degree of adverse impact would depend on the duration of the event and sensitivity of the environment.

In reality, it is not possible to exactly predict what the minimum flows would be if the regulation system did fail and they should be viewed as advisory only. All drought events are unique with varying prevailing conditions and abstraction demands creating different responses to the same rainfall patterns. However, the flow behaviour is the important result for drought planning. Should Llyn Clywedog fail, the remaining regulation support is only short term. Once the regulation system goes into failure, minimum flows can be expected to rapidly decline to baseflow rates until rainfall returns, highlighting the need to operate the River Severn Drought Order.

5.2.5.3. Drought Order Only (River Severn Drought Order)

The modelled 1976 drought event and River Severn Drought Order operation appeared reliable and results could be used with reasonable confidence. Flow impacts for the modelled 1976 portion of the event were concluded to be the same as the Acute condition, but without the immediate flow gain being achieved.

During 1977 the model activated the River Severn Drought Order on and off on three different occasions, 24 February – 4 June, 24 June to 12 October and 24 October – 1 February, all which reduced the prescribed flow at Bewdley to the 730 Ml/d. The first two activations appeared to be false, as Clywedog storage was at 84% on both occasions, whilst the Drought Order in force curve would be crossed at 40%. The third activation on 24 October, although slightly late, was an accurate response to Llyn Clywedog storage.

It is unclear what the Aquator model was responding to on the false occasions. The system is complex and Aquator (version 3) was not designed to isolate the River Severn Drought Order for

testing. A number of other triggers and linkages to system failures elsewhere could have caused these false activations.

As a result the 1977 flow results had to be assessed subjectively, making informed assumptions about how differently the flows would have responded if the River Severn Drought Order had only been activated on one occasion, likely during October. It is more likely the 'Do Nothing' flows would be matched for longer leading into the critical flow period, drawing Llyn Clywedog storage down earlier in the regulation season as a result. Flows would then be lowered to maintain the Bewdley drought flow target (730 Ml/d 5 day mean) as modelled, continuing at this flow beyond the 'Do Nothing' flow crash (as modelled). The high flows in mid October would be removed, instead maintaining the drought order prescribed flow. If the drought continued the regulation system would still inevitably fail, potentially sooner and to lower flows than currently modelled as less regulation water would be available due to higher flow maintenance earlier in the season (removing the false drought order activations).

Although the results could not be analysed in great detail owing to the modelling anomaly, the flow behaviour and trends were still valuable. By activating the River Severn Drought Order in 1976, although no flow benefits were immediately achieved 16% storage was saved at Clywedog. This enabled the reservoir to reach 96% capacity before regulation began in 1977, translating to longer regulation at 730 Ml/d (5 day mean) after the 'Do Nothing' model showed system failure and flow crashes. Modelling also suggested a greater protection of the minimum flows during any subsequent regulation failure, as Llyn Clywedog and SGS continued to have more resources than under 'Do Nothing'.

With the exception of Bryntail, where compensation flows were protected with obvious benefits, significant flow impacts were difficult to conclude with certainty for 1977, due to the modelling issues. A precautionary approach was adopted, assuming a very similar impact as assessed under the Acute condition due to the reduced flows leading into the critical drought period (which are likely to be of similar duration), but with a greater flow benefit being achieved as the drought developed. Significant flow impacts were concluded at Saxons Lode, Deerhurst and the lower River Severn (U/S Sharpness and Lower Parting).

Vyrnwy Weir response was similar to the 'Do Nothing' model. The number of days when irregular compensation failure occurred was reduced, spread over 15 days (12 to 26 October). A minimum 17.46 Ml/d occurred on 25 October. Storage again reached 14% and flows failed on 7 consecutive days.

Modelling supports the aim of the River Severn Drought Order, and demonstrated the long term benefits its operation can create in a subsequent drought year. By operating the drought order in 1976, no flow benefits were immediately observed, but the reservoir storage saved was carried over into the subsequent regulation season (1977). This more long term saving was translated into preventing regulation system failure for longer than under 'Do Nothing' (opposite to Acute scenario), and potentially maintaining higher minimum flows during any subsequent regulation system failure, if the drought were to continue.

5.2.6. Impact on Water Levels; Chronic Drought Scenario

To investigate the modelled drought conditions, Q95, Q99 and Q99.9 flows (low to drought flows only) were compared against the 'Do Nothing' baseline scenario to identify the impact. Table 12 summarises the results and provides the naturalised and gauged water levels for comparison. Green boxes show where no change against the Do Nothing baseline was identified, yellow boxes identified a reduction in levels and blue boxes an increase in water levels against the baseline.

Similar trends were identified for the Chronic Condition as with the Acute Condition modelling, although more benefits were identified. As with the Acute modelling, the Chronic results showed the River Severn Drought Order was of benefit to water levels during the extreme low flow period.

More benefits were identified in the upper catchment, at the Clywedog and Vyrnwy assessment points. At the Q95 flow, water levels remained the same as the 'Do Nothing' scenario. However, at Clywedog in particular, operating the River Severn Drought Order increased water levels by up to 0.24 meters. This reflects how the drought order protects Llyn Clywedog storage enough to enable compensation releases to continue throughout the drought period, and for longer under the Chronic Condition as the event is extended.

At the remaining 4 assessment points the water level at the equivalent Q95 flow was found to be lower under the River Severn Drought Order scenarios than the 'Do Nothing'. The decrease ranged from 0.94 meters at Buildwas to 0.14 meters at Deerhurst, very similar to the Acute Condition modelling.

Table 12: Summary of Water Level data under the Chronic scenario

Flow value	Chronic Do Nothing (meters)	Chronic EA Drought Order only (meters)	EA Naturalised 1990-2008 (meters)	Gauging Station observed 1990-2008 (meters)
Bryntail				
Q95	0.87	0.87	0.88	0.87
Q99	0.66	0.87 (+0.21)	0	0.86
Q99.9	0.63	0.87 (+0.24)	0	-
Vyrnwy Weir				
Q95	0.94	0.94	1.02	0.95
Q99	0.85	0.94 (+0.09)	0	0.92
Q99.9	0.81	0.81	0	-
Buildwas				
Q95	10.69	9.77 (-0.92)	8.36	10.44
Q99	6.14	9.60 (+3.46)	6.63	9.66
Q99.9	6.04	7.97 (+1.93)	6.63	-
Bewdley				
Q95	6.96	6.48 (-0.48)	7.08	6.91
Q99	3.68	6.42 (2.74)	6.29	6.59
Q99.9	3.55	5.41 (+1.86)	4.99	-
Saxon's Lode				
Q95	8.86	7.94 (-0.92)	11.58	11.43
Q99	5.09	5.77 (+0.68)	10.13	10.37
Q99.9	4.76	5.37 (+0.61)	5.85	-
Deerhurst				
Q95	5.96	5.82 (-0.14)	6.45	6.37
Q99	5.12	5.80 (0.68)	6.07	6.16
Q99.9	5.09	5.48 (0.39)	5.48	-

As with the Acute modelling, water levels at the equivalent Q99 and Q99.9 flows highlighted how the River Severn Drought Order would provide benefit during the extreme period of drought. Results for the Chronic Condition showed greater overall benefits to water levels at Buildwas, Bewdley and Deerhurst than found under the Acute modelling. Water levels were increased by between 0.39 meters at Deerhurst and 3.46 meters at Buildwas.

Water level changes could not be investigated at the Lower Parting assessment point because there was not enough data to produce a rating curve. This requirement has been flagged in the monitoring programme and future work section, along with the need for cross section surveys and detailed investigation into the impacts on wetted perimeter and habitat characteristics.

5.2.7. Hydrology Conclusion

It is important to acknowledge the River Severn is a large and artificial system with respect to hydrology. Models are very important but cannot fully replicate reality; all results need to be considered with this in mind. The Aquator model is the best available tool we have at this time, but was not specifically designed to predict drought flows and demands. Deliberate error was built into the model to account for weather forecast and lag time difficulties encountered in real life, but how the Environment Agency operates the different regulation sources is likely to differ during a real event. The results are an indication of the potential worse case scenarios and help us identify important trends and problems to inform better drought management, they cannot provide the exact flows or timings that will be encountered.

It also needs to be understood the drought magnitudes created have not yet occurred (i.e. not on record), so all results and impacts are theoretical. Every drought event will be unique and produce different challenges. In particular, the exact timing and severity of a drought cannot be guaranteed.

The 'Do Nothing' models represent what could occur during droughts of these magnitudes, and all impacts have been assessed against improvements or deteriorations from this baseline. It needs to be remembered that droughts are natural events, and cannot be prevented only managed. 'Do Nothing' is considered to represent what would occur if no drought management action was taken to protect water supplies or the environment.

Modelling has helped illustrate how robust the Severn regulation system is today, modelling pushed the system into very rare drought magnitudes in order to trigger the need for the Severn Drought Order. In reality, having three separate sources allows Clywedog to be rested early in the season if there is deemed to be a high regulation risk and the catchment is more likely to experience dry/drought conditions. All the actions available to the Environment Agency allow time to be 'brought' to prolong the resource available from Clywedog whilst recharge is awaited, lowering the probability of needing to utilise the drought order at present.

Real drought events have shown how the antecedent conditions at the commencement of the regulation season are the critical facture in whether a Drought Order will be required if dry weather persists. For the West Midlands Area, historic droughts have shown that two subsequent dry years are critical in reducing groundwater levels and therefore baseflows to rivers in the second year. Natural baseflow in the catchment is the primary driver for how much regulation support will be required in the absence of rainfall; low/below average baseflow will result in high regulation releases being required to supplement the deficit. Consistent releases of over 400 Ml/d can cause Clywedog to cross the RSDO in a single season if dry weather persists, as shown by modelling and the 1976 drought event. In order for baseflow to have naturally receded to significantly low levels, a long term shortage of rainfall (i.e. drought event) needs to have occurred, likely to be of magnitude greater than a 1 in 20 year over more than 6 months for the whole River Severn catchment scale.

Once Clywedog is releasing large volumes in the absence of recharge, it is clear from real events (e.g. 1976) and modelling, that storage depletes quickly. Approximately 1% is lost per day when 500 Ml/d is released, which supports the original design and 100 day rule applied to Clywedog operation. With appropriate management, which could include a drought order under rare circumstances, Clywedog is likely to avoid dead water during a one season drought and maintain some level of regulation support. The recharge season immediately following a drought/high regulation season will be critical in determining how it performs if a second drought year follows. If the drought order was operated during the first drought year and sufficient recharge is received, the water saved in Llyn Clywedog could be critical in providing significant flow improvements above the drought baseline in the subsequent drought event, demonstrated by the Chronic scenario modelling.

Modelling has shown that with prolonged droughts and insufficient recharge, the regulation system could fail (i.e. individual licences/sources begin to run out of water) even with the Severn Drought Order in operation. Depending on remaining storage in Lake Vyrnwy water bank and the SGS, modelling suggests activating the Severn Drought Order could cause regulation system failure at the same time/earlier than if no action were taken (shown by Acute scenario), as pressure is diverted to the alternative sources earlier. However, even when this occurs and the Bewdley prescribed flow of 730 Ml/d (5 day mean) is failed, the water saved in Clywedog storage then enables a higher residual flow to be maintained than if the Severn Drought Order had not been activated.

Modelling has also identified the Severn Drought Order could be operated during a drought, without flow benefits being immediately achieved (refer to the Chronic scenario). The environmental cost would be to have created additional flow stress during an already stressed period. The Environment Agency acknowledges this is a risk that would always need to be assessed against long term weather forecasts, carefully balanced against the potential flow damage not operating the Severn Drought Order could allow to happen.

Modelling the Chronic scenario has helped to demonstrate that if the Severn Drought Order is operated during an event when recharge occurred before flow benefits were achieved, the resources saved one year could be critical in safeguarding against a consecutive drought or high regulation season the following year. Therefore, even though short term savings may not be translated into immediate flow benefits, the Severn Drought Order could have an important long term role and potentially be more beneficial in long term droughts than shorter acute events. Modelling suggested the storage savings made during the first Severn Drought Order year, could prevent or significantly delay regulation failure in the following drought.

Both the Acute and Chronic modelling identified a lack of conceptualisation and data around the Gloucester & Sharpness Canal abstraction and the relationship with Bristol Water abstraction from the canal. A maximum abstraction of 300 Ml/d based on recent actual data was manually applied to the Aquator model. The situation is further complicated by the channel bifurcation through Gloucester dividing flows approximately 60:40, with the canal abstraction taking from the smaller East channel.

Real drought events (e.g. 1976) identify regulation beginning from April to early June, but reservoir storage and/or flows are not considered at significant risk until mid July onwards, when formal drought order applications were made. Variations of the Severn Drought Order typically came into force in early August through into September. Modelling identified that with the additional regulation resources now available, this risk is likely to be delayed towards the end of August/early September, although abstraction demand is an important factor.

The Severn Drought Order will reduce Severn corridor flows for a given period, but even under the rare drought magnitudes modelled, it prevents complete regulation failure at Clywedog. Ultimately the water saved early on enables the minimum flows to be increased along the whole Severn catchment when the regulation system goes into unavoidable failure as the drought continues. This reduces the severity of drought stress on flows during the most critical period. Importantly, the reduction in flow caused by the drought order prior to the obvious benefits, does not lower flows below the modelled baseflow (baseflows shown after regulation failure in ‘Do Nothing’ scenario), and is therefore still maintaining an artificially elevated flow (above natural) benefit along the River Severn.

Forward planning is needed during any event, considering the impact on the subsequent year if resources are drawn down too low.

5.2.8. Limitations and Assumptions

The River Severn is the longest river in Great Britain, has the second largest tidal range in the world, and involves numerous complex abstractions and discharges as well as artificial flow regulation. Modelling the flow response of such a complex catchment made up of so many variables is very difficult with high confidence. This investigation can only provide a snapshot of potential impacts at a limited number of locations due to the scale of catchment being considered, it is acknowledged that local variation could be significant.

Modelling can only provide a somewhat black and white interpretation of a set of events. The reality is all drought events are unique and how we respond operationally will be different to a model, according to what information and confidence we have in forecasts at the time. The flow modelling should only be used as a guide for some possible worse case drought events to highlight the risks and help the Environment Agency better plan for drought and water resource management.

Droughts of these magnitudes have never occurred within our records of flows and rainfall, therefore cannot be calibrated with accuracy. Historic droughts and previous operation of the River Severn Drought Order does provide an initial baseline, but it must be acknowledged that water resource management and demand has changed since these events and the severity and length of these actual events has been increased. The results should be used as a guide to identify potential trends and highlight monitoring needs and potential remediation; however they cannot be used as a definitive prediction of how flows will behave.

Historic data are varied and flow records in particular rarely go back as far as the 1975-1976 event, particularly in the lower River Severn. Monitoring and methodologies have also changed since records began, making it very difficult to accurately compare datasets without accumulating further errors and uncertainty.

Aquator can model Severn regulation rigidly to meet the basic prescribed flow criteria at Bewdley, but in reality forecasts and travel times do not allow for such high accuracy. Parameters within Aquator were adjusted to build in some natural error, but sudden changes in releases from all regulation sources are still evident, but unlikely to occur in reality. The SGS in particular, is modelled to on off operate, where as in reality the resource requires preparation and then would be utilised as continuously as possible, stepping other resources back where needed, in order to increase operational efficiency and staff resources. These variations need to be acknowledged and understood when using the modelling results.

Flows from effluent returns is significantly different between Aquator and the water quality model SIMCAT (details in Appendix I) and needs to be investigated further to determine which model/method should be utilised for drought management and prediction in the future. Modelling identified that Aquator's minimum flows were significantly lower (approximately half) in the lower River Severn/Severn Estuary inflows than SIMCAT could replicate. Further investigation identified that even if all natural runoff were switched off within SIMCAT, effluent alone would maintain flows significantly higher than Aquator was predicting. The greatest uncertainty was around the Severn Estuary inflows, and the worse case flows from Aquator were adopted in accordance with Habitats Regulations.

Modelling and interpretation clearly identified gaps in baseline drought data and a true understanding between how changes in flows would impact ecological flow and habitat availability on the ground. Best available methods were adopted, but expert opinion had to be adopted regularly in the absence of clear flow targets and models to predict ecological impacts based on flow reductions for a regulated river.

In an attempt to provide an indication of possible impacts EFIs were used to provide a rough indication of significance. Risk bands were calculated by subtracting 10% per band from the original EFI. Although the EFI methodology is widely used, the modelled drought scenarios only included three years of flow data from which to calculate flow duration curves. This produces a low flow biased FDC, skewing flows lower where as a longer period would have incorporated more

higher range flows, likely reducing EFI failures. This limitation was taken into account when assessing the results where possible, but will have added to the uncertainty around concluding significant flow impacts on ecology.

Overall the highest uncertainty in flow data surrounds the lower tidal River Severn and Severn Estuary inflows, also the highest environmental risk area. A lack of continuous monitoring and the tidal influences makes it very difficult to determine what the full impacts could be.

5.3. Assessment of Impact on the Current Environment: Other Abstractors

Operation of the River Severn Drought Order would have a direct impact on the amount of water within the River Severn, and could therefore affect surface water abstractions. This section summarises the impacts on the main groups of abstractors (as defined in section 5.1.5) that could be impacted.

5.3.1. Water Companies

There is a genuine risk of conflicting interests between some of the water companies Drought Permits and the Environment Agency's Drought Order. A number of proposed Drought Permits/Orders that could impact upon the River Severn are identified within STWL's and SSW's Drought Plans. These permits seek to increase abstraction or decrease compensation releases along the River Severn and/or its tributaries. The River Severn Drought Order aims to reduce water company abstractions from the River Severn by 5% (with additional requests for reductions up to 20% if emergency storage is reached), to reduce pressure on the system whilst prescribed flows are reduced. These two primary objectives conflict, with STWL, SSW and Bristol Water needing to put more strain on the River Severn and the Environment Agency attempting to mitigate the impacts of drought conditions.

The Environment Agency recognises that in extreme drought situations priority has to be given to ensuring that essential public water supplies can be met, whilst working together with water companies to minimise the effects of any resulting environmental damage. It is however important to note how the River Severn Drought Order does seek to prolong water for the benefit of water supply, therefore STWL's and SSW's drought permits/orders could be counterproductive. In the event of conflict, water companies would apply directly to the Secretary of State or Welsh Assembly Government for a drought order on the grounds of Imperative Reasons of Overriding Public Interest (IROPI).

The Environment Agency and water companies will meet to discuss the potential conflicting nature of these permissions at an early stage during a drought. This will be important to ensure proper management of water resources on the River Severn during a drought and that all parties make appropriate, timely decisions. A meeting with key partners will be triggered when Severn Trent Water crosses its 'drought action trigger' curve at Elan Valley or the Llyn Clywedog reservoir 'alert' curve is crossed, whichever the sooner.

5.3.1.1. Potential impacts from the River Severn Drought Order

To provide an indication of potential impact regardless of whether the water companies applied and operated their own drought permits/orders, the assumption of a minimum 5% abstraction reduction was adopted for River Severn Drought Order assessment purposes. Due to the modelling parameters within Aquator, the generic period of the River Severn Drought Order operation was used and optional flexibility has been considered in the discussion below.

The first consideration for water companies would be the 100 day regulation. This is not specifically related to the River Severn Drought Order and implications are outside the scope of this environmental assessment. However, it is important to note that the 100 day regulation restrictions would either already be in force, or likely to come into force soon after the River Severn Drought Order came into force. This is simply due to the nature of drought; for the River Severn Drought Order to be needed, high regulation demand would already be present on the River Severn, drawing Llyn Clywedog storage down. It is expected that the 100 day restriction would come into force before the River Severn Drought Order was activated, but a drought order application could be made prior to the 100 day restriction.

For context, the Aquator Acute condition modelling produced 166 regulation days in total (basing a regulation day as releases from any of the 3 sources, Llyn Clywedog, Lake Vyrnwy water bank and/or the SGS), with 100 days regulation reached on 26 August for both the 'Do Nothing' and 'Drought Order Only' scenarios. In reality the SGS would be operated differently to how it is represented within Aquator (less on off activation and more continuous use), which should mean that in practice the 100 day restriction will occur after the drought order is activated (even though the modelling currently suggests the drought order would be activated 1 day before). Under the Chronic condition, 179 days of regulation were modelled for the 'Do Nothing' scenario, crossing the 100 day restriction on 12 August, whereas the Chronic 'Drought Order Only' scenario modelled 157 days regulation, crossing the 100 day restriction on 3 September.

Direct implications from the River Severn Drought Order relate to the 5% reductions imposed on activation, and the further reductions (up to 20%) that could be sought if storage at Llyn Clywedog crossed the 18% emergency storage curve. A 5% reduction in abstraction is generally considered achievable by most water companies and would not be expected to have a significant impact. Making larger reductions (up to 20%) associated with the emergency storage curve on Llyn Clywedog would be likely to have a significant impact.

There is a degree of flexibility around when restrictions could be relaxed (temporarily) and/or the drought order is fully removed, extensions are also possible within the last 28 days of the agreement. Therefore determining the exact impacts of the River Severn Drought Order from modelling is impractical.

With a worst case interpretation, the River Severn Drought Order can legally remain in force for between 6 months and a full year (if the maximum extension is sought) depending on the ongoing drought conditions. For the Acute condition Aquator operated the River Severn Drought Order for a total of 144 days from 25 August, for which the minimum 5% reduction would apply. The 18% emergency storage curve was crossed for a total 22 days between 15 October to 6 November. The impacts on water companies would alter according to current abstraction demands and whether or not the Environment Agency requested further abstraction reductions. Close discussions would be held with the water companies.

At the Environment Agency’s discretion, flexibility within the River Severn Drought Order consists of the following measures:

- Consider withdrawing drought order application if storage rises above alert curve.
- Consider relaxing drought order conditions once storage rises 10% above enforce curve. *(Note: Drought order powers are in place for six months after date granted. Conditions could be implemented again without another application if storage subsequently drops below enforce curve).*
- Consider relaxing emergency storage drought order once storage rises 5% above emergency storage.

5.3.1.2. Bristol Water abstraction from the Gloucester & Sharpness Canal

Bristol Water's abstraction comes directly from the Gloucester & Sharpness Canal. The licence (18/54/20/138/C) is held by the Canal & River Trust and involves its own restrictions relating to tide

heights and Severn Regulation. Due to its proximity to the Severn Estuary, there is a risk of saline intrusion entering the canal and therefore impacting upon Bristol Water's abstraction. These risks are normally mitigated by the Canal & River Trust's operating agreement rules, all linked to tide heights and flows at Deerhurst. During a drought of the severity modelled under both Acute and Chronic conditions, the risk of saline intrusion up the lower tidal Severn is significantly increased. Therefore the risk of saline water entering the canal and affecting the abstraction is also increased. Reports identified that during the 1976 drought, salinity was reaching critical levels for public water supply. The drought broke before action was needed, but the theoretical droughts modelled for the River Severn Drought Order extend the drought period and suggest potential problems for Bristol Water.

The River Severn Drought Order would reduce flows reaching the lower tidal Severn by approximately 120-140 Ml/d. In isolation these reductions would not be expected to create additional salinity concerns for Bristol Water, however there is a greater potential for flows into the lower tidal Severn to become significantly derogated, with the Canal & River Trust potentially having to close the canal to navigation. Abstractions from the River Severn into the canal to support Bristol Water would be expected to continue, however the saline intrusion could be a concern.

A new abstraction cap of 300 Ml/d will also be imposed on the Canal & River Trust when flows drop below 1200 Ml/d at Deerhurst, and the River Severn Drought Order is active.

The main risk would develop if the drought persisted into regulation failure (which is a potential risk whether the drought order is activated or not), after which flows would suddenly fall to record lows. If regulation failure is ever reached, the River Severn Drought Order would provide a benefit to Bristol Water, as more water remains within the regulation system to provide support for longer. However saline intrusion is far more likely to be a problem after this point, although any impact would not be due to the drought order operation.

5.3.2. Agriculture

Before the River Severn Drought Order is implemented, Section 57 (S57) spray irrigation bans would be considered. This would not be a direct consequence of the drought order itself, though it forms part of the preceding drought management process. Extensive Hands off Flow (HoF) restrictions would already be in force throughout the River Severn catchment (before the drought order is applied), so applying the Section 57 restrictions would be an extension commensurate with the wider seriousness of the developing drought. There would be a direct impact on the agricultural industry from S57 restrictions, mainly on the existing Licences of Right which normally avoid flow related restrictions and may be less prepared.

The River Severn Drought Order would lower flows along the River Severn for a longer period leading into a drought, than if no action were taken. The concern to spray irrigators is the risk of HoFs being triggered for longer periods as a consequence of these lower flows. Theoretically it would only be abstractors with HoFs set below the statutory prescribed flows at Bewdley (and equivalents at other gauges) that could be at risk of additional impact from the drought order. These licences are currently protected from restriction all year round, from normal to drought year (e.g. 1995/6) events, because their HoF triggers were set below the flow we have to maintain along the River Severn. The drought order would allow us to reduce this flow, and potentially trigger the lower HoFs. However, in reality the independent drought management procedure to seek S57 restrictions begins once Llyn Clywedog storage crosses the drought order 'application' curve (because it is a key indicator of drought severity in the Severn basin). This action would precede the River Severn Drought Order, which is not implemented until a second lower trigger curve is crossed at Llyn Clywedog. Therefore the impact on agriculture would result from the S57s and not the implementation of the River Severn Drought Order.

Data from the modelled Acute event (severe summer drought) showed that if the drought order were not implemented, the 'Do Nothing (Baseline)' scenario produced 233 days of potential S57 restrictions from 3 August to 23 March the following year. By operating the drought order, the 'Drought Order Only' scenario produced 206 days of potential S57 restrictions from 3 August to 25 February the following year. This suggests the River Severn Drought Order would actually be of benefit to spray irrigators, by reducing the potential restriction period.

In reality the S57 restriction trigger curve will be used as a guide during a real event rather than a definitive start and stop trigger. When S57 restrictions would be enforced and lifted will vary with each drought event, although they will always have been assessed and where of benefit, have been enforced before the River Severn Drought Order is implemented. For context, it is more feasible that S57 restrictions would be lifted once sustained rainfall was experienced (it could be assumed that spray irrigation demand would also be reduced/removed at the same time). The modelled drought event ended at the beginning of November although storage in the reservoir takes several months to recover. However with the post drought rainfall modelled, by December S57 restrictions might have been lifted anyway. As the S57 restrictions were triggered at about the same time, whether the drought order was implemented or not, it is more likely the drought order benefits are associated with the recovery period, allowing S57s to be lifted more quickly as storage in the reservoir is better protected under drought order implementation. Therefore no additional negative impact on agriculture in the short term is concluded.

The longer-term benefit of operating the River Severn Drought Order, as shown by the Chronic condition modelling, is that Llyn Clywedog storage could be protected for a subsequent drought year. If storage could be protected by applying the drought order during an Acute drought year, the probability of needing it in two consecutive years, even if the drought persisted, would be greatly reduced. Therefore the long term benefit could be the reduced risk of Section 57 restrictions being needed in two consecutive years, with obvious benefits for agriculture, industry and other abstractors.

The extent and nature of S57 restrictions will vary with each event, however worse case large scale crop failures could be expected where no alternative water supplies can be utilised. The risk to livestock should be limited to the natural deterioration of grazing/pasture land, as the restrictions only apply to spray irrigation licences, although some farmers may struggle to fill water troughs due to the drought conditions (not in connection with the River Severn Drought Order).

The Environment Agency would be openly engaging with the National Farmers Union (NFU), Farmers Union Wales (FUW) and agricultural industry wherever possible to warn of developing drought conditions and encourage farmers to plan ahead and make essential provisions should restrictions be absolutely necessary.

5.3.3. Canal & River Trust abstractions

5.3.3.1. Montgomery Canal

The Canal & River Trust abstraction from the River Severn for the Montgomery Canal at Newtown is now licensed by Natural Resources Wales. Flows entering the canal are restricted during periods of high River Severn regulation. The River Severn Drought Order conditions are included within the abstraction licence and the Canal & River Trust would be expected to have appropriate plans in place.

The licence states that if Llyn Clywedog storage drops below 25%, then the Canal & River Trust must stop abstracting. The River Severn Drought Order Acute condition modelling indicated that Llyn Clywedog storage would be below 25% for a total of 76 days, between 16 September and 30 November. If the drought order were not operated then a greater impact would be felt, with a total of 120 days where abstraction would not be possible due to insufficient storage at Clywedog, between 2 September and 30 December. Under the Chronic drought condition, assuming a similar

initial year, the second drought year was predicted to result in a further 15 days of 'no abstraction' restrictions under the River Severn Drought Order, whereas the 'Do Nothing' scenario could create a further 80 days of no abstraction.

It can therefore be concluded that the River Severn Drought Order would be of benefit to the Montgomery Canal abstraction, potentially lowering abstraction quantities for longer but reducing the potential period of no abstraction if Llyn Clywedog storage is allowed to fall below 25%.

5.3.3.2. Gloucester & Sharpness Canal

The Canal & River Trust abstraction from the River Severn at Gloucester (and the River Frome and Cam tributaries) for the Gloucester & Sharpness Canal is now licensed by the Environment Agency. The abstraction holds an added complication, with Bristol Water making a large abstraction directly from the canal for PWS. The Gloucester & Sharpness Canal abstraction at Gloucester has a maximum daily abstraction of 398 Ml/d and is known to have a potentially significant impact on the lower tidal Severn and inflows to the Severn Estuary depending on tide heights and the volume of abstraction.

The Canal & River Trust and the Environment Agency entered into an Operating Agreement in 1998 regarding the safe environmental management of the canal, to help alleviate the known impacts and protect the National Sites Network from derogation. Essentially the agreement restricted abstraction according to specific tide heights and flows at Deerhurst flow gauge, although it is important to note clause 7;

"Neither party shall be liable to the other under this Agreement for the failure to observe any of its obligations under this Agreement due to any cause beyond its reasonable control including without limitation any act of God, sudden or threatened loss of water from the Canal, drought, flood or major pollution."

The Canal & River Trust also have their own internal Drought Plan (although there is no statutory requirement for the trust to produce one); this was not available for consideration during the impact assessment for the River Severn Drought Order but communication provided a flow trigger for consideration.

Due to the previous licence exemption, abstraction return data was not a legal requirement on the Canal & River Trust. The Environment Agency and Canal & River Trust meet annually to review operations against the agreement, abstraction data is provided to the Environment Agency. Data available at the time of modelling was used to produce an average monthly abstraction profile (Table 13) for Aquator.

Table 13: Gloucester & Sharpness Canal average monthly abstraction profile

Month	Average abstraction (Ml/d)
January	60.3
February	132.5
March	89.7
April	180.7
May	165.8
June	199.8
July	252
August	280.5
September	296.9

October	239.6
November	190.6
December	109.8

Discussions and data made available by the Canal & River Trust following the dry period 2010-early 2011, and subsequently 2018 and 2022, has highlighted these figures as not accurately reflecting the high demands during dry weather or the maximum potential abstractions (398 Ml/d) that the Canal & River Trust could legally take. Precautionary assumptions and historic evidence have been used to draw final conclusions on potential downstream impacts.

Aquator does not predict tidal movements and therefore assessing all the potential impacts on the canal abstraction is not possible with certainty. The Canal & River Trust currently consider closing the canal to navigation when flows at Deerhurst reach 1150 Ml/d or less, which can be used as a guide for the main impact on the canal abstraction. Using this as a basis, under the Acute 'Do Nothing' scenario the River Severn Drought Order modelling indicated a period of 106 days where flows were <1150 Ml/d at Deerhurst, from 2 July to 1 November. When compared with the 'Drought Order Only' scenario, 38 of these days coincided with the activation of the River Severn Drought Order. Looking to a subsequent drought year in the Chronic condition identified another similar period of potential restrictions for both the 'Do Nothing' and 'Drought Order Only' scenarios. Owing to the consistency compared to the 'Do Nothing' scenarios and period of River Severn Drought Order operation, no additional canal closures would be caused as a result of activating the drought order.

It is understood that the canal closure trigger is for the Canal & River Trust's consideration only and does not determine whether or when the canal will definitely be closed. The Environment Agency would actively encourage closing the canal for recreational use during severe drought conditions in the best interests of the environment and PWS.

The proposed new abstraction cap of 300 Ml/d, to be enforced when flows at Deerhurst drop below 1200 Ml/d, was tested. The Acute 'Do Nothing' scenario was used as a benchmark. No restrictions would have been enforced as the drought order was not active, however flows at Deerhurst dropped <1200 Ml/d for 131 days in total (modelled Jan 76-Jan 77), 25 days more than 1150 Ml/d trigger. Under the 'Drought Order Only' scenario, there were 38 days when flows dropped <1200 Ml/d at Deerhurst and the drought order was active. When compared with the 1150 Ml/d flow trigger, the exact same 38 days were found to have triggered. It can therefore be concluded that under these drought conditions, the Canal & River Trust abstraction from the River Severn was impacted for 38 days out of the year; all days which had already crossed the 1150 Ml/d Deerhurst trigger for potential canal closure and should therefore limit the magnitude of impact on the Canal & River Trust.

The complication of the Gloucester & Sharpness Canal abstraction relates to Bristol Water's reliance on the canal for its own PWS abstraction. The abstraction licence entails its own tide height and regulation specific restrictions, which would naturally vary throughout the year. For both the Acute and Chronic drought conditions, abstraction for the Gloucester & Sharpness Canal was modelled with a continuous value for each month (based on Table 13). This should support the Bristol Water abstraction, although saline intrusion into the canal would be a private consideration for the water company to plan for.

With careful water management and the continued interception of several tributaries, the Environment Agency believe a 300 Ml/d restriction from the River Severn during drought order implementation, only when flows drop below 1200 Ml/d at Deerhurst, should still allow the Canal & River Trust to supply Bristol Water with sufficient water. The Canal & River Trust have raised concerns that 300 Ml/d may not be sufficient to meet all their obligations and therefore poses a risk to its operation of the canal.

5.4. Monitoring and Mitigation Options

Water resource specific monitoring and mitigation options are contained within the Hydrology technical report in Appendix D and incorporated into the overall mitigation programme in section 14 and monitoring section 15 respectively.

6. Water Quality

6.1. Baseline Environment Water Quality

The following sections provide a description of the chemical and nutrient quality of the River Severn, and how the baseline environment meets Water Framework Directive (WFD) requirements. For a full description of baseline water quality, including the historic use of General Quality Assessment (GQA) and how the monitoring sites previously used for GQA compare to the WFD sites, refer to Appendix H and I.

6.1.1. Water Quality Assessment Schemes

The WFD water quality assessment uses a different approach based on a far wider range of assessments than the historic General Quality Assessment (GQA) classification.

In the WFD classification scheme, physico-chemical elements are supporting elements. Only biological elements are recorded on the full scale, high to bad. Physico-chemical elements are not reported below moderate status. Table 14 below gives the status of the physico-chemical elements for each River Severn water body. The status of each element will be in most cases calculated from a number of sample points within the water body. Table 14 below shows the 2021 and 2024 element classifications. Please note that Cycle 3 uses 2019 classifications for the EA and 2021 classifications for NRW.

Table 14: WFD Water Body Physico-Chemical Element Status

Water Body ID	Water Body Name	Ecological Status / Potential Cycle 3 – 2021 (2019 English waterbodies)	Physico-Chemical Element Status Cycle 3 baseline	Ecological Status / Potential Cycle 3 interim – 2024 (2025 English waterbodies)	Physico-Chemical Element Status Cycle 3 interim Welsh waterbodies (Cycle 4 English waterbodies)
GB109054049880	Vrynwy - Lake Vrynwy to conf Afon Cownwy	Moderate (Potential)	Ammonia – Good DO – High pH – High Phosphate – Good Temp – High	Moderate (Potential)	Ammonia – Good DO – High pH – High Phosphate – Good Temp – High
GB109054049720	Afon Vyrnwy – conf Afon Cownwy to conf Afon Banwy	Good (Potential)	Ammonia – Good DO – High pH – High Phosphate – Good Temp – High	Moderate (Potential)	Ammonia – Good DO – High pH – High Phosphate – Good Temp – High
GB109054049851	Afon Banwy	Poor (Status)	Ammonia – Good DO – High pH – High Phosphate – Good Temp – High	Good (Status)	Ammonia – Good DO – High pH – High Phosphate – Good Temp – High
GB109054049852	Afon Vyrnwy DS of Banwy confluence	Good (Status)	Ammonia – Good DO – High pH – High Phosphate – Good	Good (Status)	Ammonia – Good DO – Not assessed pH – High Phosphate – Good

			Temp – Good		Temp – Good
GB109054049800	Afon Vyrnwy – conf Afon Tanat to conf R Severn	Moderate (Potential)	Ammonia – High DO – High pH – High Phosphate – not assessed Temp – Good	Moderate (Potential)	Ammonia – High DO – High pH – High Phosphate – Moderate Temp – Good
GB109054044760	Afon Clywedog – Clywedog Dam to R Severn	Poor (Potential)	Ammonia – High DO – High pH – High Phosphate – Good Temp – High	Moderate (Potential)	Ammonia – High DO – High pH – High Phosphate – High Temp – High
GB109054044790	R Severn – source to conf Afon Dulas	Good (Status)	Ammonia – High DO – High pH – High Phosphate – Good Temp – High	Moderate (Status)	Ammonia – High DO – High pH – High Phosphate – High Temp – High
GB109054049310	R Severn – conf Afon Dulas to conf R Camlad	Moderate (Potential)	Ammonia – High DO – High pH – High Phosphate – Good Temp – High	Moderate (Potential)	Ammonia – High DO – High pH – High Phosphate – Good Temp – Good
GB109054049700	R Severn – conf R Camlad to conf Bele Bk	Moderate (Potential)	Ammonia – Not Assessed DO – Not Assessed pH – Not Assessed Phosphate – Not Assessed Temp – Not Assessed	Moderate (Potential)	Ammonia – High DO – High pH – High Phosphate – Good Temp – Good
GB109054049142	R Severn – conf Bele Bk to conf Sundorne Bk -	Moderate	Ammonia - High DO - High pH - High Phosphate - Moderate Temp - Good	Moderate	Ammonia - High DO - High pH - High Phosphate - Moderate Temp - Good
GB109054049141	R Severn – Sundorne Bk to conf M Wenlock-Farley Bk	Moderate	Ammonia - High DO - High pH - High Phosphate - Poor Temp - Good	Moderate	Ammonia - High DO - High pH – High Phosphate - Moderate Temp - Good
GB109054049143	R Severn conf M Wenlock-Farley Bk to conf R Worfe	Moderate	Ammonia - High DO - High pH - High Phosphate - Poor Temp - Good	Moderate	Ammonia - High DO - High pH - High Phosphate - Moderate Temp - Good
GB109054049145	R Severn – conf R Worfe to conf R Stour	Moderate	Ammonia - High DO -High pH - High Phosphate - Moderate Temp - Good	Moderate	Ammonia – Not assessed DO – Not assessed pH – Not assessed Phosphate – Not assessed Temp – Not assessed
GB109054049144	R Severn – conf R Stour to conf River Teme	Moderate (Potential)	Ammonia - High DO - High pH - High Phosphate - Moderate Temp - Moderate	Moderate (Potential)	Ammonia - High DO - High pH - High Phosphate - Moderate Temp - Good
GB109054039760			Ammonia - High		Ammonia - High

	R Severn – conf R Teme to conf R Avon	Moderate (Potential)	DO - Good pH - High Phosphate - Poor Temp - High	Poor (Potential)	DO - High pH - High Phosphate - Moderate Temp - Good
GB109054044404	R Severn – conf R Avon to conf Upper Parting	Moderate (Potential)	Ammonia - High DO - High pH- High Phosphate - Moderate Temp - High	Moderate (Potential)	Ammonia - High DO - High pH - High Phosphate - Moderate Temp - Good

6.1.2. Water discharges

There are numerous sewage and other trade effluent discharges into the River Severn. Discharges of sewage and trade effluent require discharge permits from the Environment Agency or Natural Resources Wales. The permit limits are set on both the quantity and quality of the discharge according to the amount of water available to dilute the effluent at the point of discharge without causing significant deterioration in the quality of the watercourse. Also, the limits aim to ensure that the discharge does not compromise downstream uses of the river and that the resulting downstream water quality conforms to the relevant environmental quality standards.

Sewage treatment works (STWs) that serve a population in excess of 2000 people (or population equivalent) must also comply with the minimum standards required by the Urban Waste Water Treatment Directive (UWWTD).

The majority of industrial discharges that directly enter the Severn are not of sufficient size to present any threat to the receiving watercourse. One of the largest discharges was clean cooling water from the Ironbridge Power Station, where a volume of 16 Ml/d was consented for discharge. The power station used to close down for a six week period during the summer. This had to be taken into consideration by the Environment Agency during the development of the various drought order management scenarios. However, the power station ceased operating in 2015 and has since been decommissioned, however the licence for abstraction has been traded to a downstream abstractor.

The major STW discharges to the River Severn are presented in Table 15 below. The Environment Agency reports that compliance with discharge permit conditions is generally good and the most recent Abstraction Licensing Strategy (ALS)/Catchment Abstraction Management Strategy (CAMS) for the River Severn does not identify any water quality issues directly associated with failure of consent conditions at sewage treatment works. However, STWs can have a significant impact during periods of low flow.

Table 15: Major Sewage Treatment Work Discharges to the River Severn (direct & indirect)

Name of discharge	Direct / Indirect	NGR	Consented Volume (m3/d)
Gloucester (Netheridge) STW	Direct	SO 80961594	42800
Worcester STW	Direct	SO 8449 5340	33000
Shrewsbury Monkmoor STW	Direct	SJ 5240 1357	20838
Coalport STW	Direct	SJ 7094 0134	17700
Malvern Barnards Green STW	Direct	SO 8009 4475	13400
Newtown Powys STW	Direct	SO 1380 9245	3700
Bridgnorth (Slads) STW	Direct	SO 7341 9104	2954
Welshpool STW	Direct	SJ2352007260	2021
Coventry Finham STW	Indirect (via R Avon)	SP 3361 7379	115000
Roundhill STW	Indirect (via R Stour)	SO 8698 8365	59836
Barnhurst STW	Indirect (via Staff/Worcs)	SJ 9020 0176	47500
Warwick STW	Indirect (via R Avon)	SP 2777 6290	36000
Cheltenham Hayden STW	Indirect (via R Chelt)	SO 9060 2310	35000
Redditch Spernal STW	Indirect (via R Arrow)	SP 0846 6263	27500
Kidderminster STW	Indirect (via R Stour)	SO 8256 7375	26504
Stanley Downton (Stroud) STW	Indirect (via R Frome)	SO 7910 0480	24300
Telford Rushmoor STW	Indirect (via R Tern)	SJ 6130 1354	23523
Rugby Newbold STW	Indirect (via R Avon)	SP 4942 7635	21600
Stratford Milcote STW	Indirect (via R Avon)	SP 1805 5297	13110
Bromsgrove Fringe Green	Indirect (via R Salwarpe)	SO 9596 6834	11500
Lower Gornal STW	Indirect (via Bobs Bk)	SO 9030 9075	8500
Droitwich STW	Indirect (via R Salwarpe)	SO 8626 6166	7183
Coaley STW	Indirect (via R Cam)	SO 7562 0217	6680
Trescott STW	Indirect (via Smestow Bk)	SO 8549 9763	6460
Evesham STW	Indirect (via R Avon)	SP 0318 4467	5797
Tewkesbury STW	Indirect (via Mill Avon)	SO 8812 3186	5192
Oswestry Mile Oak STW	Indirect (via R Morda)	SJ 3024 2713	6068
Redditch Priest Bridge STW	Indirect (via Bow Bk)	SO 9926 5983	3576
Ludlow STW	Indirect (via R Teme)	SO 5163 7310	3500
Market Drayton STW	Indirect (via R Tern)	SJ 6685 3320	3400
Brockhampton STW	Indirect (via Hyde Bk)	SO 9462 2593	4220
Wombourne STW (*Closed in 2013)	Indirect (via Wom Bk)	SO 8575 9213	0 (*was 3289 prior to closure)
Itchen Bank STW	Indirect (via R Itchen)	SP 4069 6281	2881
Blackminster STW	Indirect (via Badsey Bk)	SP 0661 4464	3391
Newport STW	Indirect (via Strine Bk)	SJ 7358 1924	2500
Tenbury Wells STW	Indirect (via R Teme)	SO 6044 6848	1247

Summer storms following periods of dry weather have potential to cause serious pollution and associated fish kills, either through STWs, storm water overflows or through the flushing-out of urban pollution. Most of the large public sewerage systems have intermittent storm overflows that operate within the system or at the sewage treatment works at times of heavy rainfall. The majority of the overflows operate without causing nuisance, although it is reported that those situated in areas of high public amenity do give rise to some complaint. Pollution incidents associated with storm overflows are generally of short duration, but have potential to cause long term effects on the biological and aesthetic quality of the river.

The water industry asset management plan (AMP) improvement programme runs in five year blocks and includes both water quality and water resource improvements. As part of the AMP, improvements have been delivered at a number of continuous and intermittent discharges since 2000, to improve substandard discharges or meet updated environmental standards. The STWs and receiving watercourses which have benefited from this programme for water quality are summarised in Appendix G Tables 12-16 (one table per five year programme). These improvements, which include tightening of discharge permits to reduce discharges of ammonia, phosphate and organic matter, have been driven by non-compliance with RQOs and by a number of directives (i.e. Freshwater Fish Directive, Habitats Directive, and UTWWTD) and more recently the WFD.

6.1.3. Physico-Chemical Water Quality

The WFD requires EU member states to formulate River Basin Management Plans (RBMPs) to deliver the objectives of the Directive. The River Severn RBMP divides the Severn into management catchments. The water qualities of these catchments are discussed in detail in Appendix H and I.

For most physico-chemical parameters, the River Severn is high quality as shown in Table 14. All of the River Severn WFD water bodies examined meet WFD high status for both pH and dissolved oxygen. Temperature classifications have declined since 2019 cycle 3 previously all apart from Worcestershire Middle Severn were achieving high, now only 5 sites are high classification with the rest in good classification and Severn Road Foot Bridge (GB109054032750).

Although the ammonia concentrations in the River Severn generally increase with distance downstream of the source, all sampled River Severn Waterbodies meet the WFD Good Status standard of 0.3/0.6mg/l (90%ile). In fact, in cycle 3 all River Severn waterbodies achieve High Status for ammonia (except for GB109054049145 that has yet to be assessed but achieved High in 2019). Improvements at many of the sewage works within the Severn River Basin district have contributed to the overall reduction in ammonia levels since 1996. This is demonstrated by Figure 11 below showing ammonia trends at sample points along the length of the Severn from 1996 to 2026.

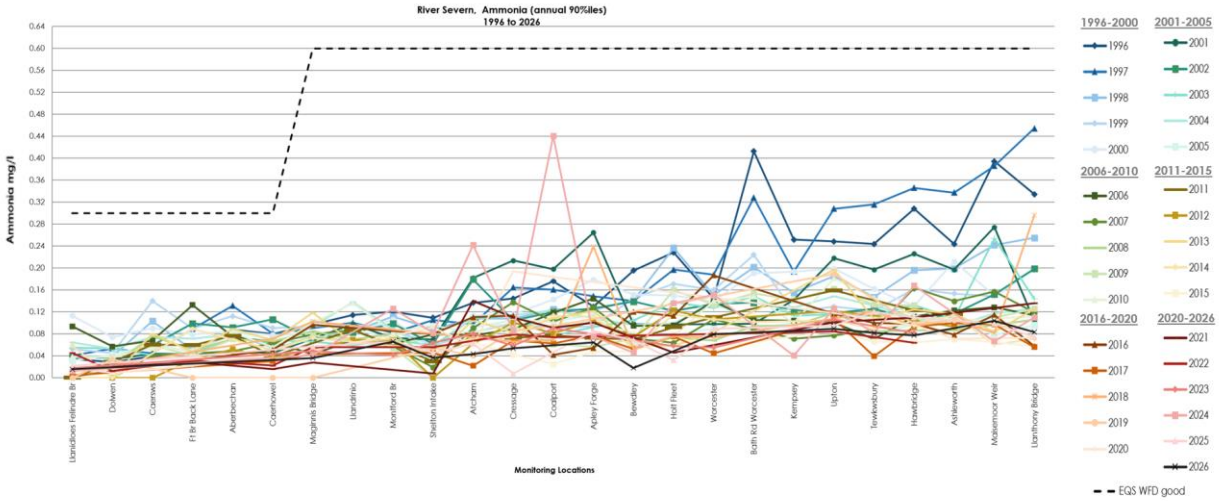

Figure 11: River Severn, Ammonia Annual 90 Percentile Concentrations 1996 to 2026

Phosphate concentrations in the River Severn generally increase with distance downstream of the source. Multiple water bodies have improved classification in cycle 3 against the site specific targets since 2019, with only the Afon Vyrnwy – conf Afon Tanat to conf R Severn and the nine most downstream waterbodies not achieving good status. The site specific phosphate targets (which are annual means) are shown plotted on Figure 12 against the mean annual phosphate concentrations for various sample points down the River Severn. Improvements at many of the sewage works within the Severn River Basin district have contributed significantly to the overall reduction in Phosphate levels since 1996. However even with these notable improvements, phosphate is the physico-chemical element contributing to most River Severn water bodies failing to achieve good status. Where we have evidence that nutrient enrichment impacts the ecology, within waterbodies that do not reach good status both point and diffuse sources of phosphate will need tackling. Further improvements are planned to reduce phosphate inputs throughout cycle 4 of the Severn River Basin Management Plan.

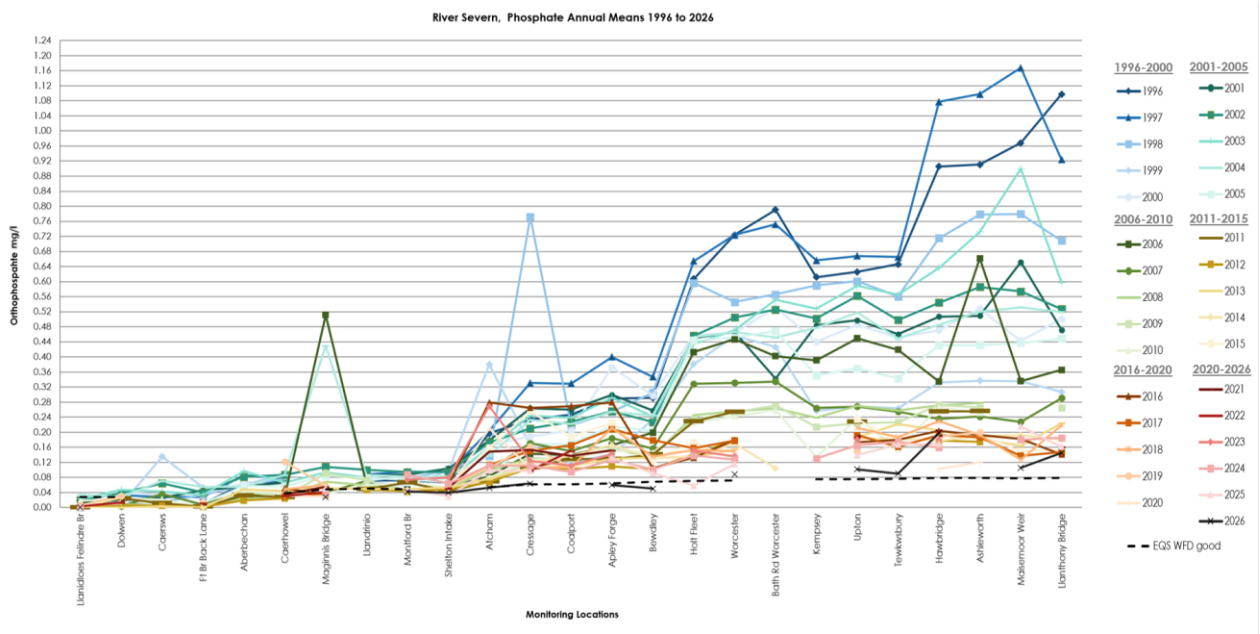

Figure 12: River Severn, Phosphate Annual Means 1996 to 2026

As with ammonia and phosphate, nitrate concentrations in the River Severn generally increase with distance downstream of the source displayed in Figure 13 below. Overall levels have decreased, but not to the same extent. In Nitrate is not used as a physico-chemical element in freshwater riverine WFD classification and there is no associated environmental quality standard.

Most of the east side of the River Severn catchment below Montford Bridge and parts of the west side below Worcester is designated as a Nitrate Vulnerable Zone (NVZ) under the EC Nitrates Directive (see Figure 14). This should contribute to reduced diffuse nitrate pollution, through restrictions in the use and storage of nitrate fertilisers for farms located within the NVZ.

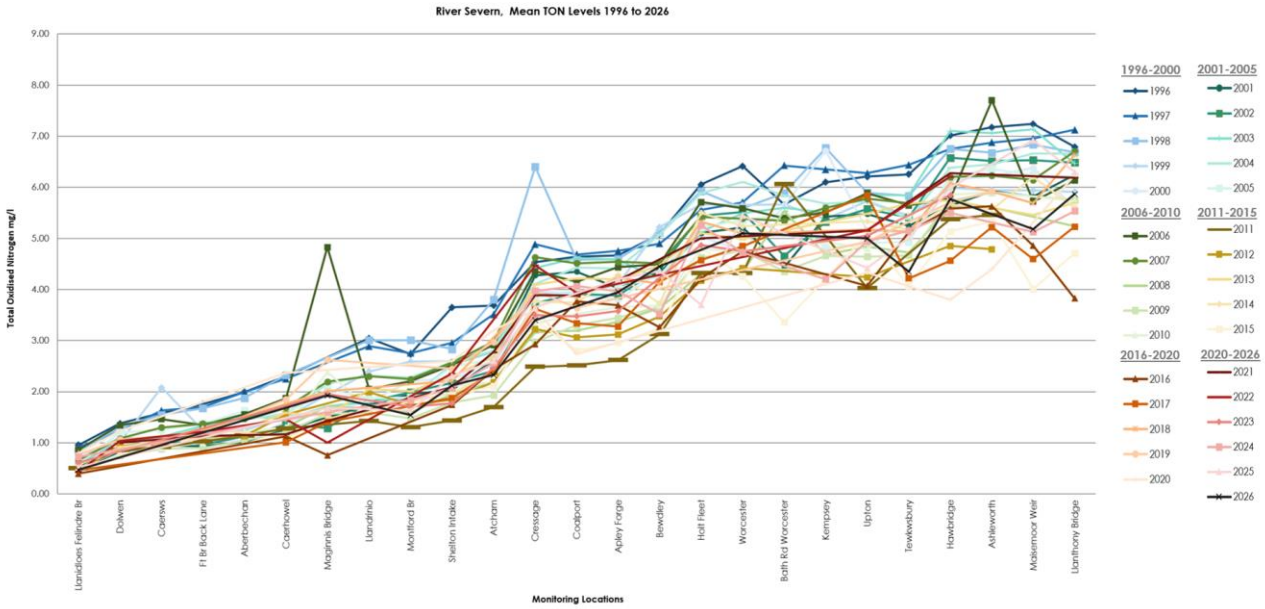

Figure 13: River Severn, TON Annual Means 1996 to 2026

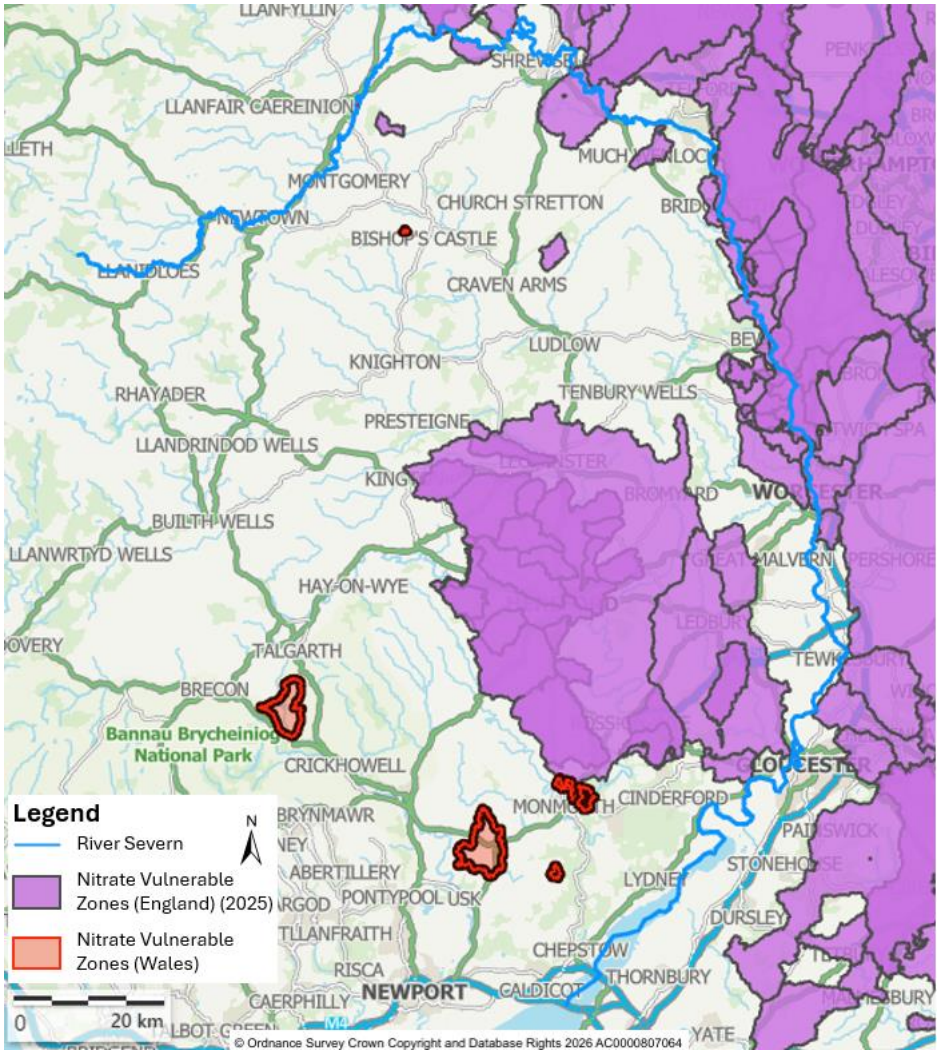

Figure 14: Nitrate Vulnerable Zones

6.2. Sonde Data

There are several water quality monitoring stations (Sondes) within the Severn catchment, data from which is included below and shows the trends of temperature, dissolved oxygen (DO) and Ammonium throughout the catchment.

Sonde on River Avon at Lucy's Mill

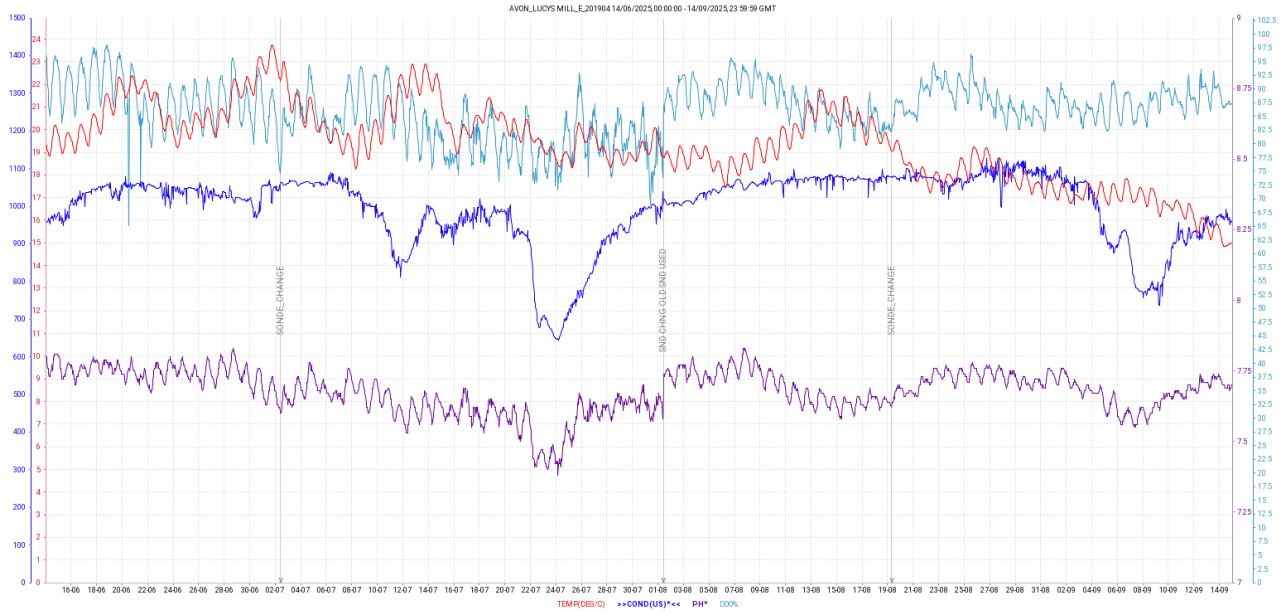

Figure 15: 2025 Sonde data on the River Avon at Lucy's Mill from May-September

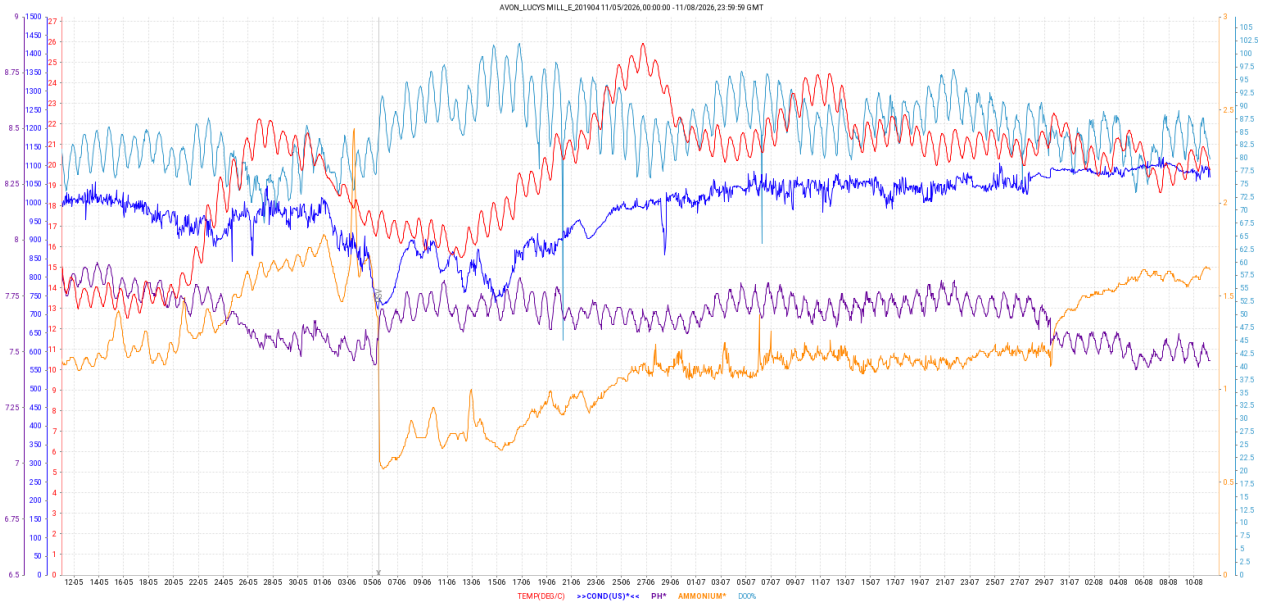

Figure 16: 2026 Sonde data on the River Avon at Lucy's Mill from May onwards

Sonde on River Severn at Upper Lode

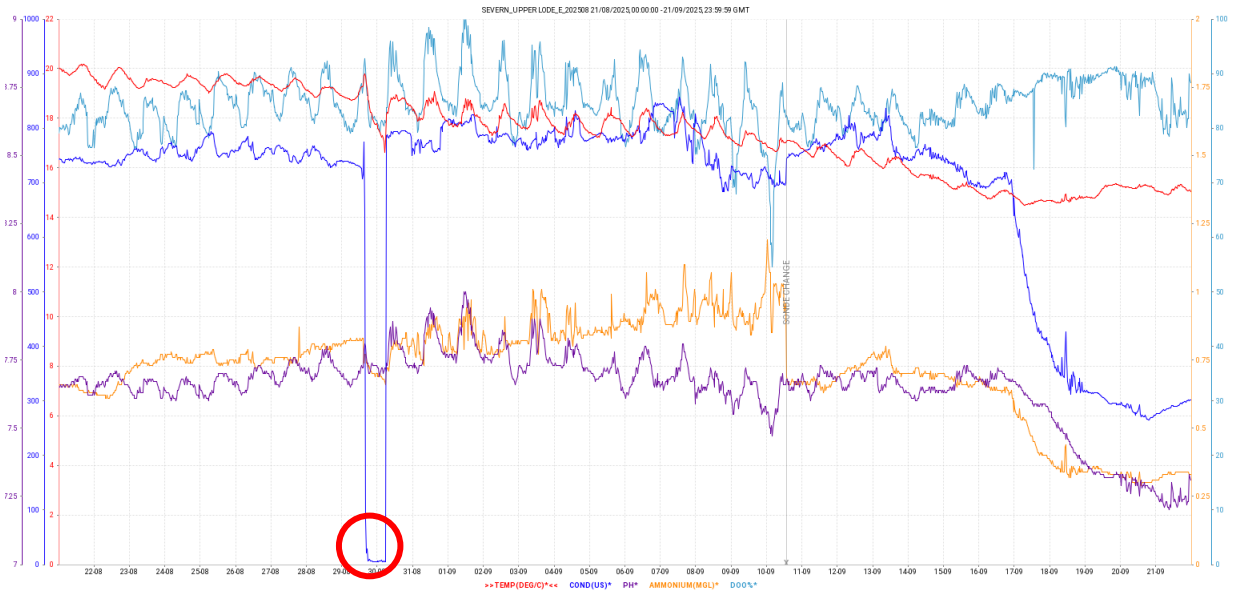

Figure 17: 2025 Sonde data on the River Severn Upper Lode from August-September. Shows reduction in PH, Conductivity and Ammonium when it started raining at the end of September. End of August sonde did come out of the water temporarily (red circle)

Sonde on River Severn Montford

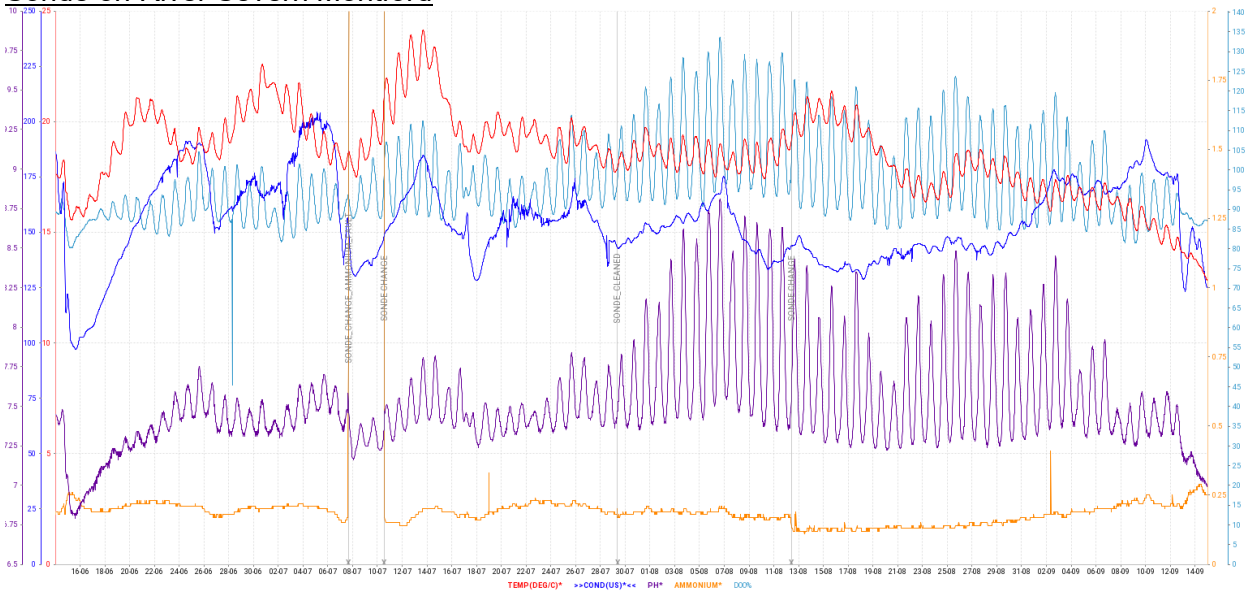

Figure 18: 2025 Sonde data on the River Severn at Montford from June to September

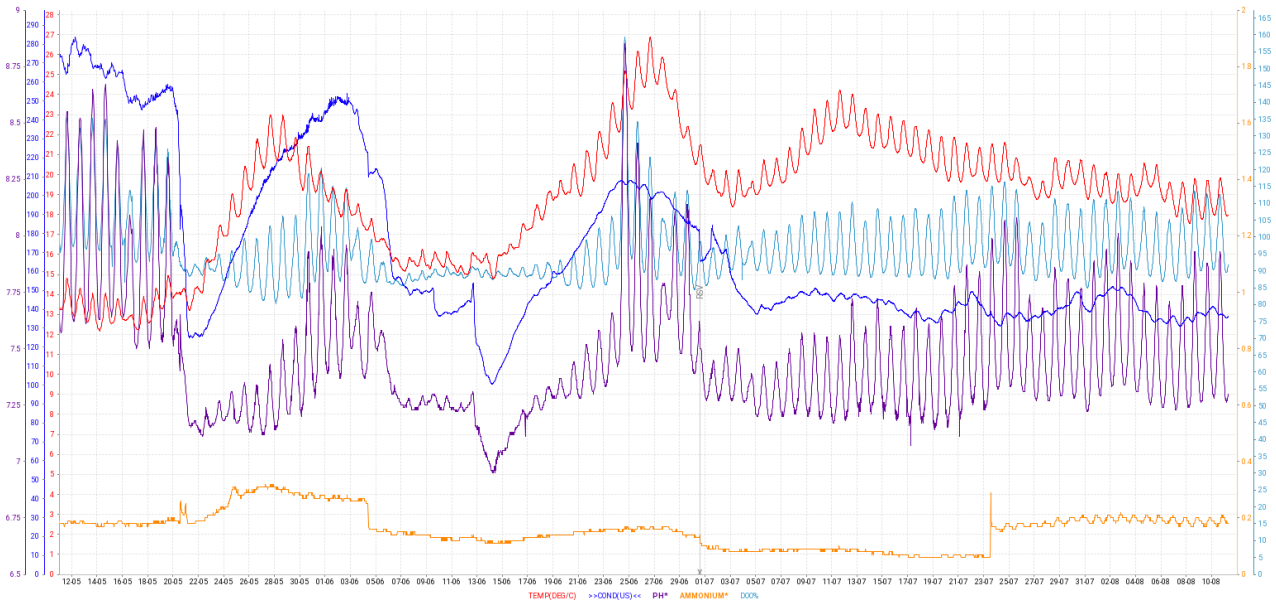

Figure 19: 2026 Sonde data on the River Severn at Montford from May onwards

6.3. Assessment of Impact on the Current Environment Water Quality

The complete SIMCAT Water Quality modelling and assessment write up is contained within Appendix I.

6.3.1. SIMCAT overview

As the only current water quality modelling tool available that includes the River Severn corridor from source to estuary, including the ability to model the inputs from all tributaries and the flow control measures at Lake Vyrnwy and Llyn Clywedog reservoirs, the River Severn River Basin District SIMCAT model represented the best option for assessing the Severn Drought Order options. SIMCAT cannot work as a water quality prediction tool for manually altered drought flows.

SIMCAT is a proven modelling tool for water quality planning and has been used by the Environment Agency for over 20 years. It has been developed as a software package that can represent point and diffuse source inputs as well as in-river decay. SIMCAT is used for the calculation of water quality statistics (usually mean and 90th percentiles) and for the determination of discharge consent conditions.

The model, rebuilt in 2009 using the most up to date data available, was deemed fit for purpose in terms of both quality and quantity calibration at the time of its completion[27]. SIMCAT models are constructed using mean and standard deviation quality data and mean and 95% low flow data for flow.

The model operates on the relatively simple principles of mass balance calculations in which upstream loads and discharge loads are mixed to provide a downstream estimate of load, it is possible that it does not necessarily represent the best way of assessing extreme low flows as experienced during drought conditions. It is however the best suited water quality modelling tool available for a whole catchment assessment, and as such, the best available tool for the Severn Drought Order water quality assessment.

In terms of flow data, the model has been built on data provided from 57 flow gauges throughout the catchment and daily mean flow data provided by Severn Trent Water where available for the discharges included in the model. Where actual data was not available, the permitted discharge volumes were used.

Major abstractions are also included in the SIMCAT model where it was felt they had a significant impact upon the flows in the environment (29 sites in total). Where applicable, the appropriate hands-off flows can be incorporated in order to limit how much water can be taken from the environment at times of very low flow. The model, however, does not incorporate drought permit requirements at any features.

The water quality data used to build the final SIMCAT model came from a variety of sources including a total of 499 river quality sites, 334 sewage treatment works and 50 industrial discharge sites.

[27] Models are now available based on 2015 to 2018 data but these have not been re-run for this assessment.

6.3.2. Water Quality Assessment Methods

To assess the impact of the operation of the River Severn Drought Order on water quality, an assessment of compliance against both Water Framework Directive (WFD) targets and Fundamental Intermittent Standards was carried out for phosphates, ammonia and biochemical oxygen demand (BOD). The relative standards for the various sections of the River Severn corridor can be found in Table 16. A comparative assessment of Total Oxidised Nitrogen was also included for reference.

Table 16: Water Framework Directive Targets and Fundamental Intermittent Standards

River Severn Stretch	Parameter	WFD Good (mg/l)	FIS 99%ile (mg/l)
Llanidloes Felindre Bridge to Caerhowell	Ammonia	0.3	0.6
Caerhowell to Llandrinio	Ammonia	0.6	0.6
Llandrinio to Gloucester	Ammonia	0.6	1.5
Llanidloes Felindre Bridge to Llandrinio	BOD	4	5
Llandrinio to Gloucester	BOD	5	9
Llanidloes Felindre Bridge to Aberbechan	Phosphate	0.04	n/a
Aberbechan to Gloucester	Phosphate	0.12	n/a

Results from the River Severn Drought Order Acute and Chronic conditions were plotted against the relevant assessment graphs to determine the relative impact in terms of water quality concentrations.

6.3.3. Impact on Water Quality: Acute Drought Condition

The complete SIMCAT Water Quality modelling technical report containing all graphs is contained in Appendix I. Findings have been summarised for the 'Drought Order Only' scenario, compared against the 'Do Nothing' scenario for the Acute drought condition. Refer to section 6.3.5 for the worst-case scenario summary of both Acute and Chronic conditions.

Under the Acute drought condition the managed and reduced mean reservoir release from Clywedog results in a reduction in the mean flow throughout the river corridor whilst the increase in the released Q95 flow identified an improved situation along the same length of river.

Assessing the BOD and ammonia concentrations predicted only very limited areas of deterioration as a result of the drought order operation. Overall water quality under the 'Drought Order Only' scenario was predicted to improve compared with the unmanaged 'Do Nothing' scenario. The only areas of minor deterioration in either determinand were predicted to be:

- BOD - maximum 5% deterioration between Montford Bridge and Cross Houses on the River Severn;
- BOD - minor deterioration at Caerhowell on River Severn (1.5%); and
- ammonia – 25% increase in concentrations on the Afon Vyrnwy d/s of Llansantffraid.

At none of the above locations however, was the predicted deterioration great enough to cause any failure of WFD targets. In fact, no failures of the respective WFD target were predicted in either the 'Drought Order Only' or 'Do Nothing' scenarios.

The same two determinands (BOD and ammonia) were plotted as 99 percentiles; use of such high percentiles allows a direct application of the results to the extreme low flow and subsequent reduction in dilution predicted during the drought scenarios. For example, the 99 percentile effectively represents the concentrations which are exceeded for just 1% of the time or, the equivalent of just 3.65 days/year.

Although it is immediately evident that phosphate concentrations exceed WFD standards in both the 'Do Nothing' and 'Drought Order Only' scenarios, this is of lower concern as WFD compliance for phosphate along the River Severn corridor is currently already less than good at all locations downstream of Cressage and so the predicted exceedences are not new failures. That said, it is still important to assess the degree of deterioration resulting from each scenario.

Results suggest there would be a significant length of new WFD failure for phosphate as a consequence of the unmanaged 'Do Nothing' scenario. Operation of the River Severn Drought Order was generally predicted to improve concentrations throughout the Severn catchment compared with the unmanaged 'Do Nothing' scenario.

The same can be said for Total Oxidised Nitrogen concentrations which were not predicted to deteriorate following commencement of the River Severn Drought Order.

6.3.4. Impact on Water Quality: Chronic Drought Condition

The SIMCAT Water Quality modelling technical report containing all graphs is contained in Appendix I. This section summarises the 'Drought Order Only' scenario against the 'Do Nothing' scenario under the Chronic drought condition. Refer to section 6.3.5 for the worst-case scenario summary of both Acute and Chronic conditions.

The Chronic condition comparison shows barely any difference in the Q95 flows (the River Severn Drought Order scenario effectively tracks the ‘Do Nothing’ drought conditions) whereas the Chronic mean flows show significant benefit from the River Severn Drought Order, through the sustained releases from both reservoirs into the second drought summer.

Consideration of the Chronic drought condition shows a very similar situation to that predicted under the Acute drought condition. No significant deterioration in any determinand at any point in the Severn or Vyrnwy catchments was predicted as a result of operation of the River Severn Drought Order.

This is of no real surprise given the increased flows modelled throughout the catchment as part of the 'Drought Order Only' scenario (in comparison with the 'Do Nothing' scenario) and the fact that operation of the drought order would result in greater mean and Q95 flows released from Llyn Clywedog and mean flows from Lake Vyrnwy.

As with the Acute drought condition, no new WFD failures were predicted for either BOD or ammonia as a result of the environment experiencing drought conditions ('Do Nothing' scenario). The same is true of the 99 percentile standard applicable to the River Severn corridor, the maximum concentrations predicted in the worst case scenario both largely remain below 3 mg/l and 0.3 mg/l for BOD and ammonia respectively (tightest applicable targets = 5 mg/l and 0.6 mg/l)

Not unexpectedly, achievement of WFD Good Status for phosphates is predicted to be harder to achieve during the modelled 'Do Nothing' scenario with a general increase in nutrient concentrations predicted across the board. As with the Acute drought condition however, the operation of the River Severn Drought Order is predicted to marginally improve the situation with increased dilution reducing both phosphate and Total Oxidised Nitrogen concentrations.

6.3.5. Impact on Water Quality: Worse Case testing for Acute and Chronic drought conditions

Consideration of the zero natural flow scenario (representing conditions more extreme than the Drought Order Only' scenario) showed a similar situation for both ammonia and BOD under both Acute and Chronic drought conditions. Comparison with the previous work suggests that predicted concentrations for both determinands under this scenario were not particularly elevated and, as such, failures of the required WFD standards were not predicted for either the 'Do Nothing' or 'Drought Order Only' scenarios. This is reassuring considering the lack of natural dilution, even when measured at the 99%ile (Table 17 and 18). The results indicate the application of the River Severn Drought Order improves the predicted water quality in comparison with the unmanaged 'Do Nothing' approach.

Table 17: BOD and Ammonia predicted concentrations for Acute zero natural flow scenario

		No Drought Order		River Severn Drought Order	
Flow Gauge Location	**FG Ref**	**BOD 99%ile (mg/l)**	**Ammonia 99%ile (mg/l)**	**BOD 99%ile (mg/l)**	**Ammonia 99%ile (mg/l)**
Bryntail	2109	1.6	0.05	1.6	0.05
Vyrnwy	2003	1.67	0.03	1.67	0.03
Buildwas	2134	2.13	0.36	1.84	0.31
Bewdley	2001	1.61	0.47	1.36	0.36
Saxons Lode	2032	2.32	0.45	2.1	0.38
Deerhurst	2057	2.28	0.39	2.17	0.36
Lower Parting		2.08	0.35	1.96	0.33

Table 18: BOD & Ammonia predicted concentrations for Chronic zero natural flow scenario

		No Drought Order		River Severn Drought Order	
Flow Gauge Location	**FG Ref**	**BOD 99%ile (mg/l)**	**Ammonia 99%ile (mg/l)**	**BOD 99%ile (mg/l)**	**Ammonia 99%ile (mg/l)**
Bryntail	2109	1.6	0.05	1.6	0.05
Vyrnwy	2003	1.67	0.03	1.67	0.03
Buildwas	2134	2.42	0.43	1.88	0.35
Bewdley	2001	1.73	0.48	1.42	0.37
Saxons Lode	2032	2.44	0.46	2.18	0.4
Deerhurst	2057	2.35	0.41	2.23	0.37
Lower Parting		2.12	0.36	2	0.33

The operation of the River Severn Drought Order was also predicted to improve water quality in terms of nutrient concentrations in the zero natural flow scenarios. Although maximum concentrations were predictably higher in this situation compared with the more realistic scenarios already discussed, it was noticeable in Tables 19 and 20 that concentrations reduced once revised regulation of the flows from Llyn Clywedog and Lake Vyrnwy were employed.

Table 19: Predicted nutrient concentrations for Acute zero natural flow scenario

		No Drought Order	Drought Order

Flow Gauge Location	FG Ref	Phosphate 99%ile (mg/l)	TON 99%ile (mg/l)	Phosphate 99%ile (mg/l)	TON 99%ile (mg/l)
Bryntail	2109	0.06	1.07	0.06	1.07
Vyrnwy	2003	0.06	0.58	0.06	0.58
Buildwas	2134	1.39	7.14	1.27	5.93
Bewdley	2001	1.07	6.69	0.97	6.1
Saxons Lode	2032	1.69	12.95	1.6	11.73
Deerhurst	2057	1.21	15.73	1.17	15.01
Lower Parting		1.11	15.56	1.07	15.04

Table 20: Predicted nutrient concentrations for Chronic zero natural flow scenario

		No Drought Order		Drought Order	
Flow Gauge Location	FG Ref	Phosphate 99%ile (mg/l)	TON 99%ile (mg/l)	Phosphate 99%ile (mg/l)	TON 99%ile (mg/l)
Bryntail	2109	0.06	1.07	0.06	1.07
Vyrnwy	2003	0.06	0.58	0.06	0.58
Buildwas	2134	1.61	8.18	1.4	6.52
Bewdley	2001	1.21	7.4	1.05	6.6
Saxons Lode	2032	1.79	13.49	1.66	12.34
Deerhurst	2057	1.24	16.02	1.19	15.16
Lower Parting		1.14	16.06	1.09	15.28

6.3.6. Water Quality Conclusions

Some local areas of deterioration were predicted under the 'Do Nothing' scenario which are important to be aware of for drought management:

- Phosphate - Afon Vyrnwy d/s of Llansantffraid - 33% increase in concentrations - no resultant failure of WFD targets.
- BOD - Maximum of 5% deterioration between Montford Bridge and Cross Houses. Minor deterioration at Caerhowell on River Severn (1.5%) - no new WFD failures.
- Ammonia - Afon Vyrnwy d/s of Llansantffraid - 25% increase in concentrations - no resultant failure of WFD targets.
- Nitrogen - General deterioration in concentrations throughout the Vyrnwy catchment.

However results identified no new failures to achieve Water Framework Directive good status for ammonia or BOD for either the 'Do Nothing' or 'Drought Order Only' scenarios. Widespread phosphate failures persisted, but were present under normal conditions.

To test the extreme low flows predicted by the Water Resource model Aquator, 99 percentile water quality results were plotted against the appropriate standards. No failures of the 99% targets associated with the river reach classes imposed under the River Ecosystem Classification were identified.

Even under zero natural flow scenarios, maximum ammonia concentrations are predicted to equal 0.47 mg/l with BOD pollution topping out at 2.32 mg/l, both well within the WFD 90%ile standards.

Nutrient concentrations continued to breach the required standards and were, indeed, elevated further without the benefit of any natural dilution flow for the treated effluent discharges.

No significant deterioration for any determinands at any point on the River Severn or Vyrnwy catchments was identified as a result of the River Severn Drought Order. Operation of the River Severn Drought Order resulted in a varying degree of improvement in water quality concentrations compared to the 'Do Nothing' situation under all the scenarios modelled. It can therefore be concluded that the River Severn Drought Order would be of benefit to the River Severn during a severe drought.

6.3.7. Limitations of the SIMCAT Modelling

The SIMCAT models used in this modelling work have been updated since this report was written and will be used as part of the next full review project. The general limitations of SIMCAT as a water quality modelling tool in drought conditions will not have changed with the new models. What will have changed is a better representation of diffuse pollution sources and the use of more up to date data for the model calibration of the model, including more accurate discharge flow data and a better representation of the improved effluent quality.

Throughout this exercise to determine the impact of drought conditions on the water quality of the River Severn corridor and also the impact of managing the flows through implementation of the Severn Drought Order, it became obvious that the SIMCAT models at our disposal, although the best available tools, were not necessarily the right tools for drought impact assessment.

The verification exercise initially attempted to match SIMCAT predicted and theoretical Aquator observed drought flows at the various assessment points proved to be fraught with difficulty and was eventually abandoned in favour of a number of logical assumptions. This was predominantly due to the fact SIMCAT models are based on current day populations rather than those present at the time of the drought situations attempting to be matched (1976/77). However additional discrepancies between the SIMCAT and Aquator models relate to SIMCAT being unable to represent drought permit/order abstraction changes, and Aquator being unable to reduce discharges to better represent reduced storm runoff during real droughts. Therefore it became apparent that like for like flows were not being produced for comparison, but selecting which model was representing the most realistic flows was not possible in the project timescales. Therefore the precautionary worst case predictions produced by Aquator were used.

Being a spatial rather than a temporal model, it also proved impossible to provide the data for ecological appraisal in the form that was required. Whereas the ecological impact would be best assessed using an indication of the varying ammonia and BOD concentrations at one location with time and flow (temporal model), SIMCAT was only able to provide a worst case scenario for the entire length of river with no immediate link to the flows at the corresponding time. In other words, an assumption had to be made that the 99th percentile value for each determinand represented the worst case scenario when, in fact, higher concentrations would be present for a maximum of 4 days in a year.

SIMCAT is also a tool more suited to representing more stable conditions and can struggle to represent prolonged, extreme events such as droughts. By its nature of representing mean and standard deviation statistical input, it is not inherently designed to predict environmental conditions in extreme, worst case scenarios.

Although a specific modelling tool cannot be recommended, any tool which is better suited at representing a temporal link between flow and pollutant concentration would probably be better suited to the tasks required in this water quality assessment.

The SIMCAT model itself could be improved by more sophisticated and numerous water quality and flow monitoring. Currently, the model is based upon the known input data, in other words

measured data from flow gauges, water quality monitoring points, measured discharge volumes and quality. From this data, the model must make assumptions on the source of any errors that may occur following mixing of all the known data.

Without enhanced monitoring, much larger data sets encompassing all possible sources of pollution and diffuse flow inputs and highly detailed knowledge of the catchment, this calibration process can be fraught with problems. The SIMCAT models employed in this assessment have been signed off and accepted as the best possible representation of the environment given the data available but it also has to be recognised that the model contains numerous locations where accurate representation of the environment was not possible. Calibration errors such as this can only successfully be rectified through the use of greater amounts of top quality monitoring of all potential sources of pollution and flow.

6.4. Monitoring and Mitigation Options

Based on the conclusion that water quality is not predicted to significantly deteriorate under the perceived worst case scenario of zero natural flows and that, under the same conditions, the predicted 99%ile quality remains within WFD concentration criteria for ammonia and BOD, there appears to be little benefit in employing mitigation measures for water quality in drought conditions.

With regards to phosphate and nitrogen, the drought is likely to cause a further increase in concentrations. As water quality standards are already breached and environmental damage is already likely to be occurring in non-drought conditions, continuation of the current regime of work to reduce nutrient enrichment is seen to be the best way forward with no further mitigation measures required.

Water quality specific monitoring options are contained within the Water Quality technical report in Appendix I and incorporated into the overall monitoring programme in section 15.

7. Ecology of the Severn Corridor

7.1. Baseline Environment: Macroinvertebrates and Macrophytes

This section provides a summary of the separate macrophytes and macroinvertebrate technical assessment, which is provided in Appendix K. Details of the methods used to carry out ecological assessments are included in the Appendix; these are based mainly on indices relating to the macroinvertebrate community, as this is a widely studied biological quality element with well-established indices of specific environmental pressures. The primary macroinvertebrate index used for this assessment is the LIFE (Lotic invertebrate Index for Flow Evaluation) score, which is based on the current velocity preferences of different taxa. A ratio of observed LIFE scores (O) to those expected (E) at a given site in the absence of human impact can be calculated to give an indication of impact. Also of value in assessing potential impacts of drought and low flow is the PSI (Proportion of Sediment-sensitive Invertebrates) score, as increased sedimentation is a common consequence of reduced flows. The BMWP (Biological Monitoring Working Party) score, indicating sensitivity to organic pollution, and its derivative the ASPT (Average Score per Taxon), were used to indicate responses of the fauna to reduced water quality.

Other ecological assessment has been carried out using River Habitat Survey (RHS), an assessment of physical habitat quality and measures of macrophyte assemblages. Water Framework Directive (WFD) status and classification has also been considered as part of the assessment.

7.1.1.1. General Impacts of Low Flows

Droughts can naturally have the following impacts on river channels:

- a reduction in the wetted width of the river, reducing the availability of habitat for invertebrates, and exposure of river bed sediments;
- reduced flow, leading to reduced mixing and oxygenation, which can be compounded during warmer periods, when oxygen solubility is reduced by increased water temperature;
- increased sedimentation, clogging invertebrate respiratory systems or smothering their food sources;
- exposure of stream margins and breakage of hydrological linkages to the channel edge;
- increased concentration of contaminants, exacerbating impacts of low water quality;
- an increase in algal blooms, which can smother other organisms and can cause large daily fluctuations in dissolved oxygen as they produce oxygen in the day and then use it up overnight; and
- in extreme cases, complete cessation of flow and formation of discrete pools, eliminating all species which require continuous flow.

Conversely, downstream of a regulating reservoir, drought conditions can lead to increased flow if higher compensation flows are released to mitigate reduction in inputs further downstream. Following cessation of a drought, natural flow variability may be suppressed downstream of a reservoir as water from high flow events is captured to replenish the reservoir; in consequence, sediment can build up, while less ecologically competitive species, which rely on periodic high flow events to ‘reset’ the community, can lose out to more competitive species.

Ecological resilience to flow stress is greater in more natural channels, due to the greater habitat diversity and substrate stability that provide more refugia for the invertebrates at extreme high and low flows.

There are two sources of information from which to predict impacts of droughts on the ecology of the River Severn:

- previous droughts, most notably in 1975-76, were intensively monitored, providing valuable information from which to predict future impacts; and
- modelling of potential impacts. The Environment Agency is commissioning work to build an hydroecological model that will help us better understand how changes in regulation might impact the ecology.

During the 1975/76 drought period, water from Llyn Clywedog was used to provide flow for the Severn system. This resulted in higher than normal flows and lower temperatures during spring emergence and oviposition periods of aquatic insects. Conversely, it greatly reduced the level of the Llyn Clywedog, requiring a greater proportion of inflow to be retained in order to refill the reservoir. As a consequence, river flows were reduced for considerable periods even after rain returned, removing some of the natural flow variability along the river and leaving large areas of river bed exposed for long periods. Within the reservoir, silt build up increased and compensation water was taken from the bottom in order to remove this silt; its deposition in the Afon Clywedog, exacerbating the ecological problems.

7.1.1.2. Assessment of the River Severn

Water flow in the River Severn is regulated by two headwater reservoirs: Lake Vyrnwy on the Afon Vyrnwy and Llyn Clywedog on the Afon Clywedog and the Shropshire Groundwater Scheme. Therefore, to provide baseline information, two sources were used:

- Monitoring sites along the River Severn and its two main source tributaries: Afon Clywedog and Afon Vyrnwy. Several monitoring sites were chosen, each representing one of seven sections of the river, and each having a robust historical dataset. The exception to this is the most downstream section, for which no suitable macroinvertebrate data were available due to the methodology being unsuitable for this size of river and impacts of saline intrusion.
- Monitoring sites on two unregulated tributaries, the Afon Tanat and the River Teme were added as control points to compare the low flow responses on unsupported rivers.

Table 21 contains the ecological assessment sites and how they were paired up to the relevant River Severn Drought Order assessment point for this report.

Table 21: River Severn Drought Order ecological assessment points

Assessment Point	Watercourse	Invertebrate Site	Biosys ID	Grid reference
Clywedog (Bryntail)	Afon Clywedog	Park (BIO SP PT)	49874	SN94504 85475
-	River Severn	Dolwen	52148	SN9970085200
Vyrnwy (Vyrnwy weir)	Afon Vyrnwy	Mill Bridge Dolanog	50350	SJ06780 12860
-	River Severn	Lower Isle of Bicton	173804	SJ46198 16554
-	River Severn	Cressage	52526	SJ59472 04613
Buildwas	River Severn	Buildwas	158364	SJ64620 04425
Coalport	River Severn	Coalport	52795	SJ 70200 02100
Bewdley	River Severn	D/S Dowles Brook	52393	SO78000 76400
Saxons Lode	River Severn	Upper Ham[28]	172484	SO86177 40354

[28] Renamed to Upper Ham.

Deerhurst/Haw Bridge	River Severn	Hawbridge	51327	SO84500 27720
U/S Sharpness	n/a	n/a	n/a	n/a
Lower Parting	n/a	n/a	n/a	n/a
Control site	Tanat	Llanyblodwel	50766	SJ 24200 22900
Control site	Teme	Tenbury	48210	SO 59942 68511

The locations of these monitoring sites are shown in Figure 20.

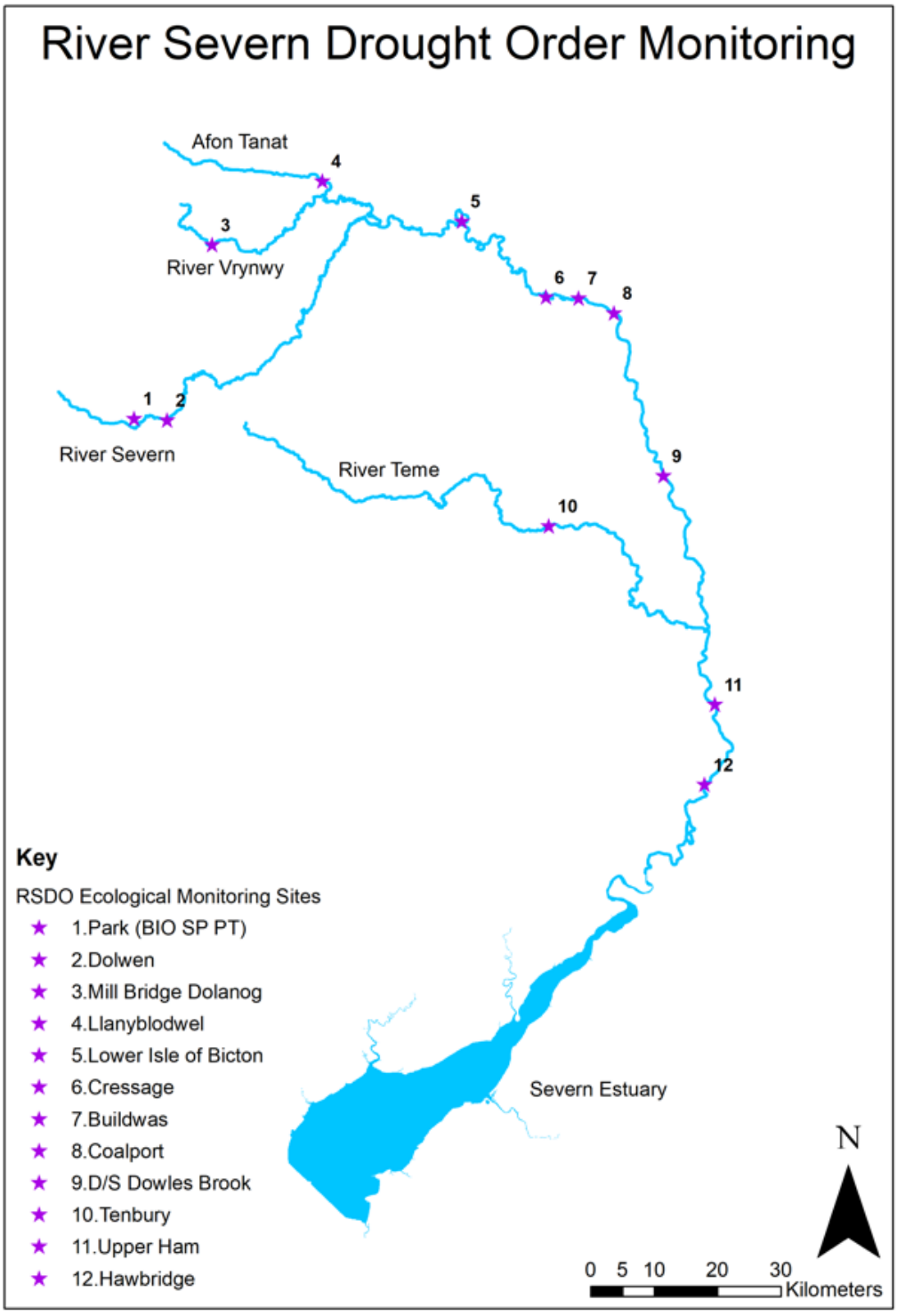

Figure 20 – Ecological sampling sites

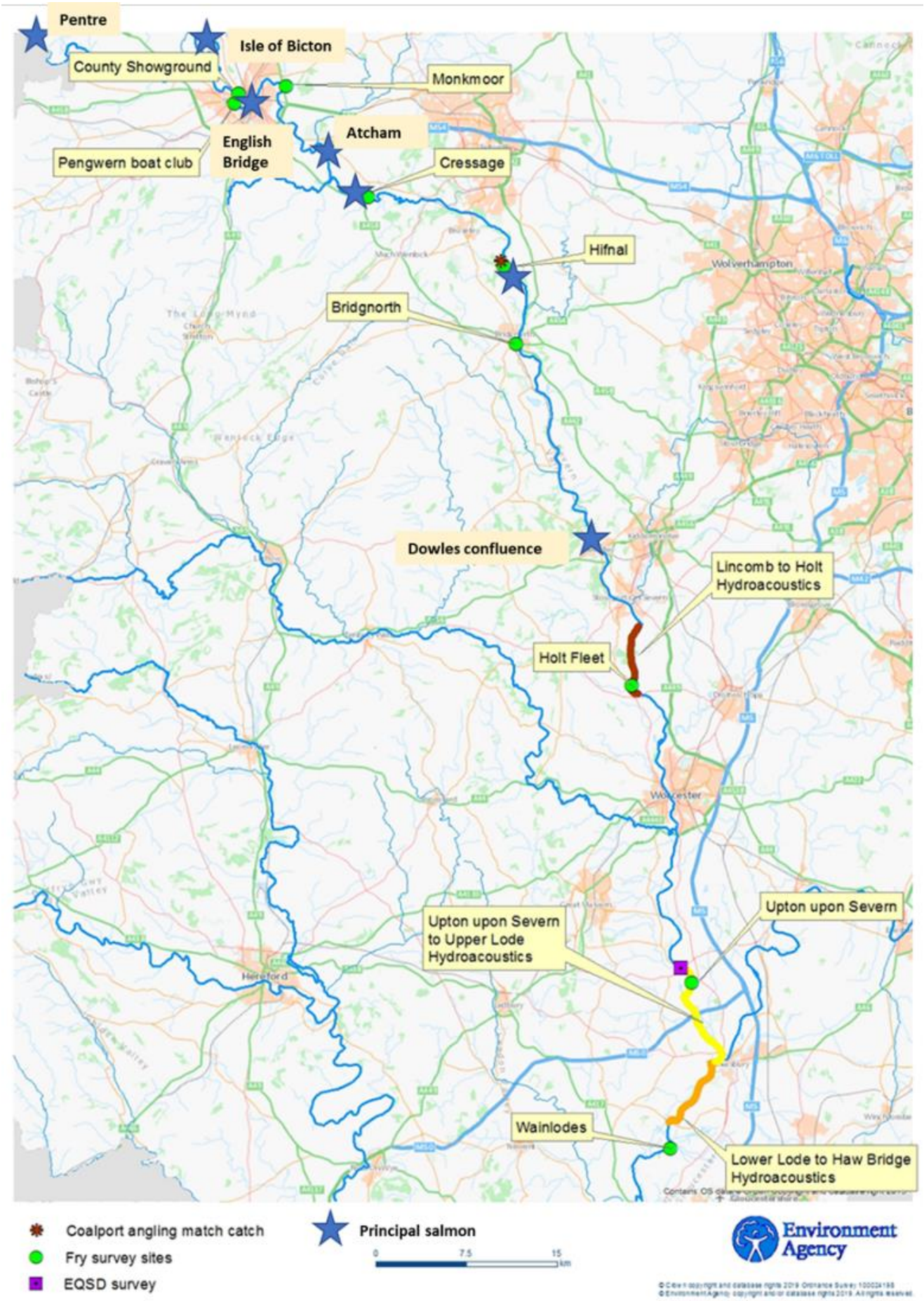

Figure 21 - Fish sampling sites in England

7.1.1.3. Water Framework Directive Status

The majority of the waterbodies on the River Severn, Afon Vyrnwy and Afon Clywedog have been designated as Heavily Modified Water Bodies (HMWBs) due to the regulation of river flows, flood protection and navigation measures. No HMWB is considered to achieve higher than Moderate potential, this is because until appropriate ecological mitigation measures are agreed/in place, the HMWB status limits the waterbody from achieving anything above Moderate status. All other waterbodies fail to achieve Good status

Table 22: Water Framework Directive (WFD) status of water bodies for main waterbodies impacted by Severn Regulation (Welsh waterbodies 2024 classification, English waterbodies 2025 classification)

Waterbody		Water Framework Directive Quality Elements						
Id number and Name	Overall Status/Potential	Mitigation measures	Chemical	Physico-chemistry	Diatoms	Macrophytes	Invertebrates	Fish
GB109054049880 R Vyrnwy – Lake Vyrnwy to conf Afon Cownwy	MODERATE POTENTIAL	MODERATE	GOOD	GOOD			GOOD	HIGH
GB109054049720 Afon Vyrnwy – conf Afon Cownwy to Afon Banwy	MODERATE POTENTIAL	MODERATE	GOOD	GOOD	GOOD	HIGH (NRW 2024 classification)	HIGH	HIGH
GB109054049851 Afon Banwy*	GOOD STATUS	NYA	FAIL	HIGH			HIGH	POOR
GB109054049852 Afon Vyrnwy – DS of Banwy confluence	GOOD STATUS		GOOD	GOOD	GOOD		HIGH	
GB109054044760 Afon Clywedog – Clywedog dam to R Severn	MODERATE POTENTIAL	MODERATE	GOOD	GOOD		HIGH (NRW 2024 classification)	GOOD	POOR
GB109054044790 R Severn – source to conf Afon Dulas	MODERATE STATUS	NYA	GOOD	HIGH	HIGH	GOOD	HIGH	MODERATE

								STATUS
GB109054049310 R Severn – conf Afon Dulas to conf R Camlad	MODERATE POTENTIAL	MODERATE	GOOD	GOOD	GOOD		HIGH	HIGH
GB109054049700 R Severn – conf R Camlad to conf Bele Bk	MODERATE POTENTIAL	MODERATE	GOOD	GOOD	MODERATE	MODERATE	HIGH	
GB109054049142 R Severn - conf Bele Bk to conf Sundorne Bk	MODERATE STATUS	N/A	FAIL	MODERATE	GOOD	MODERATE	HIGH	
GB109054049141 R Severn - Sundorne Bk to conf M Wenlock-Farley Bk	MODERATE STATUS	N/A	FAIL	MODERATE	GOOD	MODERATE	GOOD	
GB109054049143 R Severn – M Wenlock-Farley BK to conf R Worfe	MODERATE STATUS	N/A	FAIL	MODERATE	MODERATE	MODERATE	HIGH	
GB109054049145 R Severn - conf R Worfe to conf R Stour	MODERATE STATUS	N/A	FAIL	NOT ASSESSED	MODERATE	HIGH	HIGH	
GB109054049144 R Severn – conf R Stour to conf R Teme	MODERATE POTENTIAL	MOD/LESS	FAIL	MODERATE	GOOD	HIGH	GOOD	
GB109054039760 R Severn - conf R Teme to conf R Avon	POOR POTENTIAL	MOD/LESS	FAIL	MODERATE	MODERATE	GOOD	POOR	
GB109054044404 R Severn - conf R Avon to conf Upper Parting	MODERATE POTENTIAL	MOD/LESS	FAIL	MODERATE		GOOD	POOR	
GB109054032750	MODERATE POTENTIAL	MOD/LESS	FAIL	MODERATE			BAD	

R Severn (E Channel) - Horsebere Bk to Severn Est								

*Water body ID GB109054049850 Afon Vyrnwy – conf Afon Gam to conf Afon Tanat was split into two in cycle two and now comprises of waterbodies GB109054049851 and GB109054049852 Please note there is a difference in methodologies between how the EA and NRW calculate chemical status.

7.1.1.4. Physical Habitat

River Habitat Surveys (RHS) demonstrate increased incidence of heavily modified habitats and lower habitat quality assessment scores with increasing distance from source, demonstrating that there are fewer habitats and refugia available for macroinvertebrates and therefore probably reduced resilience to drought impacts.

7.1.1.5. Macrophytes

Submerged aquatic macrophytes are only present in any numbers on the River Severn upstream of Bewdley and on the Afon Vyrnwy. In general there is an increase in indicators of both increased nutrient status and reduced flow variation, reflecting the changing abiotic status of the river. The absence of macrophytes in the lower reaches of the Severn is an indication of the extent to which the channel has been physically modified. The RSDO monitoring programme has provided an increase in available macrophyte data, however the tools have yet to be developed to confidently determine whether periods of very low flow are having an effect on the macrophyte communities in the Severn, Clywedog and Vyrnwy.

7.1.1.6. Macroinvertebrates

All HEV plots can be found in Appendix J.1

Afon Clywedog
As part of the River Severn Regulation system, water releases are made from Llyn Clywedog reservoir during periods of low flow in order to maintain river flow further downstream (in the River Severn at Bewdley). As a consequence flows increase in the Afon Clywedog during periods of regulation. Data from six periods of summer flow release since 1989 generally showed a slight increase in LIFE O:E ratios, suggesting that flow-tolerant macroinvertebrates in this reach were benefiting from release of extra water. Number of taxa was generally low at this site, probably due to the unstable nature and the compacted substrate of the Afon Clywedog caused by releases of water from Llyn Clywedog. However, water quality indicators such as ASPT score highly, so poor water quality is unlikely to be a confounding factor.

The site does not generally suffer from siltation, although some build up is probable in spring before flow regulation releases begin.

Afon Vyrnwy
The lowest LIFE scores for the Afon Vyrnwy at Dolanog were recorded in autumn of 1996 and 2004. This may reflect the low flow years 1995/6 and 2003 but there is a lack of data collected for this site in the years preceding these dates, making interpretation of the data unreliable. The lowest PSI score occurred in autumn 1996, suggesting a build-up of fine sediment that may be a result of the low flows experienced during the previous year's drought.

River Severn upper reach (sampling points Isle of Bicton to Coalport)
This River Severn in England can be difficult to sample, particularly during higher flows, and this has resulted in data gaps that make interpretation difficult. However, there is evidence that there has been a general improvement in water quality since 2001; as poor water quality can compound drought effects, this improvement will have increased resilience of macroinvertebrate assemblages relative to previous low flow periods.

There is evidence of decline in LIFE scores and LIFE O:E following the low flows of 1995/96 and 2010/11, followed in the latter case by a recovery in LIFE by autumn 2012. The PSI scores

suggest an increase in fine sediment build up as a consequence of the reduced flows during these historic drought periods.

River Severn upper middle reach (sampling point at Bewdley)
Data are available for this sampling point from the mid 1970s onwards. This reach shows a clear macroinvertebrate response to low flows, with reduced LIFE scores (demonstrating loss of species with high velocity requirements) in the 1975, 1989/90 1995/96, and 2010/11 drought periods. Where data are available, however, they show evidence of recovery the summer after these drought periods. The PSI results suggest that periods of low flow are marked by an increase in sedimentation.

River Severn lower middle reach (sampling point at Upper Ham) and River Severn lower reach (sampling point at Hawbridge)
Sampling in these reaches has traditionally been by dredging but latterly by airlifting rather than kick-sampling, making comparison with sites in the upper catchment difficult. However, there are some important patterns in the data. There is little evidence of an invertebrate community response to reduced flows. Low PSI scores are recorded consistently; these may be partly due in the modified nature of the site, but also to the natural sedimentation that occurs in the lower reaches of the Severn.

Reference sites - River Tanat and River Teme
Both reference sites have diverse instream habitats which ensure that the macroinvertebrate community is resilient to the effects of low flow. Both sites show invertebrate response to variation in flow, but neither shows evidence of major changes due to severely reduced flow. The greatest impact on macroinvertebrates is following a second year of low flows, after which the time taken to recover is extended.

7.2. Baseline Environment: Fish of the Severn Corridor

This section provides a summary of the separate fish technical assessment, which is provided in Appendix K. Severn Estuary fish populations and their migration into the River Severn corridor have been investigated in more detail for the HRA. To save repetition this information is largely provided within the Habitats Regulations Assessment report in Annex 1.

A range of habitats are present in the Severn catchment, from high gradient, nutrient poor upland water courses, to lowland, low gradient, nutrient rich conditions, and the system supports a correspondingly broad range of fish species. The River Severn is a designated fishery under the EC Freshwater Fish Directive (2006/44/EC) (repealed by the Water Framework Directive in December 2013). A salmonid fishery extends upstream from the Shrewsbury weir and encompasses the Afon Vyrnwy, while a cyprinid fishery extends downstream of the Shrewsbury weir to Upper Lode near Tewkesbury.

7.2.1. Fish species of Conservation Importance

Alosa alosa (allis shad) and *Alosa fallax* (twaite shad) are classified as rare and listed in the Bern Convention and Annexes II and V of the EC Habitats Directive. They are primary features of the Severn Estuary SAC. Both shad species are anadromous and migrate from the Severn Estuary to the River Severn to spawn; up until recently the upstream extent of shad movement has been restricted by the weir at Diglis. However with the Unlocking the Severn project creating fish passage on the four navigation weirs on the River Severn (Lincomb, Holt, Bevere and Diglis) shad should now be able to get to the Severn Vyrnwy confluence.

River and sea lamprey are also anadromous Annex II species (river lamprey is also listed under Annex V of the Habitats Directive) and are designated features of the SAC. Lamprey species are

also notable sub-features of the ‘Estuaries’ SAC feature. In addition, three other species are notable sub-features: Atlantic salmon (Annex II species), sea trout and European eel (eel are also protected under the Severn Estuary Eel Management Plan).

Sea lamprey, River lamprey and Twaite shad are considered primary reasons for the selection of the site. Furthermore, the Severn Estuary also has notable species sub features, including an assemblage of over 100 fish species, of which, eel, sea trout, Allis Shad and salmon are noted as notable species sub-feature of estuary feature.

The main migration periods for these species within the Severn catchment are indicated below:

- Adult shad tend to migrate upstream between April and June with spent adults migrating downstream June to August, and juveniles moving downstream to the estuary in August/September.
- Migration of adult sea lamprey to the River Severn usually occurs in April to June, with the adult river lamprey tending to migrate upstream during autumn flows (August to December). Sea lamprey often travel up the Severn as far as Shrewsbury and have been known to get as far as Newtown and Llanymynech. Juvenile migration downstream occurs between October and February for both species.
- The main salmon runs up the River Severn are in spring (entering May to July and spawning in late autumn/early winter) and autumn (entering late September to early December and spawning in autumn/early winter). Salmon can migrate up the Severn to ‘Severn breaks it neck’ in the Hafren Forest, encompassing the regulated section of the River Severn, and to Dolanog Falls on the River Vyrnwy
- Glass eels mainly enter the Severn Estuary between February and May. The migration of elvers in the River Severn is limited by the presence of weirs and by flood defence works in the lower and tidal reaches. However, individuals do reach the upper reaches of the both the River Severn and River Vyrnwy.
- Migratory trout tend to migrate from the sea to the River Severn from summer into autumn, generally utilising gravels for spawning in autumn/early winter.

7.2.1.1. Population Assessment Methods

A combination of electrofishing in the narrower reaches of the Severn and hydroacoustic survey in the wider and deeper areas has provided fish population data for the Severn catchment. In addition, rod catch data were available for salmon and sea trout, while a database of catches from angling matches provided information for coarse fish species. Seine netting for coarse fish on the main River Severn in England helps give an indication of how successful that year’s spawning has been.

Data were also available from three types of fish counter in the catchment: a resistivity counter at Carreghofa on the Afon Tanat; a Vaki counter on the River Teme at Ashford; and a video camera system with motion detection on the River Severn at Shrewsbury. Only the fish counter at Carreghofa is at present operational and collecting data. There is also a video camera set up in the fish pass viewing window at Diglis which is used for upstream salmon counts at certain times of year. 2026 saw the highest number of spring run salmon pass through Diglis since recording began back in 2022.

7.2.1.2. Fisheries Baseline Environment

Atlantic salmon rod catches for the period 1951 – 2025 have fluctuated considerably across years. Since the late 1980s, however there has been a substantial decline. The current (2025) Atlantic salmon stock assessment for the River Severn is “At Risk” of failing its management objective, with a likelihood of failure of meeting the management objective in 5 years’ time. Returning stock estimates are at an all time low with numbers below 10% of the conservation limits in recent years.

Comprehensive datasets are available for 0+ salmon on the Afon Tanat and Rhiew from 2002 - 2010. After this date surveys are more sporadic. No significant correlation between egg deposition rates and numbers of juvenile salmon is apparent. Declines in salmon numbers are most evident at Pedair-fford and Glan Hafren on the Afon Tanat, while no clear trends are apparent at any of the sites on the Afon Rhiew.

Principal salmon catch per unit effort timed electric fishing surveys on riffles within England show that Atlantic salmon spawn in the main river from the Welsh border down as far as Bewdley. Coarse fry netting surveys in 2022 and 2023 between Shrewsbury and Upton upon Severn show that barbel fry were caught from Shrewsbury downstream to Bridgnorth, while gudgeon was the only species caught at all eight sites. Highest number of fish caught was at Holt Fleet in the middle reaches of the Severn.

The main long-term dataset available for the fish counters is from the Afon Tanat at Carreghofa which indicates that since 2006 there has been a gradual decline in the number of adult salmon recorded moving upstream. A comparison of upcounts against flow indicates salmon at the site demonstrate a tendency to move upstream during the period following high flows.

Hydroacoustic surveys conducted in the middle and lower sections of the River Severn have indicated fish densities are generally high in localised areas, particularly at weir pools. Overall, however, a national programme of these surveys has indicated that fish densities in the Severn are low when compared with other UK rivers. Observations during 2026 surveys suggest high densities of fish between Upton upon Severn and Upper Lode.

Recent match catch data from Rowley District Angling Club (Coalport) shows dace, bleak, chub and barbel were the most common fish caught. Numbers of the ‘silver’ fish (dace, chub, roach and bleak) have increased in the Severn over the last 10 years as can be seen in the match catch data

Monitoring in 2017 for Unlocking the Severn estimated a run of approximately 15,000 shad, while 2020 monitoring suggested a run of approximately 11,678. Based only on citizen science observations at Upper Lode weir the 2022 run of shad was only estimated to be a much smaller run of 3,500 shad. However, 632 shad were recorded as passing through Diglis fish pass in 2026, which is second highest number recorded, from reviewing camera footage taken at the viewing window. More recent estimates suggest that the annual spawning run to range between 8,500 and 30,000 (95% confidence limits).
The main breeding population of shad in the River Severn are twaite shad, although recent DNA analysis has shown a number of twaite x allis hybrids, which are fertile and continue to contribute to the population. Twenty eight different fish species have so far been recorded using the fish pass at Diglis highlighting the large species diversity of this section of the river which includes allis shad, twaite shad, Atlantic salmon, European eel, barbel, bleak, bream, brown/sea trout, bullhead, carp, chub, dace, grayling, gudgeon, river lamprey, sea lamprey, minnow, perch, pike, roach, ruffe, stone loach, tench, three spined stickleback, rainbow trout and zander.

7.3. Assessment of Impact on the Current Environment: Macroinvertebrates & Macrophytes

The main aim of this report is to separate the impacts of the River Severn Drought Order on the ecology of the River Severn from the impacts of the ‘Do Nothing’ scenario i.e. allowing the natural drought event to take its course, resulting in a potential complete loss of flows in the upper reaches of the Severn. There are two possible scenarios under a future drought episode, ‘Do Nothing’ and ‘Drought Order Only’, as defined in section 4.5. Each of these was modelled under two drought conditions, Acute and Chronic, as defined in section 4.4.

7.3.1. Assessment Methods

Of the four ecological indicators used in WFD classification (benthic macroinvertebrates, diatoms, macrophytes and fish), fish are considered in section 7.4, while macrophytes and diatoms were considered unsuitable for assessment. Therefore, this assessment considers potential impacts of the River Severn Drought Order on ecology with respect to macroinvertebrates only.

At present it is not possible to use the hydroecology toolkit that has been developed from the DRIED UP (Distinguishing the Relative Importance of Environmental Data Underpinning flow Pressure assessment) model to assess the potential impacts of the River Severn Drought Order because it is a regulated river. However, by looking at available historical macroinvertebrate data (including data from historical low flow periods) it is possible to suggest what may happen to macroinvertebrates under the different scenarios, using the hydrological modelling described in section 5.2.

Note that the impacts predicted below only relate to the Afon Vyrnwy, the Afon Clywedog and the two upstream sections of the Severn itself (upper reach and upper middle reach based on data gathered at Coalport and Bewdley respectively). In the lower sections of the River Severn the macroinvertebrate community appears not to be responding to variations in flow based on historical data. It must be noted that the sampling methods suitable for these sites are not compatible with the use of LIFE and PSI scoring indices.

7.3.2. Impact on Macrophytes

Although macrophyte data have been collected in recent years, the tools for assessing accurately how periods of very low flow would impact the macrophyte communities along the River Severn, Afon Clywedog and Afon Vyrnwy have not been available. Diatoms are generally not considered to be appropriate for use in drought monitoring and assessment at present, however monitoring has been undertaken ensure that we have some baseline data available should this change

7.3.3. Impact on Macroinvertebrates: Acute Drought Condition

Under the ‘Do Nothing’ scenario, upstream reaches were predicted to undergo severe declines in flow, and historic data suggest that the macroinvertebrate fauna would be affected, with a decline in flow-sensitive species (reduced LIFE scores) considered likely. Compensation flows were predicted to fail on the Afon Clywedog in late September and for 35 days flows of less than 10 Ml/d were predicted. Based on the hydrological modelling, this river and the Afon Vyrnwy were predicted to experience narrowing of the wetted channel and exposure of sediments. Following the drought there was predicted to be an extended period (at least 170 days) with no flow variation while the reservoirs refilled. It is considered likely that this would lead to sediment build up, dominance by more competitive species, and disruption of life cycles. Further downstream, exposure of as much as 50% of the river bed was predicted; at Coalport, the flow was predicted to remain at 1100 Ml/d for nearly 2 months but then was predicted to reduce to below 600 Ml/d towards the end of October. At Bewdley, river flow was predicted to fall even lower during the autumn, with a minimum flow of 336 Ml/d predicted.

Operation of the River Severn Drought Order would bring forward flow reduction in the Afon Clywedog by a month, but would ensure compensation flows continued for longer, thereby reducing the impact on macroinvertebrates. Following the end of the drought, loss of flow variation was predicted to occur for 224 days (whilst the reservoir refilled), 82 days fewer than under the ‘Do Nothing’ scenario, allowing the invertebrate community to recover more quickly. No change in flow relative to the ‘Do Nothing’ scenario was predicted on the Afon Vyrnwy as a result of application of the drought order. At Coalport river flows were predicted to drop by approximately 200 Ml/d during August and September, but were still predicted to be higher than naturalised. The River Severn

Drought Order was predicted to provide a flow benefit for approximately 20 days in the latter half of October. Further downstream, flows were predicted to be maintained at 730 Ml/d, there was no evidence of significant deterioration based on historical data, and flows were predicted to be higher than under the 'Do Nothing' scenario, until the start of the modelled rainfall at the beginning of November. Reductions in water quality were a confounding feature of the 1976 drought, but improvements since this time are expected to reduce this potential issue in future drought events.

7.3.4. Impact on Macroinvertebrates: Chronic Drought Condition

Under the 'Do Nothing' scenario, continuous low flows were predicted to have a dramatic impact on macroinvertebrates, with severe decline in low flow sensitive taxa. In the upstream reaches, flow failure was considered a strong possibility, and the length of time over which the impacts occur would have a consequent impact upon recovery times. Further downstream at Coalport and Bewdley, no significant flow failure was predicted but low flows were still predicted to cause a major impact.

Operation of the River Severn Drought Order was predicted to reduce impacts on the Afon Clywedog and Afon Vyrnwy, as there would be no compensation flow failure and there would also be a reduction in the length of post-drought time without flow variation. Further downstream at Coalport and Bewdley, no significant flow failures were predicted and a flow benefit was predicted to occur in the latter part of autumn.

7.3.5. Macroinvertebrate Conclusions

The biological data assessed within this report suggests that in the upper and middle reaches of the River Severn, macroinvertebrate assemblages respond to changes in flow. The available historical data indicate that flow sensitive ecology has been affected by low flows/drought events in the past. Reductions in LIFE scores in relation to the 1975/76, 1989/90, 1995/96 and 2010/11 droughts were detected and therefore it is probable that in the 'Drought Order Only' scenario (Acute and Chronic), the reduction in the amount of water used for regulation would have a negative impact on the macroinvertebrate community. Nevertheless, evidence from historical data suggests that macroinvertebrate assemblages will recover relatively quickly following drought. However, it must be remembered that the proposed drought order would be used to prolong the length of time water is available for regulation of the River Severn. If the drought order was not applied (i.e. the 'Do Nothing' scenario), there would be a much greater deterioration in the macroinvertebrate community and the length of time taken for the ecology to fully recover from the effects of a drought would be greatly increased.

Further work on the understanding of how flows impact the ecology of rivers and new tools will hopefully become available that will allow us to calculate the impact of modelled flows. The new Hydroecology toolkit developed from the DRIED UP (Distinguishing the Relative Importance of Environmental Data Underpinning flow Pressure assessment) model, at present is not suitable for use on regulated rivers to predict ecological response to altered flow, but work is ongoing in this area and it is hoped in future it will be possible to use a modelling approach on the regulated Severn.

7.3.6. Limitations and Assumptions

The main limitation on the predictions given here is the patchy nature of the biological data available. The lower reach has no data that could be used, while two of the other reaches have macroinvertebrate data that are not comparable, in terms of collection method, with those from

upstream. The need for further monitoring in the lower River Severn has been identified in Appendix N and airlift sampling methods are now being used.

At the time of this investigation river channel cross sectional data (e.g. depth, width, wetted perimeter etc) was not available at the required locations. Specific channel dimensions would allow the potential changes to in-river habitats to more quantifiably assessed, showing the direct impact that lowering water levels could have on the wetted perimeter or how much reduced flows might reduce velocity. This omission has been highlighted in the future work recommendations section **Error! Reference source not found.**.

A key assumption is that the macroinvertebrate community will respond to droughts, in this heavily regulated river system, in the same way as is predicted for rivers with more natural flow; this is largely borne out by the historical data available. The need for better prediction models, calibrated to regulated rivers such as the Severn, has been highlighted in the future work recommendations section **Error! Reference source not found.**.

A second assumption is that there has been no deterioration in water quality impacts on drought-stressed invertebrates since intensive data were last collected in the 1970s. Again, this is believed to be a valid assumption as evidence points to an improvement in water quality since this period.

7.4. Assessment of Impact on the Current Environment: Fish of the Severn Corridor

7.4.1. Assessment Methods

As part of the overall assessment, flows have been modelled at a range of locations (assessment points) for potential Acute (one year) and Chronic (two year) drought conditions. The assessment points were Clywedog, Vyrnwy, Buildwas, Bewdley, Saxon's Lode, Haw Bridge/Deerhurst, and Lower Parting.

The main approach was to look at hydrographs depicting the modelled flow at these locations under two scenarios:

- Do Nothing (baseline) scenario
- Drought Order Only

An assessment was then undertaken as to whether the flow was lower under the 'Drought Order Only' scenario or the 'Do Nothing' Scenario and what impacts there could potentially be on fish.

The assessment also considers the modelled flow in relation to the Environmental Flow Indicator (refer to Appendix C) values used within the water resources CAMS process.

For the twaite shad assessment, data were available for Saxons Lode indicating flows considered to be acceptable for this species for the period May to October (the acceptable flow ranged from 847 to 1426 Ml/d). Considerations for salmon, lamprey and elver were mainly based on whether the migration of individuals would be restricted. In addition, for the coarse fish assessments the potential for weirs and very shallow riffles to form potential barriers during low flows was considered.

Other aspects taken into account during the assessment, where appropriate, included the potential effects of low flow on water temperature and dissolved oxygen levels, and the potential effects of decreases in wetted width increasing susceptibility to predation e.g. by cormorants and goosander and leading to increases in competition for food, habitat and spawning areas.

7.4.2. Impact on Severn Corridor Fish: Acute Drought Condition

Clywedog
Under the 1976 'Do Nothing' scenario dead water was predicted for a period of 35 days. In addition, the flow was predicted to fall below a critical level of 70 Ml/d (determined from a PHABSIM assessment) for 397 days under the 'Do Nothing' scenario, while under the 'Drought Order Only' scenario the flow was predicted to fall below 70 Ml/d for 305 days. Overall, the significance of impact under the 'Drought Order Only' scenario is considered to be minor.

Vyrnwy
The Afon Vyrnwy site is dominated by salmonids. Having a drought order in place was predicted to make a negligible difference to flows when compared to the 'Do Nothing' scenario. As the low flows between November to April could potentially limit migration of Atlantic salmon to the upper sections of the Vyrnwy the significance of impact with the 'Drought Order Only'' scenario is considered to be minor.

Buildwas

This site on the River Severn is dominated by coarse fish, but used by migratory Atlantic salmon, eels and lamprey. Negligible differences in flow were predicted between the ‘Drought Order Only’ and ‘Do Nothing’ scenarios and flow remained above the EFI level. Available fish habitat may be reduced at the Ironbridge Gorge as the river changes form, however, overall the impact under the ‘Drought Order Only’ scenario is considered to be negligible.

Bewdley

This site is dominated by coarse fish with a number of riffles used by spawning salmonids. Under the ‘Do Nothing’ scenario flows were predicted to reduce to an average 368 Ml/d for 22 days (from 12th October), which is below the High Risk EFI level. With the ‘Drought Order Only’ scenario, river flows were predicted to drop slightly earlier in the year and remain at a higher level than predicted under the ‘Do Nothing’ scenario. The reduced ability of Atlantic salmon to migrate past fish passes and weirs due to reduced flows would make them more prone to predation and angling pressure. Overall, the significance of impact with the ‘Drought Order Only’ scenario is considered to be minor, and an improvement from the ‘Do Nothing’ scenario.

Saxons Lode

Under the Drought Order Only scenario, river flows were predicted to be around the ‘acceptable’ level for shad at Saxons Lode for August flows (acceptable level of 847 Ml/d), but were predicted to be lower than the acceptable level in September (acceptable level of 1054 Ml/d). The decrease in flow in October, however, was predicted to be more extreme under the ‘Do Nothing’ scenario and could impact twaite shad that have not migrated down to the estuary. Coarse fish fry within this section could benefit from enhanced growth due to the predicted low flows. Overall, the significance of impact under the ‘Drought Order Only’ scenario is considered to be minor.

Haw Bridge/Deerhurst

Under the 1976 ‘Do Nothing’ scenario at Haw Bridge/Deerhurst the flow was predicted to drop considerably on the 13th October for 19 days and was also predicted to drop below the High Risk EFI. Under the ‘Drought Order Only’ scenario the flow was predicted to be near the Medium Risk EFI level. The predicted reductions in flow are not expected to occur at critical times for most fish species in this section of the River Severn and overall the significance of impact under the ‘Drought Order Only’ scenario is considered to be minor.

Lower Parting
This section is within the tidal range of the estuary. High tides combined with low flows can lead to saline intrusion into the watercourse, an increase in suspended solids and low dissolved oxygen levels. It has been recommended that a critical flow of 1800 Ml/d at Haw Bridge is required to maintain critical levels for these parameters, however, this flow is not attained for 19% of the period 1975 to 1979 under all scenarios which could result in fish mortality (mainly of salmon). There is a large decrease in flow in October under all scenarios (the decrease in flow is reduced under the 'Drought Order Only' scenario) which may be detrimental to salmon and river lamprey waiting to migrate upstream and any shad that are still in the upper estuary. The significance of impact under the 'Drought Order scenario is considered to be moderate.

7.4.3. Impact on Severn Corridor Fish: Chronic Drought Condition

Clywedog
Low flows are predicted over the winter months between the first and second year of the Chronic scenario (1976-1977). This could limit the dispersal of salmon spawning in the upper Severn due to insufficient flows to stimulate movement up the catchment.

At Dolwen the flow was predicted to fall below 70 Ml/d (1975-79) for 469 days under the 'Do Nothing' scenario, while under the 'Drought Order Only' scenario the flows were predicted to fall below 70 Ml/d for 413 days respectively, which is considered to be an improvement for salmon. Overall, however, the significance of impact under the 'Drought Order Only' scenario is considered to be moderate.

Other assessment sites
For each of the other sites specific variations and considerations were noted, however, the assessment of impact significance under the 'Drought Order Only' scenario was considered to be the same as described above for the Acute scenario.

At the River Vyrnwy site in the second year near the end of the drought under both the 'Do Nothing' Scenario and the 'DO' scenario there are 20 days of irregular flows which could impact the fish population due to both change in flow and fluctuating temperatures. It is considered that salmonids could benefit from the cooler water but it could be detrimental to the coarse fish depending on the timing and magnitude. At Buildwas, flow remains above the EFI for all management options.

Under the 'Do Nothing' scenario at Bewdley the flow falls to an average flow of 289 Ml/d for about a month in October 1977 which could lead to the drying out of riffle sections and thereby have an impact on salmonids. Under the 'DO' scenario the fall in flow occurs much later in the year, is less extreme (fall to ~520 Ml/d), and lasts for a period of ~3-4 days. With the 'DO' in place scenario, however, flows from July 1977 onwards are lower than under the 'Do Nothing' scenario which could prevent salmon from negotiating fish passes leaving them more prone to predation and angling pressure.

At Saxons Lode under the 'Do Nothing' scenario flow falls to an average of 428 Ml/d for 22 days from the 10th October, whereas under the 'DO' scenario the decrease in flow is to ~530 Ml/d and lasts for a few days. As for Bewdley, flows from July onwards are lower under the 'DO' scenario which could have an impact on adult salmonid upstream movement. The impacts at Haw Bridge/Deerhurst are expected to be similar to those at Saxons Lode although modelling for 1977 suggests there could be saline intrusion in October due to the low flows.

A large drop in flow is predicted in October 1977 under the 'Do Nothing' scenario which could cause considerable problems for fish in the upper estuary waiting for autumn high flows due to potential saline intrusion and low oxygen levels. This is avoided under the 'DO' scenario, however, with these in place flow is modelled to decrease from July 1977 onwards which could lead to

freshwater flows into the estuary being too low to prevent saline intrusion and oxygen level sags which have the potential to be detrimental to fish within the upper estuary.

7.4.4. Fish Conclusions

The closest events in recent history to these modelled scenarios were the droughts of 1976 and 1989, when the River Severn Drought Order was operated. During the droughts of 1976 and 1989, water regulation releases were found to mainly benefit the upper Severn and had little effect on the lower river and estuary in which serious problems were recorded.

Twaite and allis shad
During drought events of similar magnitude to 1976 and 1989, the main concern would be related to shad within the upper estuary in the late autumn under the 'Do Nothing' scenario. Under this scenario, freshwater flows were predicted to be very low meaning that saline intrusion and reduced oxygen levels could cause distress.
River flows are also predicted to be lower during early summer under the 'Drought Order Only' scenario in comparison with the 'Do Nothing' scenario which could limit upstream migration of adult shad.

Sea and river lamprey
Sea and river lamprey are not expected to be significantly impacted under any of the different modelled scenarios. River lamprey migration could potentially be slightly delayed; however, as this species can migrate between August and April such a delay is unlikely to be detrimental.

Atlantic salmon
Regulation releases under the 'Drought Order Only' scenario would be generally beneficial to salmonids. There could still be problems with salmon mortality in the upper estuary due to low oxygen levels.

European eel
Although baseline drought conditions might impact the movement of elvers upstream it is considered that the various drought management scenarios assessed would not have a significant impact on the eel population.

Sea trout
Adult sea trout in the upper estuary waiting to migrate upstream could potentially be impacted by low flows under all scenarios. Regulation releases under the 'Drought Order Only' scenario would provide higher minimum flows, offering more protection than under 'Do Nothing.'

Overall
In the event of an Acute and especially a Chronic drought it is considered that under the 'Do Nothing' scenario there would be a significant adverse impact on the fish population of the River Severn, especially in the upper sections of the catchment at Clywedog and within the estuary.

Under the 'Drought Order Only' scenario, river flows in the upper catchment were not predicted to fall to the extremely low levels predicted under the 'Do Nothing' scenario. It is considered that implementation of the River Severn Drought Order would be beneficial to the fish population in the upper River Severn although further downstream, and in particular near the estuary, the benefits will be greatly reduced.

7.4.5. Limitations and Assumptions

Both the Environment Agency and Natural Resources Wales acknowledge minimal coverage of assessment points in Wales, which limits the ability of this report to fully assess the impacts in the upper Severn. This limitation will be addressed as part of the next review of the assessment.

The main difficulty in quantifying the impacts on fish was limited baseline data, specifically relevant to low flows and drought conditions. This issue relates to both the difficulty with monitoring larger sections of the River Severn and the routine timing of annual sampling. Quite often when suitable comparison flows occur, the annual monitoring programmes do not have a scheduled sample to take and therefore the opportunity to gather information has been lost.

The difficulty with monitoring larger sections of the River Severn, and particularly the Severn Estuary, is you cannot guarantee you are catching a representative sample of species present. Fish may avoid sampling nets or not be present at the sampling location on the day of monitoring; however they are known to be present because of information/data collected from anglers. However older data collection sites and methods are no longer consistent with WFD standards.

The need for more specific low flow data, in the lower tidal Severn and upper estuary in particular, has been included in the monitoring programme (section 15.2 and Appendix N) and further work recommendation sections.

7.5. Invasive Non-Native Species

Plants, aquatic life forms and animals that have been introduced to a place where they do not naturally occur are known as non-native species. Many of these live in the UK without causing a problem but a few become what's called invasive, resulting in damage to our environment, leisure and economy.

Invasive species upset the balance of the ecosystem as they may be bigger, faster growing or more aggressive than our native species. They also have fewer natural predators, diseases or parasites to control numbers. Our native species are often unable to compete and the invasive species increasingly take over.

Invasive non-native species (INNS) in our watercourses pose a threat to biodiversity, increase flood risk, affect the state of our water environment and cost the British economy by impacting on tourism and industry.

The Non-Native Species Secretariat (NNSS) is an organisation with responsibility for helping to coordinate a preventative approach to invasive non-native species in Great Britain, providing tools and information to help meet the challenge. NNSS is funded by Defra and the Welsh and Scottish Governments. The Environment Agency works in partnership with NNSS to promote what they do and to develop our own approaches to managing invasive non-natives in the course of our day to day duties.

Raw Water Transfers are being risk assessed by water companies through a tool that has been produced for Strategic Resource Options e.g. Severn Thames Transfer. All the water that is part of Severn regulation is from the Severn catchment so shouldn't need to be risk assessed for the purpose of this application for a drought order.

7.5.1. Invasive Non-Native Species for review

Spread of Invasive Non-Native Species (INNS) is an ever-increasing problem in the United Kingdom, especially with the added pressure of climate change. The following list of INNS is a diverse list of organisms that cover a wide array of threats to the freshwater environment within the Severn catchment;

1. Ponto Caspian shrimps – these invasive shrimps are voracious predators, killing other macro-invertebrates and small fish. They quickly dominate invaded habitats significantly altering their ecology. They can survive out of water in damp conditions for several days and their main pathway of spread is thought to be water users.
2. Water primrose (*Ludwigia grandiflora)* – this plant spreads vegetatively from plant fragments and also by seed. It can out compete native species and clog up waterways.
3. Floating pennywort (*Hydrocotyle ranunculoides)* – this plant spreads vegetatively and can grow up to 20cm per day, forming thick mats and impeding water flow and amenity use. It out-competes native species and blocks out light causing deoxygenation.
4. American signal crayfish (*Pacifasticus leniusculus)* – these crayfish spread up and downstream and have been known to cross land to colonise adjacent waterbodies. They outcompete native crayfish and are also a carrier of crayfish plague (fungal disease). They burrow into river banks causing destabilisation and predate on native invertebrates and fish eggs.
5. Topmouth gudgeon (*Pseudorasbora parva)* – this species has a very rapid reproductive cycle and can lay eggs on a range of surfaces, which helps dispersal. They compete for food with other fish and can live in very high densities. They can also be a carrier of infectious diseases.
6. Giant hogweed (*Heracleum mantegazzianum)* - this plant can grow up to 3m tall and it produces large numbers of seeds (approximately 20,000) to aid dispersal. It produces a phytotoxic sap that can cause severe blistering of skin.
7. Japanese knotweed (*Reynoutria japonica)* – this plant spreads vegetatively through plant fragments or roots. It out competes native species and dies back over winter leaving river banks unstable/ It can also cause structural damage.
8. Himalayan balsam (*Impatiens glandulifera)* – this plant spreads through seeds and is helped by a dispersal mechanism where seed pods ‘explode; sending seeds up to a distance of 7m. It out competes native species and dies back over winter, leaving river banks unstable.
9. Mink (*Mustela vison)* - mink are able to spread rapidly over land or via water. The main impact of these species has been predation of native species, especially ground nesting birds and small mammals.
10. Asiatic clam (*Corbicula fluminea)* – these bivalves are self-fertile (single individual can start a new population). They are often found in large densities (>2500 individuals/m^2) altering ecosystem dynamics.
11. Zander (*Sander lucioperca*) – these fish are a voracious predator and in some locations have been shown to impact native fish populations.
12. Chinese mitten crab (*Eriocheir sinensis*) – this invasive crab has been found down lower in the Severn estuary around Bristol. And can impact native benthic macroinvertebrates through predation and competition. Also burrowing can destabilise flood banks.

All of the INNS in the above list have been found in the Severn River Basin District.

7.5.2. Assessment of Invasive Non-Native Species

These INNS have been considered in relation to the River Severn Drought Order operations;

13. Ponto Caspian shrimps – at present killer shrimp (*Dikerogammarus villosus)* have not been found in the River Severn itself, although its ‘cousin’ *Dikerogammarus haemobaphes* has been recorded in the River Severn (Cressage to Haw Bridge) and the Gloucester & Sharpness

Canal. The most likely spread of these invasive shrimps would be through water users (e.g. anglers and boat traffic) and the application of the River Severn Drought Order is unlikely to impact their spread. The natural spread of the shrimps upstream would possibly increase due to lower flows but any obstructions like navigation weirs would be more difficult for them to be able to pass. Potential that decreasing wetted perimeter would mean they would outcompete our native shrimps to an even greater extent.

14. Water primrose – all known populations of the water primrose in the Severn catchment are in still water environments that are not directly connected to the River Severn. Therefore the application of the River Severn Drought Order is unlikely to impact this species.
15. Floating pennywort – the main populations of floating pennywort in the Severn catchment have been found in canals and ponds that are not directly linked with the River Severn. However, a growing population has been found on the River Avon between Tewkesbury and Evesham. If this was to get into the main River Severn changes in flow caused by decreases in regulation releases could allow this species to establish however it would most likely be washed away in winter floods.
16. American signal crayfish – the signal crayfish has been found throughout the Severn catchment and is the main reason for the decline in our native white clawed crayfish. It is unlikely that the implementation of the River Severn Drought Order would impact the further spread of this invasive crayfish.
17. Topmouth gudgeon – four populations of topmouth gudgeon have been recorded within the Severn catchment in offline pools and three have been eradicated. Two of these pools however are in close proximity to the River Severn. If topmouth gudgeon did have a population in the River Severn lower flows and warm weather would be ideal conditions for population increase.
18. Giant hogweed – this poisonous invasive plant has been recorded at numerous locations throughout the Severn catchment. Between Caersws and Welshpool giant hogweed can be found on the banks of the River Severn. Decreases in flow are only likely to reduce this plant's potential to spread seeds downstream.
19. Japanese knotweed – this plant is throughout the whole of the Severn catchment. During drought periods river levels would be lower and due to habitats being stressed there is potential for larger growths of Japanese knotweed. This plant spreads through vegetative reproduction and often high flows increase this. The changes from the implementation of the Severn Drought Order are unlikely to alter the spread of Japanese knotweed.
20. Himalayan balsam – this is another plant that is spread throughout the catchment. During drought periods river levels would be lower and due to habitats being stressed there is potential for larger growths of Himalayan balsam. Unlike Japanese knotweed this plant spreads through seed dispersal, but also high flows do improve dispersion. The changes to flows from the implementation of the Severn Drought Order are unlikely to alter the spread of this species.
21. Mink – this animal continues to be spread throughout the Severn. During times of drought fish will become stranded in pools and so therefore will be easier to catch by predators such as mink. On the main River Severn this should not happen but wetted width would decrease and so predation is likely to still increase. The application of the Severn Drought Order will maintain flows for longer and so decrease the problems of predation that would happen in the higher reaches of the Severn under the Do Nothing flow crash scenario.
22. Asiatic clam – this bivalve has been recorded in the lower Severn (around Tewkesbury and down to Gloucester). During drought periods the flow would be lower and temperature warmer, this would potentially suit the Asiatic clam. The application of a Severn Drought Order is unlikely to have an impact on the spread of this species.
23. Zander – this fish is already prevalent in the lower reaches of the River Severn (Upton upon Severn to Tewkesbury) and is quite prized by anglers. A lowering of flow would likely increase the ease of zander to catch prey species. The Severn Drought Order therefore might be beneficial to zander populations in the Lower Severn.
24. Chinese mitten crab – at present the distribution of this species is only in the lower Severn estuary and so the changes in flow from the Severn Drought Order is unlikely to have any

impact however in their home range the mitten crab can migrate upstream long distances, depending on the timing of the drought order this could make upstream migration easier.

7.5.3. Invasive Non-Native Species conclusion

With specific regard to the area covered by the River Severn Drought Order, only American signal crayfish, giant hogweed, Japanese knotweed, Himalayan balsam, topmouth gudgeon,mink and zander are likely to be problematic. Considering the individual reproduction and dispersion methods for each of these species the majority of them did not identify an increased risk through the River Severn Drought Order implementation.

Mink and zander were the only species known to be in the River Severn that may benefit from improved predation opportunities experienced during a natural drought event. However modelling found although the River Severn Drought Order would initially lower water levels and flows along the main River Severn corridor, the Acute and Chronic Conditions both showed that if the drought persisted, higher flows and water levels would be supported than under the 'Do Nothing (Baseline)' scenario. Therefore additional protection would be provided to fish and other vulnerable species under the River Severn Drought Order implementation, helping to reduce the benefit to mink. Any adverse impacts would be temporary and have no prolonged adverse impact; therefore no adverse impact is concluded. Topmouth gudgeon could possibly be in the River Severn, although there are no records at present. If they are found to be within the Severn then low summer flows would suit this species. The application of the Severn Drought Order would likely be a benefit for this species.

Looking into the future there are a number of other species that could possibly become an issue within the River Severn. While the implementation of a drought order might favour certain species it is still a better option than the Do Nothing scenario.

7.6. Monitoring and Mitigation Options

Ecology specific monitoring and mitigation options are contained within the Ecology technical report in Appendix J, Fish technical reports in Appendix K, and incorporated into the overall mitigation programme in section 14 and monitoring section 15 respectively.

INNS have not been specifically considered for monitoring purposes due to the conclusion of no impact. Routine work and monitoring to target INNS will continue but is not within the remit of this environmental assessment report.

8. Designated sites connected to the River Severn

The River Severn Drought Order could have an impact, whether positive or negative, via primary or secondary pathways (refer to section 4.1). Any sites which are in hydraulic continuity with the main River Severn could potentially be impacted and therefore needed considering as part of this environmental assessment report.

Hydraulic continuity means a site is connected to the main River Severn by some form of water pathway. For example this could be a tributary river, a drainage ditch or a canal, which would allow species to move from the main River Severn into the site and vice versa. It can include wetland sites which are directly connected to the River Severn, or within flood plains along the banks.

8.1. Sites in Hydraulic Continuity with the River Severn

There are numerous designated sites within the River Severn catchment, this environmental assessment report has identified all those sites which have the potential to be impacted because they are in hydraulic continuity with the River Severn. These sites are listed in the table in Appendix A.

8.2. Assessment Method

The sites were initially screened to test what the main flow parameter was, identifying the type of water levels that would be important to the health of the site. For example, sites that relied on flood water would not be impacted by the River Severn Drought Order, as the natural weather phenomena driving a drought would exclude these sites anyway. The screening identified which sites were reliant on normal to low flows, and sites with clear impact pathways were identified (red font in the table in Appendix A) and taken forward into the Habitat Regulation Assessment process for greater scrutiny.

In summary, the geological sites are unlikely to be affected by the River Severn Drought Order as they are not dependent on water. They are more likely to be eroded/damaged by flooding events arising from prolonged or heavy rainfall events. Geological sites were therefore screened out as not impacted by the River Severn Drought Order.

Many sites were found to be dependent on/benefit from being flooded, and were therefore unlikely to be affected by the River Severn Drought Order, which would be impacting flows below the sites needs. During drought conditions evaporation would be expected to exceed precipitation so those sites in hydrological continuity with the river would be more significantly impacted by natural weather conditions. Regulation of the river guarantees continued water supply to sites along the main River Severn (in channel) which places them at significant advantage over neighbouring catchments that are routinely impacted by natural low flows.

Application of the River Severn Drought Order should be beneficial in ensuring the continuation of flows throughout the worst period of a long term drought. Evidence to oppose these conclusions, along with site specific water level and minimum flow requirements would be required for individual sites if further investigation was requested.

8.3. HRA Screening Conclusions

From the sites identified in Appendix A, 13 relevant sites were taken through the Habitats Regulation Assessment (HRA) screening process on the basis that they were in direct hydraulic connectivity with the River Severn, were linked to the Severn Estuary or were a species which migrated through the estuary. These sites are all listed in Table 23.

Table 23: HRA screened sites in Hydraulic continuity with the River Severn

Site	Designation	Relationship to River Severn	Risk of Likely Significant Effect (LSE)
Berwyn and South Clwyd Mountains	SAC	Headwaters of the Afon Vyrnwy which provides a component of the River Severn regulation	No
Berwyn	SPA	Headwaters of the Afon Vyrnwy which provides a component of the River Severn regulation	No
Montgomery Canal	SAC	In direct hydraulic connectivity with the River Severn as it is fed by water taken from River Severn and River Tanat. This is allowed under an abstraction licence granted by Natural Resources Wales	No
River Clun	SAC	In direct connectivity with the River Teme which is a major tributary of the River Severn. Salmon which are a feature of the Severn Estuary are a feature of the Freshwater Pearl Mussel life cycle.	No
Downton Gorge	SAC	River Teme which is a major tributary of the River Severn flows through this site. Salmon migrate up the River Teme to get to the River Clun where they are a feature of the Freshwater Pearl Mussel life cycle	No
Walmore Common	SAC	In direct hydraulic connectivity with the River Severn via ditches	No
Walmore Common	Ramsar	In direct hydraulic connectivity with the River Severn via ditches	No
Severn Estuary	SAC	In direct hydraulic connectivity with the River Severn	Yes
Severn Estuary	SPA	In direct hydraulic connectivity with the River Severn	No
Severn Estuary	Ramsar	In direct hydraulic connectivity with the River Severn	Yes
River Wye	SAC	Although not linked to the River Severn are linked to the Severn Estuary	No
River Usk	SAC	Although not linked to the River Severn are linked to the Severn Estuary	No
River Tywi	SAC	NRW requested the inclusion in relation to migratory fish and the Severn Estuary	No

The majority of sites were concluded as not being negatively impacted by the River Severn Drought Order, and/or receiving benefits from its operation. The HRA screening did identify potential impacts for further investigation as follows:

- for the Severn Estuary SAC overall estuarine feature it was uncertain whether there was a likely significant effect, either alone or in combination; and
- for the Severn Estuary SAC and Ramsar site there was likely to be a significant effect on the fisheries feature of the site.

The HRA screening results led to an Appropriate Assessment being carried out for the estuarine and fisheries features of the Severn Estuary SAC and Ramsar. Further detail can be found in the Severn Estuary section 9.

The Habitats Regulation Assessment (including the Screening and Appropriate Assessments) produced for the Severn Estuary National Site Network, and other potentially impacted sites can be found in full in Annex 1.

9. The Severn Estuary

The Severn Estuary is protected by the Habitats Directive (Directive 92/43/EEC on the conservation of Natural Habitats and Wild Flora and Fauna), Birds Directive (Directive 79/409/EEC on the protection of wild birds) and Ramsar Convention 1971 (Internationally important wetlands, afforded the same protection as SPAs and SACs by UK Government) legislation.

The Environment Agency and Natural Resources Wales are both a 'competent authority' under Regulation 7(1) of the Conservation of Habitats and Species Regulations 2010 (SI No. 2010/490), commonly referred to as the Habitats Regulations. Under Regulation 9(5) it states 'a competent authority must have regard to the requirements of the Habitats Directive when exercising any of its functions.' In accordance with the legislation, a Habitats Regulations Assessment (HRA) for the modelled Drought Order scenarios has been carried out for all the relevant sites along the River Severn. Natural England and Natural Resources Wales have been consulted throughout.

Now that Natural Resources Wales has been formed, it has a second role in safeguarding the Severn Estuary. Natural Resources Wales will now also be a statutory consultee under the Habitats Regulations (similar to Natural England). Functional separation between these sections of Natural Resources Wales will ensure transparent and rigorous scrutiny of the HRA proposals.

To save duplication, this section only contains some background information on the Severn Estuary and a summary of the HRA assessment conclusions and mitigation options. For more detail please refer to the complete **'Habitats Regulations Assessment (River Severn Drought Order)'** report in Annex 1.

9.1. Baseline Environment

The Severn Estuary is the largest example of a coastal plain estuary in the United Kingdom and one of the largest estuaries in Europe, shown in Figure 22. The overall area of the estuary covered by European and International conservation designations is 73,715.4 ha of which roughly two thirds is composed of subtidal habitats (stable sandbanks and shifting sediments of gravel, sand and mud) and one third is composed of intertidal habitats (tide washed mud and sand, salt marshes and rocky shores).

The estuary lies in the broad Severn Vale, with most of the sediments on the margins of the estuary having accumulated since the last ice age. It has been a focus for human activity, a location for settlement, a source of food, water and raw materials and a gateway for trading and exploration. As well as supporting the cities of Cardiff, Bristol, Newport and Gloucester, major industries are sited around the Estuary's shores including modern port installations, chemical processing companies and nuclear power stations. Aggregate extraction also occurs within the estuary.

Alongside all these competing activities, the Estuary also supports a wide array of habitats and species of international importance for nature conservation. A number of habitats and species have also been recognised through the designation of several Sites of Special Scientific Interest (most notably, the Upper Severn Estuary, Severn Estuary and Bridgwater Bay SSSIs in the 1980's) which underpin the European and International designations.

The Severn Estuary is designated on the basis that the immense tidal range (the second highest in the world) and classic funnel shape make the Severn Estuary unique in Britain and very rare worldwide. The intertidal zone of mudflats, sand banks, rocky platforms and salt marsh is one of the largest and most important in Britain. The estuarine fauna includes: internationally important populations of waterfowl; invertebrate populations of considerable interest; and large populations of migratory fish, including the nationally rare and endangered Allis Shad *Alosa alosa*. The SSSI

forms the major part of a larger area of estuarine habitat, which includes the Upper Severn Estuary, the Taff/Ely Estuary and Bridgwater Bay. The estuary also has a diverse geological setting and a wide range of geomorphological features especially sediment deposits.

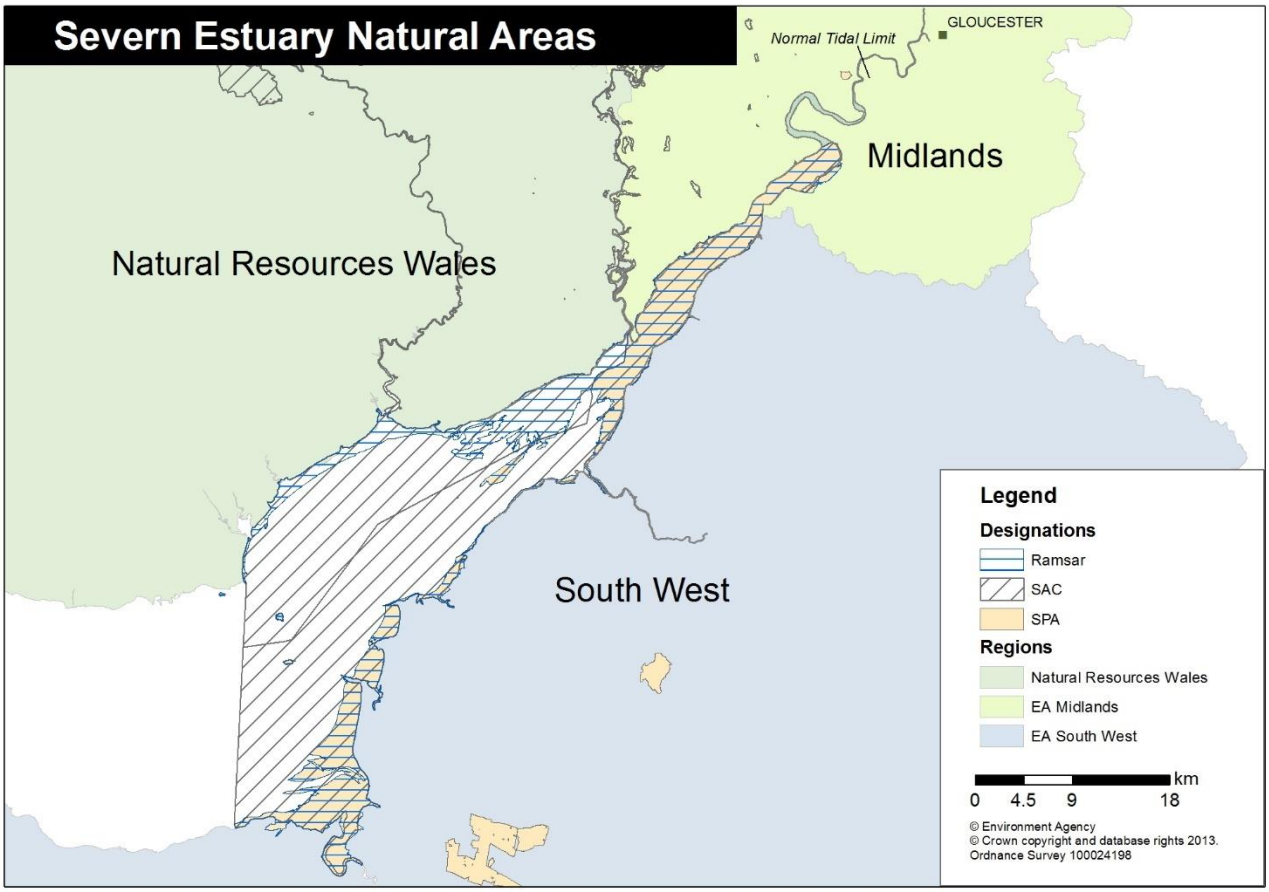

Figure 22: Severn Estuary National Site Network designations

Table 24 shows the wide range of nature conservation features for which the estuary is valued and the interrelationship of these features by designation. This table outlines features of European and International importance in their own right and others of national importance for which the Severn Estuary has been designated as a Site of Special Scientific Interest (SSSI) but which form an intrinsic part of the Severn ecosystem and therefore contribute to the overarching “estuary” feature of the SAC and Ramsar Site.

Table 24: Summary of Notified features of each designation:

Feature	SAC	SPA	Ramsar Site	SSSI (Nationally important feature)
Estuary	Yes	*Supporting habitat to designated bird interests*	Yes	Yes
Subtidal sandbanks	Yes	No – outside boundary of SPA	No – outside boundary of Ramsar Site	No– outside boundary of SSSI
Intertidal Mud and Sand	Yes	Supporting habitat to designated bird interests	*Component of Ramsar "estuaries" feature and supporting habitat to designated bird interests*	Yes
Atlantic salt meadow / salt marshes	Yes	*Supporting habitat to designated bird interests*	*Component of Ramsar "estuaries" feature and supporting habitat to designated bird interests*	Yes
Reefs	Yes	No	*Intertidal Sabellaria contiguous with subtidal reefs is a component of the hard substrates subfeature of the Ramsar "estuaries" feature*	No – outside boundary of SSSI
Migratory fish (river & sea lamprey & Twaite shad)	Yes	No	Yes	Yes
Migratory fish (salmon, eel, sea trout and Allis Shad)	*Part of notable species sub-feature of estuary feature*	No	Yes	Yes
Assemblage of fish species (>100 species)	*Notable species sub-feature of estuary feature*	No	*Notable species sub-feature of estuary features*	Yes
Internationally important populations of migratory bird species	*Notable species sub-feature of estuary feature*	Yes	Yes Internationally important populations of waterfowl	Yes
Internationally important populations of	*Notable species sub-feature of estuary feature Yes*	Yes		Yes

wintering bird species				
Assemblage of nationally important populations of waterfowl	*Notable species sub-feature of estuary feature*	Yes	Yes	Yes
Hard substrate habitats (Rocky shores)	*Notable species sub-feature of estuary feature*	*Supporting habitat to designated bird interests*	*Component of Ramsar "estuaries" feature and supporting habitat to designated bird interests*	Yes
Freshwater grazing marsh / Neutral grassland	No	*Supporting habitat to designated bird interests within SPA but outside European Marine Site* **and therefore not addressed in this Regulation 33 advice document**		Yes (currently England only)

9.2. Assessment of Impact on the Current Environment: Severn Estuary

As a 'competent authority' under Regulation 7(1) of the Conservation of Habitats and Species Regulations 2010, under Regulation 9(5) we "must have regard to the requirements of the Habitats Directive when exercising any of its functions", which includes activities authorised by a drought order. It is therefore necessary for the Environment Agency to undertake a Habitats Regulations Assessment (HRA) for this Drought Order. The HRA tests whether the impacts identified as arising from a permit/order, project or plan are likely to have a significant effect on European sites.

9.2.1. Assessment Method: HRA Screening

For the River Severn Drought Order HRA screening was conducted to identify the likely impact of the Acute and Chronic drought conditions (and subsequent scenarios) on the relevant European sites and determine whether they are likely to be significant. This process identifies those sites and features of the sites where an Appropriate Assessment of the drought option is required. The River Severn Drought Order HRA screening identified;

- for the Severn Estuary SAC overall estuarine feature it was uncertain whether there was a likely significant effect, either alone or in combination.
- for the Severn Estuary SAC and Ramsar site there was likely to be a significant effect on the fisheries feature of the site.

The screening results determined an Appropriate Assessment was required for the estuarine and fisheries features of the Severn Estuary SAC and Ramsar. The Appropriate Assessment document includes the sites and designated features, determines whether there is the potential for likely significant effects or whether significant effect is uncertain and needs further investigation.

The **'Habitats Regulations Assessment (River Severn Drought Order)'** is available in Annex 1 as a separate report and contains all the relevant site information, HRA screening and appropriate assessment work for the Habitat Directive sites and the Severn Estuary.

9.2.2. Severn Estuary HRA Findings: Drought Order Only scenarios

In Section 4.1.1.1 of the Severn Estuary SAC, SPA and Ramsar Site: Regulation 33 Advice from CCW and Natural England, June 2009 it states that ‘A failure to meet these conditions, which is entirely a result of natural process will not constitute unfavourable condition, but may trigger a review of the definition of favourable condition’. The Regulation 33 advice recognises variable weather conditions, tidal surges and the fact that estuaries are dynamic systems and that particular communities can have short term disappearances or crashes.

Drought is a natural event and will cause low flows that result in various effects, having a particularly adverse effect on fish migration. The impacts on the designated migratory fish was identified under both scenarios; the extreme natural drought ('Do Nothing (baseline)') and 'Drought Order Only' scenario. Fish passage was identified as the major issue and unlikely to be improved without the removal of barriers to migration. The impact on migratory fish was identified for the 'Do Nothing' scenario and although the River Severn Drought Order provided benefits, the failure was still found to be likely under the 'Drought Order Only' scenario. As the initial 'Do Nothing' failure was a result of the natural drought process and not the operation of the River Severn Drought Order (WFD Article 4.6, refer to section 10) it should be short term and therefore would not constitute the migratory fish feature being in unfavourable condition.

During previous drought events, prior to the implementation of the River Severn Drought Order, fish mortalities were recorded in the Severn Estuary and lower tidal Severn. Water quality has significantly improved at Netheridge STWs (Appendix L and M) since these droughts. Modelling found the implementation of the River Severn Drought Order in conjunction with these water quality improvements should reduce the risk of fish mortalities resulting from water quality issues, and certainly provide an improvement to conditions under the natural drought (Do Nothing scenario). This will help support any migratory fish waiting in the Severn Estuary and reduce the natural risks that have been recorded during previous droughts. Implementation of the River Severn Drought Order was also found to provide resilience should there be an ongoing drought, better supporting fish migration in subsequent years, which could support a faster recovery of fish species during post drought years.

For the 'Drought Order Only' scenarios under both the Acute and Chronic Conditions it was concluded the baseline drought conditions caused the adverse effect on the migratory fish while implementation of the River Severn Drought Order would lessen or minimise the impacts. **Therefore it was concluded that implementation of the River Severn Drought Order alone (‘Drought Order Only’ scenarios), did not have an adverse effect on the designated migratory fish features of the Severn Estuary SAC and Ramsar.**

9.3. Mitigation Requirement

This Appropriate Assessment determines whether, in view of the European site’s conservation objectives, the implementation of a River Severn Drought Order ‘either alone or in combination with other plans or projects’ would have an adverse effect on the integrity of the site. Where adverse effects are identified, which cannot be avoided or mitigated for, alternative options or solutions must be considered.

If it is not possible to identify mitigation or alternatives, consideration should be given to whether the sites host priority habitats/species, and if there are important human health/safety considerations 'imperative reasons of overriding public interest' (IROPI). If Imperative Reasons of Overriding Public Interest (IROPI) are determined, then compensatory measures must be designed, assessed and put in place, prior to the commencement of the plan. This is not considered a standard part of the process and will only be carried out in exceptional circumstances.

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9.4. Severn Estuary Conclusions

As a drought progresses flows get lower and to be in a situation where a River Severn Drought Order is being applied for, flows will already be impacted by drought, especially where the channel splits around Gloucester. It should be noted that it is not the effects of the drought that is being assessed but the effects of implementing options considered in the River Severn Drought Order.

The modelling undertaken for the HRA and historic drought reports from the 1975/6 and 1984 droughts as well as anecdotal evidence found the lowest flows were experienced in the Lower Tidal Severn (especially around Gloucester). Implementation of the River Severn Drought Order alone was unlikely to cause likely significant effects on the overarching designated estuary feature, sub features or supporting habitats. In particular modelling demonstrated that WFD targets were unlikely to be failed during low flows.

As well as being the stretch of river experiencing the lowest flows, the Lower Tidal Severn was particularly vulnerable due to the combination of low flows and saline intrusion associated with Spring and Neap tides, another natural event. The combination of low flow and increased salinity has led to dissolved oxygen lags resulting in fish mortalities in the past. However despite the improvements in water quality, which have greatly reduced the risk, migratory fish are still vulnerable given the reduction of flow that can occur, potentially leaving them stranded in pools and at the periphery of the river. They would be at even greater risk if the drought was accompanied by high temperatures as ponded areas or fringes of the river would dry out more quickly and the temperature of the water rise. Besides the risk of fish kills, low flows could also impact on their migration up or down the river, which has been discussed in the Appropriate Assessment.

The Gloucester & Sharpness Canal abstraction was assessed during the Review of Consents (RoC) Stage 3 process[29], to determine whether it had a significant effect on freshwater flows from the Severn into the Estuary. Both influenced (current observed) and natural flows were found to be above 'Good ecological status,' and therefore concluded as providing sufficient flows into the estuary. The work on migratory fish also concluded that none of the abstractions (including this one) had an impact on the integrity of shad or lamprey alone or in-combination. It is important to note the RoC did not cover the impacts of lowering the regulation flows for drought management; the work conducted for the River Severn Drought Order environmental assessment report builds on the RoC process to investigate severe drought scenarios.

An Operating Agreement (1998) between the Environment Agency and the Canal & River Trust largely safeguards the Severn Estuary during normal regulation years. Clause 7 of the Operating Agreement however excludes drought conditions, during which the Gloucester & Sharpness Canal could legally abstract up to 398 Ml/d. The Canal & River Trust remain committed to making best endeavours to meet the obligations set out in the Operating Agreement. The impact on the Severn Estuary and migratory fish would vary according to when and how much water is abstracted from the River Severn at Gloucester.

It is recognised that sufficient abstraction for the Gloucester & Sharpness Canal is needed to support Bristol Water's PWS abstraction from the canal, however the ability to abstract 398 Ml/d remains a potential risk and could also be considered to negate the benefits intended by implementing the River Severn Drought Order.

Through the River Severn Drought Order modelling and historic drought information that has become available since RoC, the potential effects of the Gloucester & Sharpness Canal abstraction during severe low flows has been fully realised. The maximum abstraction of 300 Ml/d

[29] The initial summary provided during external consultation stated the Gloucester & Sharpness Canal abstraction had not been assessed during RoC. A more thorough investigation of the audit reports forming the RoC process identified the abstraction was in fact considered and investigated as far as possible at the time.

in combination with the River Severn Drought Order should not cause a likely significant effect on the designated estuary and its features.

The HRA Appropriate Assessment concludes that while the natural drought could be impacting fish migration, no additional adverse effect on integrity should result because of operating the River Severn Drought Order. Water quality has improved in the lower tidal Severn enough to ensure fish should not be harmed by the 'Drought Order Only' scenarios, even if the fish are delayed or fail to migrate as a natural consequence of the drought.

The most appropriate option to balance water needs and the requirements of the Habitats Directive was found to be limiting the abstraction to the Gloucester & Sharpness Canal. Because the Habitats Regulations Assessment was able to conclude a maximum abstraction of 300 Ml/d to the canal was unlikely to cause harm to the National Site Network designations, applications for this Drought Order will include an abstraction cap of 300 Ml/d on the Canal & River Trust, when flows at Deerhurst drop below 1200 Ml/d. If the Drought Order is granted, the conditions set would become legally enforceable. This action should successfully mitigate any potential harm to the National Site Network and satisfy the Habitat Directive requirements.

The Environment Agency views the restriction as aiming to protect environmental needs whilst still allowing the Canal & River Trust enough water to meet its main obligations. The Canal & River Trust has raised concerns that 300 Ml/d could pose a risk to their operations.

9.5. Limitations and Assumptions

Uncertainty remains around the Gloucester & Sharpness Canal abstraction volumes and timings, which introduces uncertainty within the assessments. The Canal & River Trust have their own statutory obligations to protect the environment and an internal Drought Plan with advisory trigger for closing the canal to navigation.

The appropriate assessment was carried out using the specific Acute and Chronic drought conditions; however the exact timing of a real drought may be different to what has been outlined in this assessment.

It is important to note the models used are based on daily flows and cannot account for tidal variations. These impacts have been considered outside of the drought flow model (Aquator) but again the timing and exact magnitudes coinciding with low flows cannot be guaranteed. All droughts will be different.

Specific flow targets, variable flows, maximum and minimum flow guidance is lacking for the Severn estuary site. It has numerous designations but still only limited data and quantifiable targets in relation to freshwater flow requirements. This limits the accuracy of assessments and better science and tools are needed in the future to help all the organisations involved understand the sensitivities of the site and its designations, and how to accurately assess the impacts.

9.6. Monitoring and Mitigation

The process of carrying out this appropriate assessment has identified gaps in our knowledge and how additional monitoring would contribute to the overall understanding of the Lower Tidal Severn and the Severn Estuary. During low flow conditions it is vital that we have base line data against which monitoring undertaken during a drought can be assessed. It is also necessary to undertake post-drought monitoring so that the recovery of habitats and species can be assessed. It is only by obtaining this whole suite of data that the whole process of a drought and its impacts can be fully assessed and understood. Estuary specific monitoring options are contained within the HRA report in Annex 1 and incorporated into the overall monitoring programme in section 15.

10. Water Framework Directive

The European Water Framework Directive (WFD) established a legal framework for managing the water environment across Europe. It focuses on an ecosystem-based approach that promotes the sustainable use of water and seeks to protect and improve inland surface waters, groundwater and coastal waters with the aim of achieving good status. The Directive recognises the importance of collaboration between interested parties in designing and implementing improvements through t holistic and integrated approaches to managing the water environment.

The WFD requires a River Basin Management Plan (RBMP) to be prepared for each for each river basin district. In England, the Environment Agency is the competent authority for the WFD and it published the first river basin management plans in December 2009. These plans outlined the measures needed to bring more waters to good status by 2015 and what needed to be investigated to test whether all waters could justifiably achieve this aim by 2021 or 2027.

The plans, including their objectives and measures must be reviewed and updated every 6 years. The 2009 plans were updated in 2015 and the third cycle River Basin Management Plans were published in 2022 (covering 2022 -2027).

The plans support the government's wider environmental ambitions, including those originally set out in the 25-Year Environment Plan (2018) and subsequently developed through the Environmental Improvement Plan. They harness the potential of data, local partnerships, environmental technology and environmental markets to improve the water environment while supporting economic growth.

Temporary deterioration in status

Extreme natural events such as drought are recognised within WFD. In certain circumstances (set out in Article 4.6 of the WFD) a temporary deterioration in status of a water body, caused by exceptional or unforeseen events such as extreme floods, prolonged droughts or accidents, may be permitted. The exception does not apply to those effects of extreme floods and prolonged droughts which could reasonably have been planned for and prevented, nor does it apply in the case of accidents which could reasonably have been foreseen.

The exemption requires responsible authorities to demonstrate that:

- All practicable steps were taken to prevent further deterioration in status.
- The measures to be taken under exceptional circumstances are included in the Programme of Measures and will not compromise the recovery of the quality of the body of water once the circumstances are over.
- All practicable measures are taken to restore the body of water to its status prior to the effects of those circumstances as soon as reasonably practicable.
- A summary of the effects of the circumstances and the measures taken are included in the next update of the River Basin Management Plans.

Prolonged droughts

When assessing impacts on WFD for this assessment, consideration should be given to whether any deterioration is attributable to the natural drought event itself, whether the impacts are temporary in nature, and whether the affected waterbody is expected to recover naturally once conditions return to normal. Consideration should also be given to whether recovery can occur without the need for additional measures.

For additional information regarding the Water Framework Directive and our approach to river basin management planning in England please go to https://www.gov.uk/government/collections/river-basin-management-plans-2015.

10.1. Water Framework Directive Baseline Environment

There are eleven WFD River water bodies along the main River Severn from source to the tidal limit and a further six along the River Vyrnwy catchment. The River Severn waterbodies are listed in Table 25, and the complete list of water bodies is contained in table 26.

Table 25: River Severn water bodies

Water body ID	Water body Name
GB109054044790	R Severn - source to conf Afon Dulas
GB109054049310	R Severn - conf Afon Dulas to conf R Camlad
GB109054049700	R Severn - conf R Camlad to conf Bele Bk
GB109054049142	R Severn - conf Bele Bk to conf Sundorne Bk
GB109054049141	R Severn - Sundorne Bk to conf M Wenlock-Farley Bk
GB109054049143	R Severn conf M Wenlock-Farley Bk to conf R Worfe
GB109054049145	R Severn - conf R Worfe to conf R Stour
GB109054049144	R Severn - conf R Stour to conf River Teme
GB109054039760	R Severn - conf R Teme to conf R Avon
GB109054044404	R Severn - conf R Avon to conf Upper Parting
GB109054032750	R Severn (E Channel) - Horsebere Bk to Severn Est

A network of monitoring sites is used to establish the status of all water bodies in terms of their ecology, chemistry, hydromorphology and groundwater level. For a particular point in time a classification will show whether the quality of the environment is good, or where it may need improvement.

For surface water bodies there are two separate classifications: ecological and chemical. For a water body to be in overall good status both ecological and chemical status must be at least good.

For groundwater bodies there are two separate classifications: chemical status and quantitative status. Each must be reported in addition to the overall groundwater body status. For a groundwater body to be at good status overall both chemical status and quantitative status must be good.

Classification uses a principle of ‘one out, all out’ which means that the poorest individual result drives the overall classification. It reports on over thirty measures, grouped into ecological status (including biology and ‘elements’ such as phosphate and pH) and chemical status. A summary of compliance with good overall status/potential is shown in Table 26.

Artificial and heavily modified water bodies

Some surface water bodies are designated as ‘artificial’ or ‘heavily modified’ because they have been created or modified for a particular use such as water supply, flood protection, navigation or urban infrastructure. By definition, artificial and heavily modified water bodies are not able to achieve natural conditions. Instead, the classification and objectives for these water bodies, and the biology they represent, are measured against ‘ecological potential’ rather than status. Whilst good ecological status is defined as a slight variation from undisturbed natural conditions in natural water bodies, artificial and heavily modified water bodies are unable to achieve natural conditions. Instead, artificial and heavily modified water bodies have a target to achieve good ecological potential, which recognises their important uses, whilst making sure ecology is protected as far as possible. Ecological potential is also measured on the scale high, good, moderate, poor and bad. The chemical status of these water bodies is measured in the same way as for natural water bodies.

For further details on surface water and groundwater classification refer to Section 4.2.3 ‘Assessment of water body status’ of Part 2 of the River Basin Management Planning Overview linked here: https://www.gov.uk/government/publications/part-2-river-basin-management-planning-overview-and-additional-information

Classification changes since first cycle (new building blocks)

Water body status classifications are based on a set of building blocks. These are:

- The water body and monitoring networks
- The designation of artificial and heavily modified water bodies
- The standards and boundaries used in assessment
- The tools used to derive classification results for individual elements from monitoring data

A number of significant changes to the original building blocks used in the 2009 River Basin Management Plans were introduced for the second cycle of river basin management planning. These were:

- Updated standards were used to determine good status for nutrients and some chemical substances.
- New chemical standards were introduced as a result of the 2013 Environment Quality Standards Directive (EQSD) amendments.
- A second generation of biological classification tools to ensure biological classification were better at reflecting local conditions.
- The size and shape of some water bodies changed so that they became more logical management units (a number of very small streams had been removed that were less than 1km in length or with a catchment of less than 10 km^2). These water bodies still remained protected by law from pollution, modification and abstraction and could be improved where local actions and assessments deem it to be a priority.
- The process to designate heavily modified water bodies improved.

These changes ensured that the second cycle plans could be based on the best possible evidence and would make a difference to the number of water bodies reported as being in high, good, moderate, poor and bad ecological status.

Since the publication of the second cycle River Basin Management Plans, river basin planning has continued to evolve. The third cycle plans, updated in 2022, retain the core objectives of the Water Framework Directive while placing greater emphasis on addressing the significant pressures affecting the water environment and delivering coordinated action through catchment-based approaches.
The principal developments since the second cycle include:

- Updated classifications and monitoring data have been used to provide a more current assessment of the condition of surface waters and groundwater.
- Greater focus has been placed on tackling the main reasons water bodies fail to achieve good status, including pollution from wastewater, agriculture, urban runoff, physical modifications to watercourses and the impacts of climate change.
- River basin planning is now more closely aligned with wider environmental policy, including the Environment Act, the Environmental Improvement Plan and national programmes for improving water quality, biodiversity and climate resilience.
- Catchment-based partnerships have become increasingly important in identifying and delivering local improvements, bringing together regulators, water companies, local authorities, land managers, businesses and communities.
- The third cycle plans place greater emphasis on identifying the investment and actions required to achieve long-term environmental objectives and to prevent deterioration of the water environment.

These developments ensure that the third cycle plans are based on the latest available evidence and provide an updated framework for protecting and improving the water environment while supporting sustainable economic growth and resilience to future environmental pressures.

A summary of compliance with good ecological status/potential and good chemical status is given in Table 26 below and also Appendix H Table 7.

Table 26: Compliance with WFD Objectives

Water Body ID	Water Body Name	Overall Status/Potential Cycle 2 2015	Overall Status/Potential Cycle 3 2019 (EA) / 2021 (NRW)	Overall Status/Potential Cycle 3 – 2024 Interim (NRW) / Cycle 4 – 2025 (EA)
GB30937446	Llyn Clywedog	Moderate (Potential)	Moderate (Potential)	Moderate (Potential)
GB109054044760	Afon Clywedog - Clywedog Dam to R Severn	Moderate (Potential)	Moderate (Potential)	Moderate (Potential)
GB109054044790	**Severn – source to conf Afon Dulas**	**Good (Status)**	**Poor (Status)**	**Moderate (Status)**
GB109054049310	**Severn – conf Afon Dulas to conf R Camlad**	**Moderate (Potential)**	**Moderate (Potential)**	**Moderate (Potential)**
GB109054049700	**Severn – conf R Camlad to conf Bele Bk**	**Moderate (Potential)**	**Moderate (Potential)**	**Moderate (Potential)**
GB109054049142	**Severn – conf Bele Bk to conf Sundorne Bk**	**Moderate (Status)**	**Moderate (Status)**	**Moderate (Status)**
GB109054049141	**Severn – Sundorne Bk to conf M Wenlock-Farley Bk**	**Moderate (Status)**	**Moderate (Status)**	**Moderate (Status)**
GB109054049143	**Severn conf M Wenlock-Farley Bk to conf R Worfe**	**Moderate (Status)**	**Moderate (Status)**	**Moderate (Status)**
GB109054049145	**Severn – conf R Worfe to conf R Stour**	**Poor (Status)**	**Poor (Status)**	**Moderate (Status)**
GB109054049144	**Severn – conf R Stour to conf River Teme**	**Moderate (Potential)**	**Moderate (Potential)**	**Moderate (Potential)**
GB109054039760	**Severn – conf R Teme to conf R Avon**	**Moderate (Potential)**	**Moderate (Potential)**	**Poor (Potential)**
GB109054044404	**Severn – conf R Avon to conf Upper Parting**	**Moderate (Potential)**	**Moderate (Potential)**	**Moderate (Potential)**
GB109054032750	**Severn (E Channel) – Horsebere Bk to Severn Est**	**Moderate (Potential)**	**Moderate (Potential)**	**Moderate (Potential)**
GB30935568	Lake Vyrnwy / Llyn Efyrnwy	Moderate (Potential)	Moderate (Potential)	Moderate (Potential)
GB109054049880	Vyrnwy - Lake Vyrnwy to conf Afon Cownwy	Moderate (Potential)	Moderate (Potential)	Moderate (Potential)
GB109054049720	Afon Vyrnwy - conf Afon Cownwy to conf Afon Banwy	Moderate (Potential)	Good (Potential)	Moderate (Potential)
GB109054049851	Afon Banwy	Poor (Status)	Poor (Status)	Good (Status)
GB109054049852	Afon Vyrnwy DS of Banwy confluence	Moderate (Status)	Good (Status)	Good (Status)
GB109054049800	Afon Vyrnwy - conf Afon Tanat to conf R Severn	Moderate (Potential)	Moderate (Potential)	Moderate (Potential)

*Water bodies in **bold** are River Severn water bodies.*

10.2. Assessment of Impact on WFD Status

Assessment of the River Severn Drought Order impacts against WFD compliance has been carried out within the water quality (section 2) and ecology (3 and 4) sections of this report. For more detail refer to the relevant chapters and appendices. An overall conclusion is presented within this section.

10.3. Impact on WFD Status Conclusion

Temporary deterioration of WFD status is a natural consequence of prolonged drought events, as stated by Article 4.6 of the Directive.

The River Severn Drought Order is an Environment Agency mitigation measure intended to manage deterioration of WFD designations during severe natural drought events. The drought order is expected to support essential public water supply abstraction in a sustainable manner during the severest of droughts, whilst benefiting the environment by protecting against significant flow failure should resources in Llyn Clywedog be exhausted.

Historic drought events provide evidence that lowering prescribed flows at Bewdley down to 545 Ml/d during the 1976 drought order operation, still maintained flows higher than would naturally have been occurring at Bewdley, and at least the same as would have naturally occurred at Haw Bridge.

Modelling indicated that flows and water quality would deteriorate below local WFD targets as part of the natural drought process, regardless of whether the River Severn Drought Order was operated or not. While the Severn Drought Order could marginally increase the duration of impact on flows and therefore the environment in the short term, the long term gains are clearly beneficial to the environment and WFD objectives. No additional WFD water quality failures are predicted during the River Severn Drought Order operation, and all flow and subsequent ecological impacts are expected to be short term with a quick recovery in line with the natural event.

The impacts of the River Severn Drought Order are therefore considered to come under Article 4.6 of the Water Framework Directive, allowing for temporary deterioration as a 'result of circumstances of natural cause which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts.'

For more detailed discussions and evidence refer to the individual impact assessment sections.

11. Archaeological and Cultural Heritage

11.1. Baseline Environment

The River Severn passes through a landscape exceptionally rich in archaeological sites and historic buildings. The physical evidence of past human activity covers every period, from the Palaeolithic to the modern; many of the key sites lie within the floodplain of the river. The management of this unique resource is undertaken at several levels – by international treaty, statutory protection, government guidance, registers and local plan policies.

The cultural resource of the River Severn is very fragile,and once lost it cannot be restored. Much remains unknown about the scale of survival, especially in the lower river where alluvium has covered numerous sites of importance. The concentration of known prehistoric sites in the upper Severn is greater for two reasons: there has been less deposition owing to the more active nature of the river in the upland zone; and aerial photography has been able to identify sites which have been buried under shallow deposits. In the middle and lower sections of the river, medieval and post-medieval sites assume a greater importance as a result of the use of the river as a communications route and the development of settlement and industry. Prehistoric sites are likely to be as important in these lower parts of the river, but they remain undiscovered.

11.1.1. World Heritage Sites

The UK Government, as a signatory to the World Heritage Convention, has undertaken to protect and conserve a number of sites which have been designated as of World Heritage significance. There is no special legislation for the protection of World Heritage Sites in the UK. In fact emphasis is placed upon the existing framework of protection, with the use of management plans linked to planning policies. National Planning Policy Framework (NPPF), Section 16 (conserving and Enhancing the Historic Environment) identifies World Heritage Sites as a material consideration in the planning process.

The study area includes one World Heritage Site, the Ironbridge Gorge, which comprises the Coalbrookdale, Ironbridge, Jackfield and Coalport Conservation Areas, and includes within this several Scheduled Ancient Monuments and many Listed Buildings. The River Severn passes through the World Heritage site for a distance of some 4 km.

11.1.2. Scheduled Monuments

Scheduled Monuments (SMs) are those monuments which are considered to be of national importance. While their designation goes back to 1882, the current legislation that covers their management is the Ancient Monuments and Archaeological Areas Act 1979. This restricts works to a designated monument, and requires that Scheduled Monument Consent (SMC) be sought from the Secretary of State for Digital, Culture, Media and Sports (or in Wales, by the Secretary of State for Wales), based on advice provided by Historic England and Cadw respectively. Works requiring consent can include: activities such as excavation, dumping, repair, geophysical survey and deliberate flooding, but does not include the current land use of the monument. SMs receive protection through their statutory designation and through the national planning system in the form of planning guidance (including Section 16 of the NPPF and local planning policies).

Within the study area there are a number of SMs including the first iron bridge ever built, located at Ironbridge, SMs associated with battlefield sites in Shrewsbury and Lydney Dock.

11.1.3. Listed Buildings

The Secretary of State for Digital, Culture, Media and Sport (or in Wales the Secretary of State for Wales) is required to compile a list of buildings of special architectural or historic interest, for the guidance of local planning authorities in the exercise of their own planning functions under the Town and Country Planning Act 1971 and as revised in Section 1 of the Planning (Listed Buildings and Conservation Area) Act 1990. The principles of selection for the lists were drawn up by the Historic Buildings and Monuments Commission (HBMC) (formerly the Historic Buildings Council and now using the working title Historic England) and approved by the Secretary of State.

Within the study area, there are a very large number of listed buildings, especially in the historic urban centres of Gloucester, Tewkesbury, Worcester, Bridgnorth, Shrewsbury and in Telford, Coalport and Ironbridge.

Local listing is a concept (identified in the Government's Planning Practice Guidance (para 39 and defined in the NPPF) which allows local authorities to develop lists of non-designated heritage assets which have a degree of distinctive historic character and interest of local importance but which do not meet the criteria to be designated as being of national importance. There is no obligation on local authorities to draw up a local list or to maintain/update the list once it is in existence. Similarly, there is no requirement for local lists to be addressed with Local Plans although the NPPF does encourage the development of plan policies which address all aspects of an area's heritage – this could usefully include local lists.

It is unclear at present how many local authorities are in the process of developing lists of locally important heritage assets within the River Severn study area.

11.1.4. Conservation Areas

The designation of conservation areas has also been developed over a number of years, but most recently through the Planning (Listed Buildings and Conservation Areas) Act 1990. The management and conservation of these areas is guided by national policy, NPPF (Section 16) and local planning policy. The primary aim of conservation areas is to protect the built environment and the settings of listed buildings.

Within the study area most of the historic centres have been designated conservation areas, which include the river and its banks. Historic centres include Gloucester, Worcester, Shrewsbury and the smaller towns, through to the Central Marches Bridgnorth, Upton on Severn, Bewdley, Stourport and many villages.

The objective of this environmental assessment is to assess the potential impacts imposed by the River Severn Drought Order. Imposing a drought order would not significantly impact upon the architectural setting. However, it is accepted that there may be adverse impacts for plants shrubs and trees through shortage of water. However, this would be temporary and not significant for the long term therefore no further assessment has been undertaken. However, older trees (e.g. on the Ancient Trees Inventory) are less able to cope with periods of prolonged water shortage. Such a shock could lead to rapid death or a general hastening in their decline with their weakened systems more susceptible to plant diseases.

11.1.5. Register of Historic Parks and Gardens

This register is maintained by Historic England as part of the National Heritage List for England (NHLE) (and in Wales by Cadw), to provide a list of important historic parks and gardens. It has no statutory status. However, in the NPPF, registration is considered to be a material consideration in the planning process. Most local plans contain policies for historic landscapes, parks and gardens.

Parks and Gardens in England and Wales have always been subject to variation in weather and sometimes these variations are extreme (1976 summer drought and the winter of 1962). Implementation of a River Severn Drought Order would not affect the architectural layout and landscape design of a Parkland or Garden. However, prolonged periods of drought and the general lowering of the water table could affect the stability of canalised waterways and in particular the foundations of dams which form ornamental ponds/lakes.

It is accepted that there may be adverse impacts for plants shrubs and trees. Over short periods of drought this would not be significant for the long term well-being of the Parks and Gardens and therefore no further assessment has been undertaken. However as mentioned previously, older trees (e.g. on the Ancient Trees Inventory) are less able to cope with periods of prolonged water shortage.

11.1.6. Register of Battlefields

A register is maintained by Historic England to provide a listing of important battlefields. It has no statutory status. However, in NPPF, their designation is considered to be a material consideration in the planning process. Within the study area there are three battlefield sites: at Shrewsbury, Worcester and Tewkesbury.

Historic Battlefield Sites in England and Wales have always been subject to variation in weather and sometimes these variations are extreme (1976 summer drought and the winter of 1962). Imposition of a River Severn Drought Order would not affect the geographical position or indeed its historic merit. It is accepted that there may be adverse impacts on the landscape setting (i.e. lack of water for plants shrubs and trees). However, this would be temporary and not significant for the long term well-being of the Battlefield Site and therefore no further assessment has been undertaken.

11.1.7. County Historic Environment Records

The county-based Historic Environment Records (HERs) provide a non-statutory inventory of archaeological sites (and in some cases, listed buildings). The record has been built up, over a number of years, from the National Monuments Record. It should be noted that the HER is a dynamic and constantly evolving dataset; blank areas on an HER do not necessarily mean there are no archaeological remains present, rather that none have been reported. As such, the evidence from an HER needs to be interpreted by an appropriately experienced archaeologist.

The coverage of the study area includes independently maintained HERs for Clwyd/Powys, Shropshire, Hereford and Worcester and Gloucestershire.

The existence of a site on the HER does not in itself provide for its protection or management. However, it can provide a first indication of potential archaeological interest, where development is proposed and with appropriate consultation protection of such sites can be provided through the planning process, through Planning Policy Guidance. NPPF para 189 asserts that heritage assets (archaeological deposits, historic buildings and historic landscape character) are a material consideration in the planning process.

In some cases, organizations (mainly the private utilities) which have exemptions from the planning process have undertaken to consult the HER and agree voluntary mitigation where necessary. The Water Act Code of Conduct and the Water Recourses Code of Practice emphasise the need to establish and maintain channels of Liaison and Consultation with all the appropriate consultee's (including archaeological) bodies, statutory and non-statutory, and landowners.

The Conservation Guidelines for Drainage Authorities, 1991 set out the statutory obligations of the former NRA and the Internal Drainage Boards (IDBs) which includes having regard to protecting and conserving buildings and sites of archaeology, architectural or historic importance.

11.1.8. Historic Landscape Character

The River Severn flows through some of the UK's most attractive and protected landscapes. The Shropshire Hills in the north and the Malvern Hills and Cotswolds in the south are noted as areas of Outstanding National Beauty (AONB) and the area around Telford is noted as a World Heritage Site. Many of the cities and towns of the region have attractive protected conservation areas and lie within the River Severn corridor or front on to it. The river corridor itself contributes to that attractiveness.

In 1998 and 2001, as a first step towards raising the profile of historic landscapes in Wales, Cadw, CCW and ICOMOS (UK) (International Council on Monuments and Sites) published the Register of Landscapes of Historic Interest in Wales. This is an advisory but non-statutory document highlighting what are considered to be the best examples of different types of historic landscape in Wales. The Maesmawr character area of the Caersws Basin features the fieldscape along the River Severn and the floodplain. The Trehelig-gro character area of the Vale of centres on a timber framed cottage on the bank of the Severn which was the site of a ferry and ford across the river.

Shropshire, Worcestershire, Herefordshire, Gloucestershire and Clwyd/Powys have completed Historic Landscape Characterisation (HLC) projects as part of a programme of mapping to broaden our understanding of the historic landscape. HLC projects are lodged on the relevant HER but may also be held (where appropriate) on the Archaeology Data service (ADS) website. HLC was developed to inform decision-making within local authorities which could affect landscape character in the future.

The River Severn has always been subject to variation in weather and sometimes these variations are extreme (e.g. 1976 summer drought). During high rainfall events river flow can increase significantly. High flow causes erosion by over topping or breaking through river banks, which can transform the landscape. Implementing the River Severn Drought Order is intended to protect and maintain flows at a lower rate. It is accepted that lack of rainfall during drought may have an adverse impact on the landscape (contemporary and historic) setting through a lack of rainwater for plants shrubs and trees. However, this would not be an effect related specifically to a drought order and therefore no further assessment has been undertaken.

11.2. Assessment of Impact on the Current Environment: Archaeology and Cultural Heritage

The potential effects of a natural drought on cultural heritage have been summarised as (Coles, 1995):

"a rapid fall in water levels, with the consequent desiccation of bogs and fens, increased fire risk, increased fire growth and increased activity of burrowing animals. In times of drought it is also likely that rainfall recharge of the aquifer will decrease leading perhaps to drying out of spring fed fens, particularly if conditions are exacerbated by over abstraction. None of this is good for archaeological sites and organic material will be particularly vulnerable under a regime of increased fluctuation between flood and drought."

11.2.1. Lowering of the Water Table through Reduced River Flow

Archaeologists would consider that the drying out of waterlogged sites is the most severe problem associated with drought conditions. It is often very difficult to monitor loss, and in extreme conditions all trace of these organic materials will disappear from the soil. Examples of lost evidence of past human activity includes environmental material (such as macro plant remains and wood, insects and pollen) used to reconstruct past climates, and past economic activity; and artefacts made of wood, bone, leather and textiles. Organic materials survive in the ground where they are protected from micro-organisms. Drying out allows oxygen and thus micro-organisms to come in contact with the materials, and decay rapidly follows: Experiments suggest that materials that have survived over 2000 years may decay within months. A particularly damaging situation is where wet and dry conditions exist, with seasonal fluctuations.

The scale of waterlogged preservation within the river floodplain is unknown. Excavations at Shrewsbury Abbey in the 1980s identified waterlogged medieval deposits, and it can be assumed that the other riverside abbeys contain a similar degree of waterlogged preservation. Examples would include Tewkesbury, Buildwas and Alberbury (all, except Alberbury are SMs). Features include mills; drains (and their organic fills) and fishponds. The major Roman urban/military sites of Caersws, Wroxeter, Worcester and Gloucester, although for the most part dry, have areas of potential waterlogging, especially in the base of ditches and on riverside features such as wharves and bridges. The motte and bailey castles in Powys which are close to the river will have waterlogged deposits in their ditch fills.

The desiccation of exposed topsoil could impact upon the composition of affected soils leading to an increase of susceptibility to erosion by flooding and from subsequent strong winds. This loss of topsoil could potentially expose previously buried archaeological remains to the elements, leading to an increase in their rates of degradation.

Fish weirs were a particular feature on the Severn in Shropshire. These were wooden and wicker structures and the bases probably survive in the waterlogged conditions. Reduced river flow could result in the loss of these structures.

The general lowering of the water table could also affect the stability of the foundations of listed buildings, of which there are many hundreds within the study area. Underpinning of these buildings would then be needed, and this would have a further damaging effect on the below-ground archaeology associated with these structures.

11.2.2. Changes in River Flow

The course of the river has changed considerably over the last 10,000 years, especially in the upper and middle sections of the River Severn and Afon Vyrnwy. This is visible from preserved palaeochannels, representing very substantial changes in the river courses during the period of the formation of the archaeological record. The middle sections of these rivers are still actively migrating (Lewin 1992), and this causes potential erosion and loss of archaeological sites which were once some distance from the river, but at the same time protecting others by covering them with alluvium. While this is a natural process, the present regulated flows will affect the rate of loss compared with that in the pre-regulated river. Broadly, low flows are to be preferred, and will cause the river banks to erode less; floods create major loss and, on occasions, new channels can develop.

Historic riverside structures such as wharves, weirs and bridges are also vulnerable to river flow changes. Here the effect is complicated, because a period of low flow may cause the structures to dry out and any organic component to decay, thus destabilising them. Bridges and bridge piers are particularly vulnerable in this respect.

11.3. Conclusion

The natural drought event represented by the ‘Do Nothing’ scenarios, under both the Acute and Chronic Conditions, could dry out some archaeological features and increase the risk of fires. However, many features detailed would also benefit from lower flows. Modelling found the River Severn Drought Order would initially lower water levels and flows along the main River Severn corridor. The Acute and Chronic Conditions both showed that if the drought persisted, higher flows and water levels would be supported than under the ‘Do Nothing (Baseline)’ scenario. Therefore, a benefit would be provided to those features that are considered more sensitive to low flows. Any adverse impacts would be temporary and have no prolonged adverse impact; therefore, no adverse impact is concluded.

11.4. Monitoring and Mitigation Options

The Environment Agency has an established environmental monitoring network within the River Severn catchment. On the conclusion of no adverse impact, no additional monitoring is recommended.

12. Navigation and Recreation

12.1. Baseline Environment

12.1.1. Llyn Clywedog Reservoir

It is understood that Llyn Clywedog Sailing Club has boats moored in the water and stored on the bankside between March and October. The Club's launching facilities are also used by Brenin Adventures who use the outdoor centre at the reservoir.

The reservoir is drawn-down during the summer to support the River Severn, which is the reservoir's primary function. During a normal summer the reservoir operates above 70% full. In dry summers, the level may drop and a drought order may be sought in line with drought order curves (Figure 4) in order to conserve water in the reservoir.

Historic data from the sailing club indicated that access to the water benefits from an old road; part of the infrastructure of the valley prior to flooding which provides an extension to the club's launching ramp. This allows access across the mud to the retreating water's edge in most summer circumstances, (including previous droughts). It is only in very extreme circumstances that use for sailing is ceased. This did occur in 1989, when water levels dropped so low that sailing ceased in August rather than continuing through to October. In 2018 operators were unable to launch larger boats with fixed keels from mid-June to July. They were able to carry smaller boats through the mud. The reduced levels were reduced in mid-June/July to the end of November 2018 resulted in a loss of much of the available bank to anglers. 10m of mud was exposed which prevented fishing. As a consequence there was a large reduction in the number of bank fishing tickets sold and a financial loss to the business.

The effect of severe depletion of the water resource has an impact on access to the water for recreational use. A vast expanse of mud is exposed by extensive drawdown, which creates difficulty for water users in reaching the water's edge. In addition, a much smaller body of water leads to problems of limited space for users and produces unusual wind conditions (Llyn Clywedog Sailing Club, pers. com.).

12.1.2. Lake Vyrnwy Reservoir

Lake Vyrnwy itself offers a variety of water sport and fishing opportunities, while the combined area attracts tourists throughout the year. The reservoir was created principally to provide water supplies to the North West, and is drawn down throughout the year. A smaller portion of the water is retained solely for supporting downstream watercourses and primarily the River Severn.

It is understood that Bethania Adventure provides canoeing, kayaking, sailing and windsurfing opportunities to tourists, and allows private boat launches from its facilities. As with Llyn Clywedog, depletion of the water levels had an impact on access to the water for recreational use in 2018.

Lake Vyrnwy's 1,100 acres remains the world's second oldest manmade trout fishery, with fly fishing dating back to 1818. Lake Vyrnwy Hotel and Spa have exclusive fishing rights over the reservoir, with year-round fishing reported for wild brown and stocked brown and rainbow trout. In 2018 boats were removed early because draw down made access difficult due to the exposed mud.

12.1.3. Upper Catchment

The majority of boating in the upper catchment is canoe (both Indian canoes and kayaks) and raft-based (used during raft races). Following the construction of the Llyn Clywedog reservoir, river regulation releases maintain higher river levels during summer, which benefits water-based activities. It is less beneficial for coarse fishing as releases can flush sediment down the river, increasing turbidity, smothering eggs and having a cooling effect. Low water levels and higher water temperatures tend to increase coarse fishing success, so drought can have beneficial effects, unless it is so severe that fish mortality occurs. High water levels are necessary for salmonids to move up the river to spawn, but regulated water does not necessarily achieve this as successfully as a fall of fresh rain.

The specific Montgomery Canal abstractions in Powys are covered in sections 0 and 5.3.3.

12.1.4. Middle Catchment

More commercial boating and rowing activity is associated with the middle catchment, as well as competitive angling. Previous work by the Environment Agency identified a number of sites between Buildwas and Bewdley where certain reaches of the river could become unnavigable at times of low flow, although the river is not navigable upstream of Stourport. Below Stourport the character of the river changes owing to the locks and weirs and these, together the additional input of the River Stour, help to maintain higher water levels.

12.1.5. Lower Catchment

The river downstream of Stourport is within the Canal & River Trust navigation control; locks and weirs help to maintain water levels at the crest height of the weirs.

Far greater use of the river by vessels occurs in the lower catchment. As well as canoes and kayaks, the river is used by narrow boats, powered craft and cruisers, and ocean going yachts and commercial barges still carry grain between Gloucester Dock and Tewkesbury. These all have different water depth requirements: narrow boats need 0.6 m of water while the cruisers, large yachts and commercial barges need 1.8 to 2.1 m. The Canal & River Trust are required to maintain a navigable depth of 2.4 m[30] in the River Severn, which is normally achieved by dredging. This is costly and has an adverse impact on the environment through sedimentation, the Environment Agency advice against dredging during low flows because the environment is more vulnerable during these conditions.

During the drought of 1995, commercial vessels and larger sea-going craft did experience considerable difficulty in travelling between Gloucester and Tewkesbury, because in some sections of the river only approximately 1.44m of water depth was available (Source: Inland Waterways Association, pers. comm.). The River Severn Drought Order was not in operation during 1995, which provides a useful comparison of how natural low flows and drought conditions can create the initial impacts on navigation.

As water levels fall, the effective width of the river is reduced and this can make the passing of boats in mid-stream more difficult. Risk of grounding, of keel damage or risk of collision with other vessels all increase if water levels fall severely. As water levels fall, the minimum level between Stourport (in the middle catchment) and Gloucester is set by the numerous weirs, which only allow the water level to fall to the weir crown height, below which there is no flow.

[30] navigable depths are currently (2013) under review and maybe subject to change.

The specific Gloucester & Sharpness Canal abstraction from the River Severn is covered in sections 0 and 5.3.3.

With regard to fisheries and angling, past degradation of fish habitat has occurred, owing to the construction of weirs and the use of the river for navigation purposes. Coarse fishing takes place throughout the lower catchment, but low flows have been identified as a problem at various locations. More details can be found in the Fish Technical report in Appendix L.

12.2. Assessment of Impact on the Current Environment: Navigation and Recreation

Impacts on the abstractions for the Montgomery Canal in Powys, and the Gloucester & Sharpness Canal in Gloucestershire can be found in section 5.3.3.

12.2.1. Impact on Llyn Clywedog Reservoir

No information exists which relates volumes and levels in the reservoir to recreational use. Assessment is based on historic information from discussion with Llyn Clywedog Sailing Club.

Sailing and boating activities should largely be able to continue through the drought until late in the summer (late August). The modelled River Severn Drought Order conserves water resources within Llyn Clywedog by 11% total storage, allowing sailing to continue for longer than if no action were taken ('Do Nothing' scenario). Under the 'Do Nothing' scenario, the water resource in the reservoir would continue to diminish into dead water (<5%), making it no longer possible to sail if the drought continued long enough.

Implementation of the River Severn Drought Order would clearly have a positive impact by conserving water resources and prolonging the extent of the sailing season on Llyn Clywedog. In addition, the recovery time (reservoir refill) is reduced by applying the drought order, subsequently reducing the duration of drought impact on the sailing club and helping to protect against a second year of impact.

12.2.2. Impact on Lake Vyrnwy Reservoir

No information was found which relates volumes and levels in Lake Vyrnwy reservoir to recreational use at the time of writing this report. However the River Severn Drought Order would not increase the maximum quantity of water released from the reservoir compared to normal operation. The Vyrnwy waterbank would be fully utilised, but this is in accordance with normal regulation years. Levels within Lake Vyrnwy would be lowered as a result of the drought and high public water supply demands, but this drought order does not seek to amend the quantities used. No impact was concluded on recreational use of Lake Vyrnwy.

12.2.3. Impact on River Severn Navigation

The main impact upon water-based recreation in the main river from severe drought is the effect on water levels (i.e. water depth) and channel width. This directly affects access down the river for boats. Low water levels during the summer have caused problems for large vessels, in particular the commercial barges, with concern directed towards the quantity of water abstraction (an

Environment Agency function) and frequency of dredging (a Canal & River Trust function). During 1995 commercial vessels experienced considerable difficulty in navigating between Gloucester and Tewkesbury with a water depth of only approximately 1.44 m in places (Source: Canal & River Trust, pers. comm.).

Navigation along the River Severn from the middle to lower catchment could be significantly impacted by the lowered water levels from the River Severn Drought Order preceding any regulation failure, making passage over weirs and through locks limited according to the drought severity. The level of impact is likely to vary locally and be exacerbated by abstractions, making it impractical to quantify at the River Severn catchment scale. Taking a worst-case precautionary approach, navigation by the majority of vessels could largely be prevented until high rainfall events raise water levels.

The exact duration of a future drought cannot be predicted and will depend on rainfall patterns; modelling work estimated flow depressions could last for approximately 70 days (between August and October), with approximately 20 days of severe flow depression (resulting from regulation failure) where navigation is almost certainly unlikely. However, if the River Severn Drought Order were not operated then more severe flow depressions would result after regulation failure. Realistically the impact from the River Severn Drought Order for consideration is the lead-in time, prior to regulation failure, where flows are lowered by approximately 120-140 Ml/d from Buildwas downstream. This period was modelled as approximately 45 days starting at the end of August, but every event will be different.

Data is not currently available to assess the local impacts of lowering water levels at every lock and weir along the River Severn, so a precautionary assumption of there being no navigation possible for boats has been adopted.

12.2.4. Impact on Angling

Section 7.4 contains the conclusions for fish species within the River Severn while the Habitats Regulation Assessment report considers the Estuary fish species and migration in greater detail. Please refer to this section and report for detail.

With regard specifically to angling, falling water levels are likely to have a beneficial effect upon fish catches initially. However as the drought persists, as shown by the Acute and Chronic Conditions, adverse effects upon fish survival are likely (section 7.4 contains details). Analysis showed that flows and water levels during the critical periods would be lowest in the 'Do Nothing' scenarios. Operating the River Severn Drought Order would provide benefits to fish by increasing water levels and flows, which should also benefit angling interests.

In the lower catchment in particular, where locks and weirs are extensive, water levels could fall below the weir crest height and effectively prevent flow. This can then have adverse effects upon water quality and fish movements, resulting in elevated stress and potentially mortality. At such times, if it is considered that angling is leading to further stress to fish it may be beneficial to suggest a temporary cessation of fishing activities. Although this would have a temporary negative impact on angling interests, it would benefit fish populations and recovery rates, which would be of benefit to angling in the longer term.

The extreme low flows associated with regulation failure are likely to negatively affect access for angling as well as the populations of fish that are being targeted. Therefore, delaying this by operation of the DO would be a beneficial impact on both the ecology and recreational angling.

13. Summary of Impacts

The environmental assessment report has used the water resource model Aquator to predict potential changes in River flows that may result from operating the River Severn Drought Order. Two magnitudes of drought were modelled, an 'Acute Condition' and a 'Chronic Condition,' to investigate the potential impacts from a short and a long term drought event. Within each drought condition, two scenarios were created to investigate the direct, indirect and potential cumulative impacts from the River Severn Drought Order operation.

The 'Do Nothing (Baseline)' scenario tested what could happen if the River Severn Drought Order was not used, providing the baseline drought conditions/impacts for testing the other scenarios against. The 'Drought Order Only' scenario tested the operation of the River Severn Drought Order and normal abstractions and discharges.

The results from the flow modelling have been used to assess potential impacts on the following receptors;

- Hydrology and water resources (including impacts on other abstractors)
- Water quality
- Ecology (Macroinvertebrates and fish populations, recruitment and migration)
- Designated sites connected to the River Severn
- The Severn Estuary
- Archaeological and cultural heritage
- Navigation and recreation

Individual technical reports and impact conclusions were produced for the Hydrology, Water quality, Macroinvertebrates and Fish receptors, which can be found in Appendices D, I, J and K respectively. All the designated sites in connection to the River Severn were considered and screened in Appendix A, and a separate Habitats Regulation Assessment was conducted for the Severn Estuary (Annex 1). All these documents have been summarised within the relevant sections of this environmental assessment report.

The individual assessments have investigated whether the River Severn Drought Order could have a positive or negative impact on the environment and water users under the Acute and Chronic Conditions. The assessments also discussed how the impacts would change as the drought developed and whether the impacts were likely to be temporary or permanent. The ecological assessments also discussed what could happen if a drought order application/implementation occurred at a different time of the year, and/or if adverse weather or high temperatures also coincided.

Section 4 details the method used to summarise the individual assessments into an overall risk category. This method has been applied to the two reservoirs, original eight assessment points, the Severn Estuary (due to its significance) and the two watercourses identified as potentially being indirectly (Secondary Path) at risk.

13.1. Summary of potential risk

Table 27 summarises the results of the environmental assessments.

Table 27: Summary of Potential Risk

Site Name	Do Nothing (baseline)	Drought Order Only
Llyn Clywedog reservoir	High Risk	Low Risk/Benefit
Lake Vyrnwy reservoir	Low Risk/Benefit	Low Risk/Benefit
Clywedog AP	High Risk	Low Risk/Benefit
Vyrnwy AP	Low Risk/Benefit	Low Risk/Benefit
Buildwas AP	Medium Risk	Low Risk/Benefit
Bewdley AP	Medium Risk	Medium Risk
Saxons Lode AP	Medium Risk	Medium Risk
Deerhurst/Haw Bridge AP	Medium Risk	Medium Risk
U/S Sharpness AP	Medium Risk	Medium Risk
Lower Parting AP	High Risk	Medium Risk
Severn Estuary	High Risk	Low Risk/Benefit
Tenbury control point (River Teme)	Potential Indirect Risk	Potential Indirect Risk
Llanyblodwell control point (River Tanat)	Potential Indirect Risk	Potential Indirect Risk

The conclusion for the Drought Order only scenario includes a 300Ml/d restriction on abstraction to the Gloucester and Sharpness Canal. This is because the Habitats Regulations Assessment assessed an abstraction to the Gloucester & Sharpness Canal up to 300 Ml/d as not having a likely significant effect on the National Site Network and its designated species.

13.2. Limitations

A number of limitations encountered during the individual assessments have been identified within each relevant section.

A common difficulty was a lack of predictive models specifically designed for drought purposes. Most models had to be manually manipulated to produce theoretical drought conditions, rather than allowing 'what if' queries to be run to provide a more intuitive function. The artificial nature of the River Severn and complex interactions of abstractions and regulation releases on this scale also made it difficult to model drought impacts with high certainty, particularly as all drought events will be different. The drought conditions modelled provide a steer on the potential worse case eventualities, but all droughts are different and we cannot guarantee the exact timings and magnitudes of future droughts.

Specific flow targets, variable flows requirements, and maximum or minimum flow thresholds are lacking for the Severn estuary Habitats Directive site. It has numerous designations but still only

limited data and quantifiable targets in relation to freshwater flow requirements, making it very difficult to assess the impacts of changes in inflows. This limits the accuracy of assessments and better science and tools are needed in the future to help all the organisations involved understand the sensitivities of the site and its designations, steering how to accurately assess the impacts.

Due to limited baseline drought data, uncertainty remains around the magnitude of impact which could be experienced along the River Severn in response to the River Severn Drought Order. The last drought order operation was in 1989. Sampling methods, designations, data records, water quality requirements and basic abstractions and discharges (due to population changes) have all changed considerably in the last thirty years. Specific low flow and drought order monitoring has been identified in this report as a result, however until a drought order is operated we cannot collect the most relevant data needed to improve the certainty.

Uncertainty remains around the dry weather and drought operations of the Gloucester & Sharpness Canal. The new drought order restriction will allow the Environment Agency to work with the Canal & River Trust to regulate these abstractions during a drought order implementation, a measure which has improved the certainty around the impact conclusions made.

14. Mitigation Options

This section identifies potential options the Environment Agency will consider to help alleviate environmental stress during a River Severn Drought Order magnitude event. The mitigation options aim to delay the need for the River Severn Drought Order activation, provide greater flexibility within the regulation system and/or reduce environmental impacts in the reaches identified as medium to high risk.

The options have been divided into actions the Environment Agency could achieve in isolation, and options that could be achieved through collaborative and partnership working. For more generic drought management strategies please refer to the Environment Agency area drought plans which are available on request from their National Customer Customer Contact Centre: https://www.gov.uk/government/publications/drought-management-for-england.

14.1. Environment Agency and Natural Resources Wales Mitigation Options

During River Severn Drought Order operation there are options which the Environment Agency and Natural Resources Wales could independently act upon to help remediate any resulting negative environmental impacts. The option/s taken will vary according to the unique nature of each drought event, weather forecasts and the resources present at the time.

The identified options include;

- **Fish rescues.** The Environment Agency currently undertake fish rescues where appropriate, but it should be noted Natural Resources Wales have concerns about this method and, depending on the individual circumstances of each incident tend not to use it as a first option in drought conditions. Careful consideration would be needed in deciding whether it would benefit stranded fish or create additional stress, and careful consideration is needed into where to release stranded fish. The River Severn is supported by regulation and therefore expected to be experiencing less drought stress than more natural catchments.
- **Temporary actions to make fish passes, weirs and in channel structures passable to migratory fish.** Consideration would be taken in deciding whether upstream and tributary flows were sufficient to support onward fish movement and/or spawning before taking action.
- **Temporary requests for cessation of fishing activities to reduce stress.**
- **Apply for a SGS Drought Order to provide additional support to Llyn Clywedog** (this is not currently part of the application as there is sufficient licence remaining for SGS pumping this year). This would only be beneficial if the individual annual licences or rolling 5 year licence were being approached. During the Aquator modelling for this report, the SGS annual licence quantities were found to be a limiting factor. In a real event, rather than cutting back this regulatory support an application could be made for the SGS Drought Order. The order seeks to permit an increase to the annual and five year volume licence limits to meet an extreme and prolonged drought period, similar to that modelled under the Chronic condition within this report. If granted this drought order could provide prolonged support to the River Severn and take some strain off Llyn Clywedog and Lake Vyrnwy water bank storage.
- **Seek additional reductions from abstractors of up to 20% if Llyn Clywedog reservoir reaches emergency storage.** Some water companies may be able to rely on supplies other than the River Severn (i.e. rest their Severn abstraction through transfers). Each drought is different and conditions elsewhere could be worse than in the Severn catchment. Scope for reducing demand on the Severn may be restricted by priorities elsewhere and this option is unlikely to be achievable in a large scale drought event.

- **Targeted restocking programmes.** A post drought management option to help impacted species recover and re-colonise the River Severn. The differences in policies between Wales and England would need to be carefully considered. In Wales, stocking of fertile salmonids is unlikely to be consented with the preference being for natural recolonisation. This is not likely to be a preferred option, but would be available in England.
- **Increased flexible monitoring at locations not identified in the monitoring programme**. The Monitoring programme should not be used as a rigid or limiting document, additional monitoring may be needed as localised issues arise. This includes the use of sondes (water quality dataloggers) to assess impacts of lowering the flows

14.2. Collaborative Mitigation Options

During a River Severn Drought Order operation there are options which the Environment Agency could consider in cooperation or joint management with other organisations/bodies. These options would not solely be within the gift of the Environment Agency and would require close working and communication through the River Severn Drought Management Group.

The identified options include:

- **Work collaboratively through the River Severn Drought Management Group, with all the in-combination water users, to deliver joined up mitigation options.** For example, options could involve water companies having capacity for flexibility within their supplies to divert demand to less affected sources, or more short-term changes in operation to elevate localised issues. Communication will be critical and the group would need to be mobilised early in the drought process.
- **Explore the option for utilising water company bankside storage to enable short-term reductions in abstraction.** To alleviate low flows in the lower River Severn, SSW and STWL may be able to reduce their abstraction and utilise bankside storage leaving more water in the river. This option would be short term (days to a week only) and may incur additional costs to the Environment Agency, who may need to pay SSW and STWL to enable this.

15. Environment Monitoring Programme

The drought permit and drought order guidance identifies the need for a robust monitoring programme to support any drought order application. The monitoring programme ensures evidence will be collected to identify and enable the mitigation of drought impacts.

The Environment Agency recognises it is vital to collect baseline data both during normal and low flow conditions, enabling River Severn Drought Order specific monitoring to be compared against a proven benchmark to help quantify any impact. It is also necessary to undertake post-drought monitoring to assess the extent and rate of habitat and species recovery so we can better understand any long-term implications.

This recommended monitoring programme only contains sites specific to assessing the River Severn Drought Order, however the EA (and other bodies/organisations) have an extensive monitoring network, in addition to the sites listed, and all available data would be used during a real event. For example, WFD monitoring data and reports, Severn Estuary monitoring (6 yearly Habitats Directive programme) programme etc.

15.1. Data monitoring limitations

Due to the significant size of the River Severn catchment, and area of potential impact from the River Severn Drought Order, it is challenging to design a specific monitoring programme that is not too large to be feasible, or too sparse to be useful. The proposed monitoring programme represents a range of monitoring at the key assessment locations (conditions will vary locally between these targeted sites), however the programme application may need to be flexible, and discussions will need to be held between the organisations with potential impacts on the River Severn.

Due to the large area and tidal variations within the Severn Estuary, monitoring baseline conditions in the Estuary is very challenging. For example, surveying fish at specific locations only provides a snapshot picture of what species were caught on that day according to the environmental conditions at that time. Various fish species may avoid the monitoring nets or simply be located elsewhere within the Severn Estuary and therefore be excluded.

Various Severn Estuary monitoring options and techniques were considered for this project. For transitional fish it was decided to not monitor these directly due to no effective methodology. Macrophyte surveys were considered inappropriate for the Estuary due to the absence of significant vegetation. Diatom surveys were also considered for the Upper Estuary (already conducted in the middle and lower section), however due to the dynamic nature of the system along this section the results are unlikely to be conclusive or helpful in understanding the ecosystems response to low flows/drought. Invertebrate surveys were also considered unfeasible for the lower Severn, some deep-water surveys are undertaken at Haw Bridge using air lift sampling methodology, but the size and dynamic nature of the upper Severn Estuary make it unlikely results would be conclusive for this project.

15.2. Monitoring Programme

All the proposed River Severn Drought Order monitoring sites and requirements are listed in Appendix N, starting in the uppermost catchment and working downstream towards the Severn Estuary. The monitoring programme should retain a degree of flexibility to cope with the dynamic nature of droughts, additional routine or one-off monitoring could be warranted according to each event.

All '**baseline**' monitoring specific to the River Severn Drought Order is required to collect a benchmark of the aquatic environment and ecology in the River Severn over a normal range of flow conditions. These data can then be used alongside low flow/drought evidence to determine the impact of natural drought, any additional impacts from operating the River Severn Drought Order, and help assess what the minimum flow requirements are for the River Severn. The baseline monitoring will be included in the Environment Agency's annual work programme, highlighting the River Severn Drought Order as a key driver[31].

The '**low flow**' specific monitoring is required to collect data for naturally developing drought conditions prior to a River Severn Drought Order application, building a representative benchmark for comparison. The data will inform decisions on when an application may be required and provide evidence to help separate natural drought impacts from those caused solely by the River Severn Drought Order. The low flow specific monitoring will be included within the West Midlands Drought Plan, linked to appropriate triggers.

The '**River Severn Drought Order**' monitoring will be triggered by the activation of the River Severn Drought Order conditions. The data collected will allow the state of the environment to be regularly monitored and compared against both the baseline and low flow data, to help assess the impacts associated with operation of the River Severn Drought Order. Monitoring can also be used to help target any mitigation options available at the time. The River Severn Drought Order specific monitoring will be identified in the West Midlands Drought Plan.

'**Post low flow/natural drought and/or Severn Drought Order**' specific monitoring is required to monitor the recovery time following both a natural low flow/drought event, and the use of the River Severn Drought Order. Monitoring after a natural event will provide the baseline evidence crucial for comparison against River Severn Drought Order operation. This would enable assessment to distinguish between what would have occurred even if the drought order were not operated, helping to isolate the drought order specific impacts which then need managing appropriately. Both sets of monitoring will also provide evidence on the long term implications of drought events. The Post low flow/natural drought and/or Severn Drought Order specific monitoring will also be identified in the West Midlands Drought Plan.

Refer to Appendix N for the proposed River Severn Drought Order monitoring programme.

[31] Drivers describe the justification for monitoring and support the financial investment required.

16. Conclusion

The River Severn Drought Order is the Environment Agency's final option to manage the development of a severe drought event, encompassing a dual purpose of protecting public water supply and the environment along the River Severn. It aims to extend the length of time regulation releases can be made in the absence of significant rainfall by carefully managing remaining storage in Llyn Clywedog reservoir. If we did not apply for the Drought Order, we would risk running out of water for Severn regulation.

In the short term the River Severn Drought Order alone will lower flows and water levels along the full length of the River Severn, in order to make water in Llyn Clywedog reservoir last longer to safeguard against continuing drought. During this initial period no new flow benefits would be provided along the River Severn and the river environment and wildlife could be placed under additional stress compared to normal regulation years (i.e. not drought years), although no Water Framework Directive failures would be expected as a result. It is only because flows along the River Severn are maintained artificially high to support abstraction that stress may occur from the reduced water levels; flows along the majority of the River Severn should not fall significantly below what is expected to naturally occur under these drought conditions.

Assessment found that if the drought continued, water supply from Llyn Clywedog reservoir would run out. Significant detrimental impacts would then be experienced along the whole River Severn as compensation releases stopped and no specific flow could be maintained at Bewdley. Operating the River Severn Drought Order would preserve supplies in Llyn Clywedog for longer, so even beyond the point when a prescribed flow at Bewdley can no longer be maintained (regulation failure), higher flows and water levels would be maintained than if the Drought Order were not operated. This would benefit all river users and the environment by preventing the upper River Severn catchment below Llyn Clywedog from drying up and maintaining higher flows and levels throughout the River Severn.

In the long term, the River Severn Drought Order would conserve storage in Llyn Clywedog reservoir to benefit people and the environment in subsequent years. Reservoir refill would be accelerated by reducing the amount of time and rainfall needed to restock the reservoir in time for the following year's regulation season. This would greatly reduce the impacts of a further dry winter and drought summer on the River Severn. More water would be available for a subsequent dry (i.e. high regulation) year and potentially prevent the need for a second River Severn Drought Order application. This could enable normal regulation to continue throughout a second drought summer, maintaining flows significantly higher than would naturally occur to provide significant benefits for the environment and people.

The impacts caused by the River Severn Drought Order alone are all predicted to be temporary and not cause any new failures under the Water Framework Directive when compared to baseline drought conditions. Once normal rainfall returns, the environment should improve naturally and recover within one to three years, consistent with the expected natural drought recovery period.All impacts will vary according to the time of year (e.g. Spring tides, fish migration season) and other environmental conditions (e.g. temperature) and severity of the individual drought event.

The overall conclusion is that the Environment Agency's River Severn Drought Order represents a sustainable use of water resources and attempts to appropriately balance the requirements of people and the environment; potentially conflicting uses during a severe drought event. Operating in isolation it should not cause a significant additional risk to ecology when compared to the natural drought conditions.

17. References

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