Let it Flow!

Proposals from the Cam Valley Forum for an Integrated Water Resource Management Plan for the Cam Valley

THE PROBLEM NOW: Examples of Cam Valley Chalk streams dried out by over-abstraction:

River Granta at Stapleford: September 2019

Granta headwaters Bartlow Barns: August 2019

OUR AMBITION: Examples of Cam Valley Chalk streams as they should be:

River Mel below Melbourn: May 2010

River Shep at Manor Farm: May 2013

'We hold our natural environment in trust for the next generation. By implementing the measures in this ambitious plan, ours can become the first generation to leave that environment in a better state than we found it and pass on to the next generation a natural environment protected and enhanced for the future.'

Prime Minister's Foreword to *A Green Future: Our 25 Year Plan to Improve the Environment*.

LET IT FLOW!

Proposals for an Integrated Water Resource Management Plan for the Cam Valley

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Cam Valley forum

PREFACE AND ACKNOWLEDGEMENTS

The *Cam Valley Forum* is an association of local individuals with diverse environmental, recreational, academic and business interests, concerned directly or indirectly with the River Cam. Our interests embrace not only the main river within the city, its 'beating heart' and one of the most intensively-used stretches of water in Europe, but also the smaller watercourses that convey water through the fields and villages, local towns and Cambridge suburbs.

We draw upon a range of expertise and experience among our members on many aspects of the river, its tributaries and its supporting Chalk aquifer. We have close links with the many voluntary groups that seek to protect and improve their local watercourses. They include the Hobson's Conduit Trust, the Wilbraham River Protection Society, the Friends of the River Shep, the Friends of Cherry Hinton Brook, the River Mel Restoration Group and the Mill River Reserve at Wendy.

Our mission is to be the voice for the River Cam, defending its health and wellbeing for its wildlife, environment and everyone that enjoys it, and safeguarding its historical and cultural importance. In this role, the Cam Valley Forum speaks for the very large number of local people who value its heritage, beauty and recreational value. Last year, our *River Cam Manifesto* revealed widespread support for our now diminished Chalk-stream fed river.

This report - '*Let it Flow!*' - addresses the fact that the River Cam is no longer the river it once was. This is the driest part of Britain and potentially the fastest growing in human population! Those two facts are now on a collision course. The way in which we currently demand so much water for so many things - our own personal domestic supply, our recreation, our food production and our lowland and wetland wildlife - needs much more careful planning. Moreover, we cannot rely on past ways alone for solving our own selfish water needs.

In this respect, *Water Resources East*, of which we are members, has been charged with planning the future for water resources across the Anglian Region. *Let it Flow!* is our initial contribution to this collaborative effort. We reflect anxieties about our natural environment, widely shared in the Cambridge area, and bring to bear some little known facts on the matter. Read on! We are determined to live in a community with a truly sustainable future. Much greater resilience is needed not only in our water supplies but also, crucially, in our long abused river ecosystem.

I would like to express my considerable thanks to Alan Woods, our Honorary Secretary, who has designed, collated and edited this report. Our research owes much to help from Joe Stallard and many individuals from the Forum and our local river groups. Collectively we acknowledge the valuable data, maps and insights provided by, amongst others, the Cambridge University Botanic Garden, the Environment Agency and our major local water companies.

This report is fully endorsed by the Forum's Committee, many of whom have also helped considerably in its production. We hope it will have a much needed impact and a lasting effect.

Stephen Tomkins
Chairman
Cam Valley Forum
May 2020

LET IT FLOW! SUMMARY AND RECOMMENDATIONS

0.1 Healthy water and wetland habitats, rich in fish, birds, plants and other wildlife, are what the Cam Valley Forum wants for the River Cam and its tributary rivers, streams and ditches. This is an iconic river that people need to be able to continue to enjoy in many ways. We wish to work with all our partners in Water Resources East to restore and enhance the Cam and its tributaries while also responding appropriately to the pressures of increasing population, economic growth, intensive land management, and climate change.

0.2 The River Cam and its tributaries derive much of their flow from a Chalk aquifer. Under *natural* conditions, water from Chalk aquifers, with its constant year-round temperature, stable chemistry, and reliable supply through periods of low rainfall, supports Chalk-stream habitats that are internationally rare. However, conditions in the Cam Valley have been far from 'natural' for many decades and our Chalk streams have suffered as a result:

- **Groundwater abstraction, especially for public water supplies, deprives the Cam of about half its average natural flow**. Too often, summer flows are greatly reduced and, after successive winters of below-average rainfall, daily abstraction for public supplies can exceed river flows. If abstraction lowers the water table under stream beds, water flows back down into the ground below them and they dry out.

- **The impacts of low flows are exacerbated by pollution**. Sources of pollutants include farmland (e.g. nutrients, pesticides, sediment and animal waste), urban highways and drains (e.g. hydrocarbons and silt), and sewage treatment works (especially nutrients). Inputs from sewage works are constant year-round but their impact, especially in the upper river stretches, is magnified when there is less flow available to dilute them.

- **The impacts of low flows are exacerbated by habitat modifications**. River modifications, such as over-deepening, straightening and field drainage, have disconnected rivers from their floodplains, and reduced habitat quality. River bed gravels, essential for spawning fish, have been removed by dredging or buried by sediment. Watercourses are often overgrown and excessively-shaded.

0.3 It is not realistic to expect an already over-abstracted Chalk aquifer to meet future demands for water as a result of growth and climate change. Taking more groundwater will further reduce the natural supply to Chalk streams and make them even more vulnerable to drying out in the summer. Augmentation schemes that pump groundwater from new boreholes to keep spring heads running are not the answer; they tackle symptoms not causes and, by taking more water from the aquifer, may make things worse.

0.4 We seek a different approach involving many more options. These would include: substantially reducing groundwater abstraction from the Chalk aquifer; investing in alternative sources of surface water to replace groundwater; treating sewage to high standards so that it can be reused for public water supplies and to recharge the aquifer; building rainwater harvesting and recycling systems into all new development, where possible; and resolutely driving down demand for water in homes and businesses.

0.5 Realising our vision for the Cam Valley requires an 'Integrated Water Resource Management Plan'. This is needed to bring about:

(a) **Substantial reductions in groundwater abstraction from the aquifer that feeds our Chalk streams**. Where the water environment is being damaged, licences need to be amended or terminated to deliver real cuts in actual abstraction, not just paper savings in licensed amounts.

(b) **Investment in new sources of public supplies**. Proposed strategic north-south transfers of water should be extended to benefit the Cam Valley too. Locally, high river flows should be captured in a new reservoir in the lower Cam Valley, once they have flowed through it in as natural a way as possible, and be redistributed as necessary.

(c) **Investment in water reuse and aquifer recharge schemes**. Sewage treatment works need to be upgraded to deliver better treated water to be reused for public supplies and to recharge the aquifer and/or support irrigation.

(d) **Investment in the harvesting of rainwater and recycling of greywater**. Our local planning authorities need to ensure that schemes to harvest and recycle water become commonplace and help to make Cambridge a 'Water Sensitive City'.

(e) **A step-change in attitudes to water use through metering, leakage control and demand management**. Cambridge should become the 'No. 1' water-saving city and the Anglian Region the 'No. 1' water saving region in England.

(f) **Significant reductions in water pollution and investment in work to enhance habitats and natural processes**. Action is also needed to: reduce pollution from land, businesses and homes; and to rectify the impacts of past river modifications, which have reduced connectivity between reaches (e.g. weirs) and between rivers and their floodplains.

(g) **Improved resilience, not only for public water supplies but also for the environment.** An increasing population, economic growth, intensive land management, and climate change, will all bring new pressures to bear on the Cam Valley's limited and precious water resources. We all have a moral obligation to protect our river environments for future generations to enjoy.

0.6 We set out below our 12 initial **recommendations**. These are also presented, in context, in the main text that follows. We ask Water Resources East to include them in its own forthcoming *Statement of Ambition* and, subject to investigations, analysis and debate, in its final *Integrated Water Resource Management Plan* for the whole Anglian Region.

1. The opportunity

Recommendation 1: The Regional Plan must:

(a) Prioritise action to address unsustainable groundwater abstraction and thereby restore flows so that Chalk streams can once again provide a full range of benefits for people.
(b) Set a new benchmark for ensuring 'no further deterioration' in both groundwater and surface water that is far removed from the current unsatisfactory *status quo*.
(c) Deliver practical solutions to improve the 'resilience' of the *water environment*, not just of *public water supplies*, in the face of current and future pressures from population growth, intensive land management, built development and future climate change.

2. The River Cam catchment

Recommendation 2: Water Resources East should develop the Regional Plan in close liaison with:

(a) Water Resources South East for the area covered by the Thames Region.
(b) All the water companies operating in and around the Anglian Region.
(c) The Environment Agency in both its Anglian and Thames Regions.
(d) Natural England and Defra in relation to both water and land management.

3. The challenges

Recommendation 3: The Regional Plan must recognise that the ability of the Cam Valley's rivers, streams and wetlands, and their wildlife, to cope with reduced summer flows and droughts has been greatly weakened by the impacts of groundwater abstraction on baseline flows. The changes experienced are due not so much to climate change or periodic droughts but to over-abstraction over many decades, leading people wrongly to view low flows as the norm.

Recommendation 4: The Regional Plan must seek to remedy the full range of impacts caused by over-abstraction and the accompanying and growing pressures from population growth, intensive land management, built development and future climate change. It must recognise that the groundwater augmentation schemes tried to date are inadequate and that new approaches are needed to restore natural flows and develop alternative sources of public water supplies.

4. The solutions

Recommendation 5: The Regional Plan should seek the urgent review and amendment or termination as necessary of all groundwater abstraction licences affecting the Cam Valley based on today's understanding of current rainfall and aquifer levels and environmental needs for water. This must include real cuts in actual current abstraction, not just paper savings in licensed amounts. The necessary funds will need to be made available to support this process.

Recommendation 6: The Regional Plan should: assess the opportunities that proposed north-south water transfers may offer to provide alternative sources of supply for the Cam Valley, to replace abstractions from the Chalk; and assess how the approach set out by the *Chalk-streams First* coalition for the south Chiltern abstractions managed by Affinity Water could be applied to, and implemented in, the Cam Valley as an alternative or in combination with new transfers.

Recommendation 7: Water Resources East should evaluate the feasibility and cost of treating wastewater to high standards, at all sewage treatment works in the Cam Valley, so that it can be used for public water supply, to recharge the Chalk aquifer directly, and/or to irrigate crops in locations where the contribution of treated effluent to summer river flows is not critical.

Recommendation 8: The Regional Plan should ask local authorities to require all new housing and business developments, where possible, to harvest, store and re-use rainfall, to include greywater recycling schemes, and to incorporate sustainable urban drainage systems (SUDS), building on the good practice demonstrated in the Eddington development in Cambridge.

Recommendation 9: The Regional Plan should set more demanding targets for leakage control by the water companies (e.g. a 50% reduction on current levels by 2025, 75% by 2035 and 90% by 2040) and prioritise the renewal of pipe networks outside Chalk areas where leakage will not contribute to the recharge of Chalk groundwater and will represent a net loss to the aquifer.

Recommendation 10: The Regional Plan should set more demanding targets for metering programmes (e.g. to meter at least 90% of supplies by 2025, and equip 50% of households and businesses with smart meters by then, with 100% coverage for both being the target by 2030).

Recommendation 11: The Regional Plan should seek to bring about an enduring step-change in attitudes to water use by securing support for ambitious programmes of demand management along the lines of that adopted in Cape Town. The aim should be to make Cambridge the 'No. 1' water-saving city, and the Anglian Region the 'No. 1' water saving region, in England.

Recommendation 12: For the Cam Valley, a comprehensive demand management plan should include:

(a) Defining a minimum baseline of mandatory restrictions on household and business use of water to be applied at all times.

(b) Defining further restrictions to be imposed as a matter of course at least in the four months from May to August every year (e.g. a ban on household use of sprinklers and hosepipes, including high-pressure washers used to clean driveways and patios).

(c) Agreeing groundwater level 'trigger' points at which progressively more demanding restrictions on household and business use of water will apply.

(d) Rolling out smart water meters in homes, schools, businesses, hospitals and public buildings to enable continuous tracking of water use and encourage savings supported by effective training and incentives for building managers to reduce consumption.

(e) Actively reducing water pressure as groundwater 'trigger' points are reached.

(f) Installing water management devices in pipes supplying those customers whose use of water regularly exceeds guideline targets.

(g) Working with voluntary groups and the media to communicate the importance of water and water-saving messages to households and businesses.

(h) Learning from other countries about the costs and benefits of introducing progressive tariffs, linked to water supply 'trigger' points, to discourage profligate use of water.

We recognise that further detailed work needs to be done in each of the areas identified above and signify here our willingness to work with all interested parties to achieve optimal outcomes.

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LET IT FLOW! DETAILED SUBMISSION

1. THE OPPORTUNITY

1.1 One of the perceptions widely shared in our society today is that our own species, the human race, is living well out of balance with its natural environment. Whether it is in climate change, rainforest destruction, atmospheric pollution, or plastics in the ocean there is growing apocalyptic anxiety, justifiably highlighted by many, from Sir David Attenborough to Greta Thunberg.

1.2 Our relationship with our own local water environment is no less a case in point. Chalk streams and their ecology are one of the jewels in our national crown, and ours, with their wetlands, have been abused by our exploitation over many decades. Groundwater can recover if honoured for its own essential benefit. Our rivers will then live more fully in health and biodiversity. That benefit to our rivers then brings valuable benefits to the welfare of people and natural capital benefits to the environment. We have an opportunity now to grasp this challenge.

1.3 Meeting our Future Water Needs: a National Framework for Water Resources (Environment Agency 2020a) marks the start of a new approach to water resources planning. Our regional group, Water Resources East, is charged with developing our first 'Regional Water Resource Development Plan'. This will be implemented through water company plans, River Basin Management Plans (Environment Agency 2015a), and local plans (e.g. the Greater Cambridge Local Plan). Detailed guidance on the Regional Plans (Environment Agency 2020b) states that these will:

(a) '*set out how the supply of water for people, business, industry and agriculture will be managed in the region ...*

(b) '*...create resilient water supplies for all users, while protecting and enhancing the environment and creating wider social benefits for the next 25 years or more ...*

(c) '*... be developed collaboratively by water companies, other large water-using sectors and local organisations with an interest in the water environment...*'

1.4 Water Resources East must produce a series of outputs within a strict timetable (Figure 1). The Initial Water Resource Position Statement has already been issued (Water Resources East 2020).

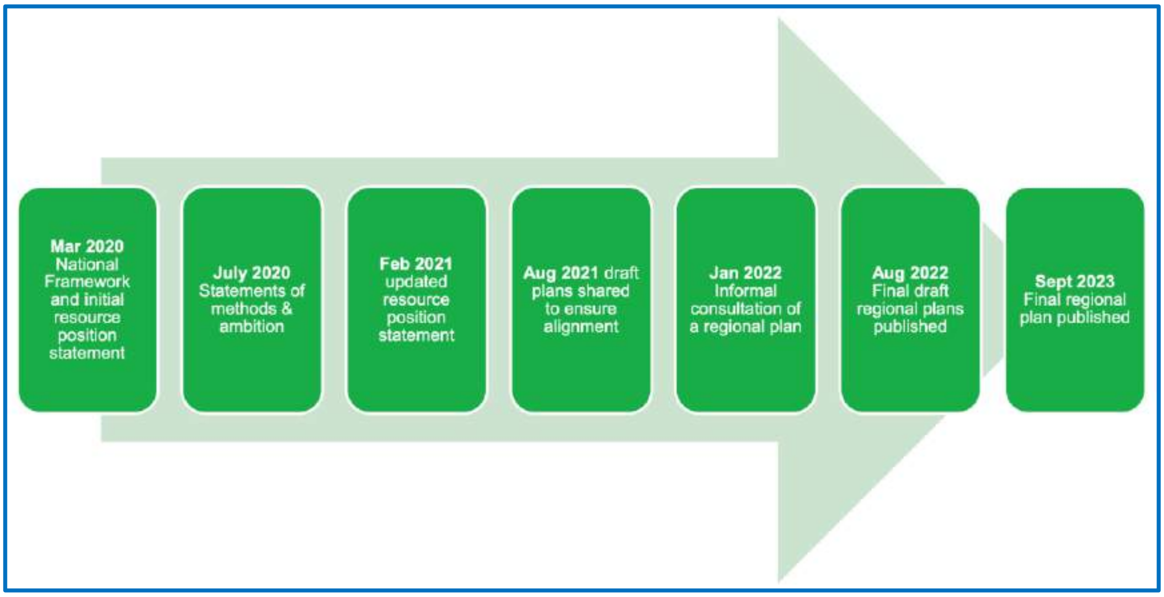


Figure 1: The timetable for delivering regional water resource management plans. Source Water Resources East (2020)

1.5 The Regional Water Resource Management Plans must:

(a) '... *understand environmental needs in the long term to inform water resources planning and deliver best value investment decisions*.'

(b) '... *develop a shared long term destination on environmental ambition*' with actions to realise it. This should '*ensure no deterioration, address unsustainable abstraction and improve environmental resilience in the face of climate change*'.

(c) Refine the Environment Agency's broad ambition, '*engaging widely on local priorities, undertaking further local and regional analysis, and exploring ... costs and benefits ... to identify the best solutions to manage water resources in a sustainable way*'.

(d) *'... be ambitious on household and non-household demand management ... to cut waste and reduce individual water use*', with water companies ... '*encouraging behavioural change*' ... and increasing '*understanding of the true value of water and the water environment ...*'.

(e) '... *plan to achieve leakage reductions of 50 per cent on average by 2050*.'

(f) '... *monitor demand savings and leakage reductions*' and '*build clear decision points into their regional plan development*' to '*allow sufficient time to develop alternative approaches for future water supply if savings and reductions do not follow the expected track*'.

1.6 The reference to improving *environmental* 'resilience' in the regional guidance is welcome as this is not mentioned at all in the National Framework. That focuses, too narrowly, on improving resilience only in relation to *public water supplies*. We consider that chronic over-abstraction of groundwater over many years has dramatically reduced environmental resilience; our springs, streams and rivers are now much less well able to cope with periods of dry weather, and droughts, than they were many years ago. Improving *environmental* resilience by reducing groundwater abstraction needs to be given just as much weight as improving *public supply* resilience.

1.7 The forthcoming 'statement of ambition' in July 2020 should focus on ending unsustainable abstraction so that we can start to put right past and continuing environmental damage to our Chalk streams. Once actions to achieve that aim have been agreed a *new* reference point for ensuring no '*future deterioration*' should then be established. This should be far removed from the *status quo*. Proposals for actions to ensure future environmental resilience, in the face of all the pressures on water from population growth, intensive land management, built development and future climate change, should then be evaluated against that new benchmark.

Recommendation 1: The Regional Plan must:

(a) Prioritise action to address unsustainable groundwater abstraction and thereby restore flows so that Chalk streams can once again deliver a full range of benefits for people.

(b) Set a new benchmark for ensuring 'no further deterioration' in both groundwater and surface water that is far removed from the current unsatisfactory *status quo*.

(c) Deliver practical solutions to improve the 'resilience' of the *water environment*, not just of *public water supplies*, in the face of current and future pressures from population growth, intensive land management, built development and future climate change.

2. THE RIVER CAM WATER CATCHMENTS

2.1 In many other parts of the country, harvesting water essentially involves creating reservoirs to store surface water abstracted from rivers, and then treating and redistributing it. In the Cam Valley, the situation is more complex. Here we need to consider **two** types of water catchment that are closely linked to each other: the **surface water** catchment defined by the watersheds (Figures 2a and 2b) and the **groundwater** catchments of the Chalk and Lower Greensand (Figures 3 and 4).

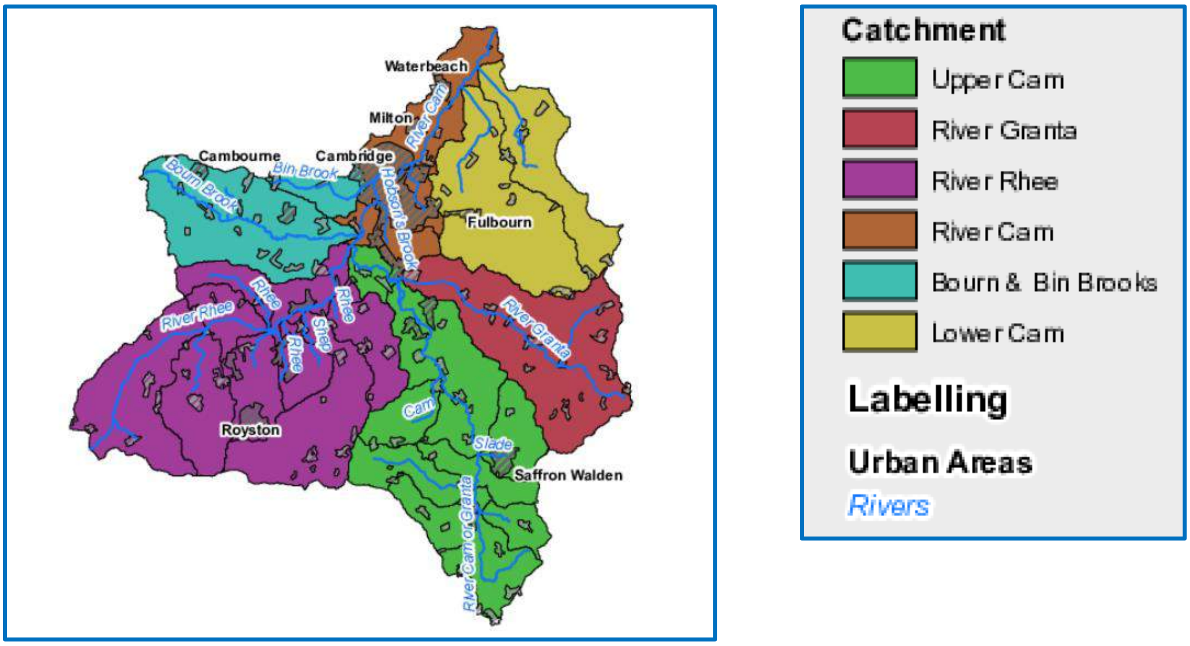


Figure 2a. The six main surface water sub-catchments of the River Cam and the main settlements. Source: Environment Agency

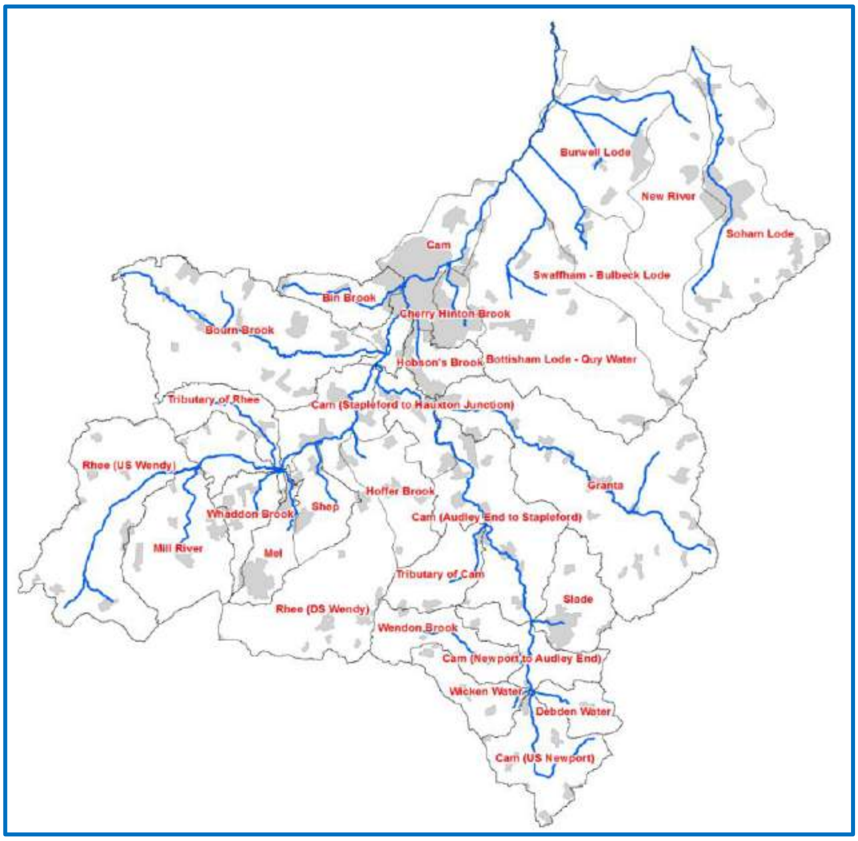


Figure 2b. The Cam Valley and its tributary rivers and streams; bounded by its watershed it comprises the full surface water catchment. Source: Environment Agency.

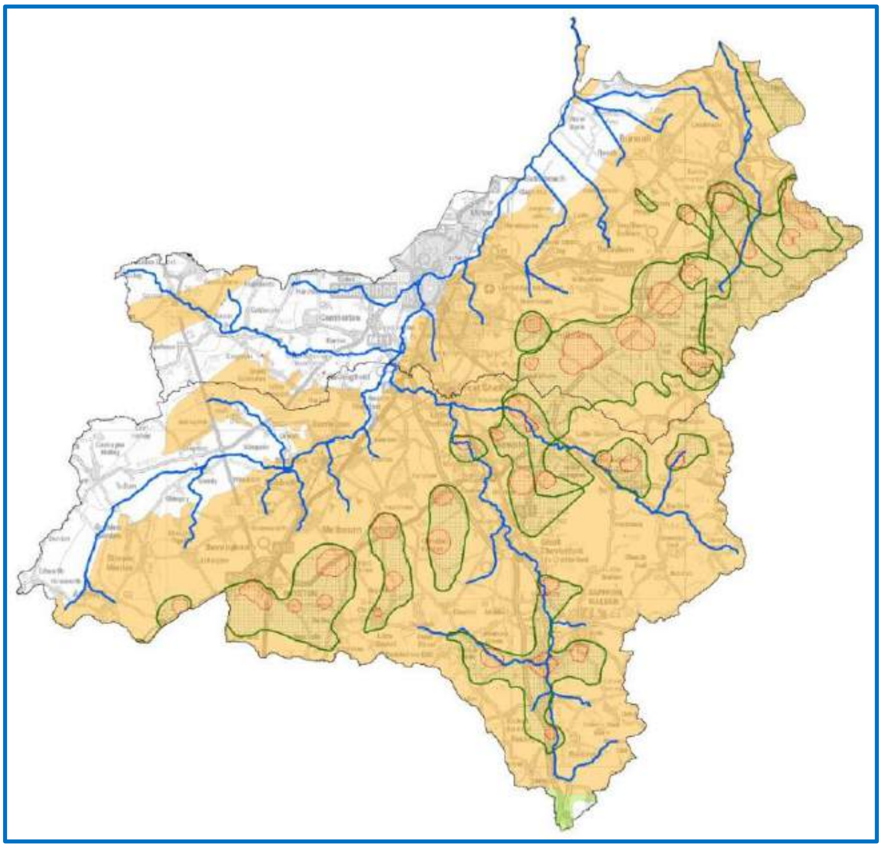
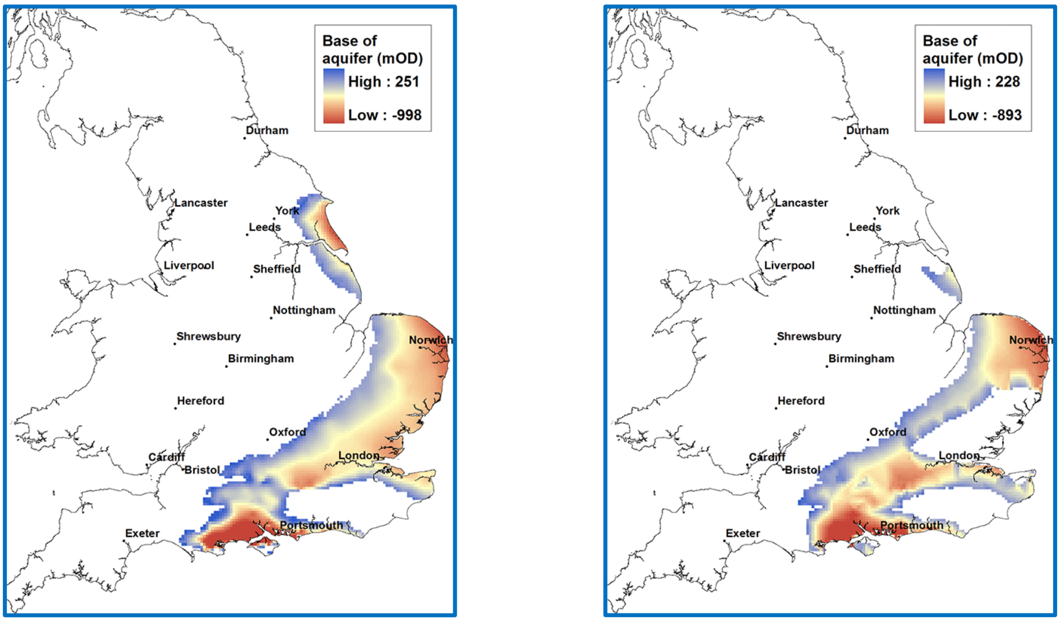


Figure 3. The Cam Valley showing in yellow the Chalk groundwater catchment. The sites of boreholes used by water companies are marked in red within their green protection zones. Source: Environment Agency.

2.2 The groundwater catchments of the Chalk and Lower Greensand extend far beyond the Cam Valley into adjacent counties (Figure 4). Their boundaries are not defined by surface watersheds. Groundwater in the Chalk, in particular, is a pooled resource and potentially the activities of any one nearby abstractor outside the Cam Valley could affect flows within it. A wider perspective is needed to embrace activities and impacts on both sides of the above-ground watershed.



Chalk Aquifers | Lower Greensand Aquifers

Figure 4. Chalk and Lower Greensand Aquifers in England. Source: [British Geological Survey](#).

2.3 The Cam is affected by the activities of three companies that supply water to the public and other customers, and also to each other, and/or treat sewage:

(a) **Cambridge Water** (owned by South Staffordshire Water Company): abstracts water from boreholes within the Cam Valley to supply an area extending well beyond the Cam surface water catchment, particularly towards St Neots, St Ives and Ramsey (Figure 5).

(b) **Affinity Water**: abstracts water within the Cam Valley to supply customers in the south and east of the Cam Valley (e.g. Saffron Walden), and beyond, in Hertfordshire and Essex.

(c) **Anglian Water**: treats sewage; also abstracts water from the Chalk north-east of Cambridge and supplies customers there and in a small area in the west of the Cam Valley catchment.

Figure 5: Local water company supply zones in relation to the River Cam catchment (from Figure 3, outlined here in black). Blue area: Cambridge Water supply area (Source: www.sswct.org/map.asp). South clear zone: served by Affinity Water. East and West clear zones: served by Anglian Water.

2.4 While the Cam Valley itself lies entirely within the Anglian Region of the Environment Agency, the Chalk aquifer straddles its border with the Agency's Thames Region to the south.

Recommendation 2: Water Resources East should develop the Regional Plan in close liaison with:

(a) Water Resources South East for the area covered by the Thames Region.

(b) All the water companies operating in and around the Anglian Region.

(c) The Environment Agency in both its Anglian and Thames Regions.

(d) Natural England and Defra in relation to both water and land management.

3. THE CHALLENGES

3.1 Pressures from water abstraction

3.1.1 The first pumping station for Cambridge was built in 1855 at Cherry Hinton. A larger pumping station opened at Fulbourn in 1890. By 1900, the Fulbourn village wetlands began to dry up. An even larger pump was in operation at Fleam Dyke from 1921. This one station provided the entire water supply for several decades and by 1954 still provided two thirds of the then county's water. Cambridge Water now pumps all its water for public supply from 26 boreholes, 97% of the total volume from the Chalk and the remaining 3% from the Lower Greensand.

3.1.2 There are also water transfers into and out of the Cam Valley. Affinity Water abstracts in total about half the volume taken by Cambridge Water from the Chalk for its customers to the south (see page 24). Anglian Water also abstracts water from the Chalk. At Ashwell, Affinity Water uses a proportion of its licences to mitigate the impact on the River Cam and Ashwell Springs of its groundwater abstractions (Environment Agency 2017). Elsewhere, a concern that some Norfolk wetland sites dried out in the summer of 2019 as a result of water transfers from Thetford to Cambridge led to the closure of a borehole that had operated since 1989.

3.1.3 A national licensing regime for water resources was first introduced in the mid 1960s. Abstraction licences were granted to formalise established rights to take water for public water supply, irrigation, and industrial purposes. Water seemed abundant and development pressures were modest. There were no formal environmental assessment requirements of the sort that exist today. Although flows in our waterways, particularly near Cambridge, had been declining for at least a century, in the mid 1960s the Chalk springs were still running throughout the year.

3.1.4 Since then, pressures on the water resources of the Cam Valley have grown inexorably, from public water supply to serve a growing population, new demands from business and industry, and to meet the needs of farmers irrigating land to grow vegetable and salad crops. For example:

(a) The population of Cambridge grew by just under 30%, from 95,527 to 123,900, between 1961 and 2011 (Wikipedia 2020).

(b) Nearly 1,000 new homes have been built in Cambridge every year since 2012, increasing the total housing stock by almost 14% in seven years (House of Commons Library 2019).

(c) The new village of Cambourne with a population of over 10,000 has been built since 1998 on what was previously 400 hectares of farmland. Further new settlements at Northstowe, Bourn Airfield, and Waterbeach, among others, will add tens of thousands of new homes.

(d) Several science and business parks have been established in and around Cambridge and the Addenbrookes biomedical campus to the south of the city has grown apace.

(e) Some farmers have made significant investments in irrigation. For example, the construction in 2010 of a 500 megalitre reservoir and 24 kilometres of pipework has enabled 19 farmers to irrigate vegetable and salad crops across some 3,800 hectares of land near Duxford (Weatherhead *et al* 2008). Much of this land could previously grow only rain-fed crops.

3.1.5 Figure 6 summarises the pressures on water supplies (Stallard 2020). The diagram shows averaged annual flows within the catchment, which vary substantially between and within years. The width of each line is directly proportional to the flow it represents. The flows have been calculated from an analysis of publicly-available data sources. The diagram shows that the total average annual rainfall across the Cam catchment is some 466 million cubic metres (Mm^3). Of this total:

- 333 Mm³ evaporate directly, or are lost to the atmosphere through transpiration by plants.
- 93 Mm³ are stored as groundwater, of which approximately half (48 Mm³) feeds the Chalk streams that flow into the Cam and the remainder (45 Mm³) is abstracted, for all purposes.
- 40 Mm³ of rainfall flow into streams and rivers directly as surface water.

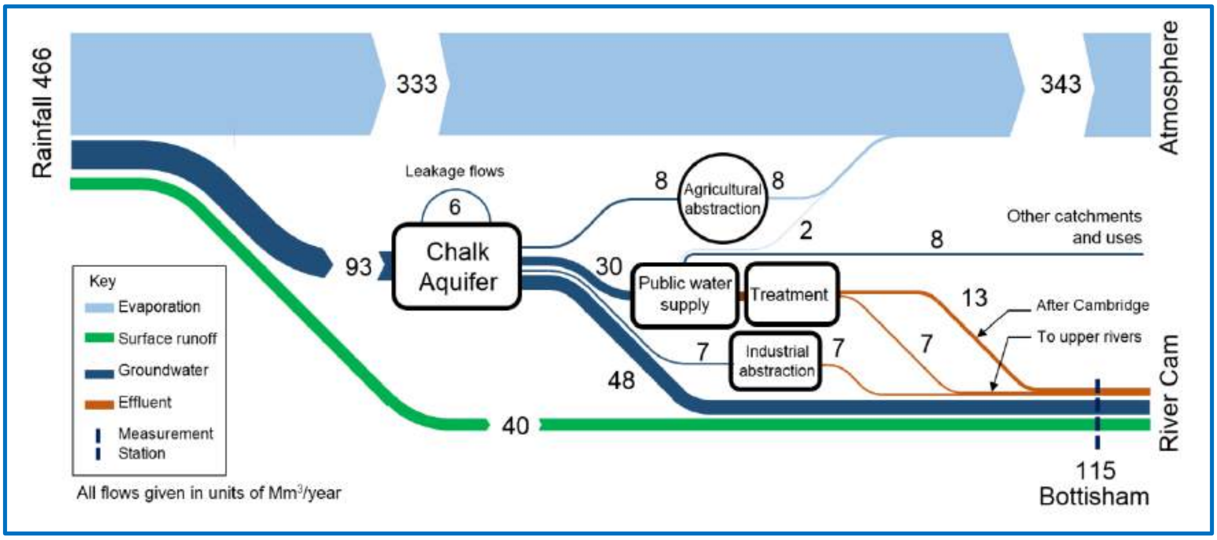


Figure 6. Average flows of water within the River Cam catchment, in units of million cubic metres (Mm³)
Note: 1 Mm³ = 1,000 megalitres. An Olympic pool = 2,500 m³ = 2.5 megalitres. Source: Stallard (2020).

3.2 The environmental consequences of over-abstraction

3.2.1 The growth in demand for public water supplies, met largely by increased abstraction from boreholes, has resulted over time in a range of environmental impacts. Observations at many Chalk streams and at high-profile sites suggest that there has been a step-change in hydrology in the Cam Valley since the 1940s, as a result of increased abstraction. There needs to be a corresponding step-change back to naturalise flows from groundwater into our Chalk streams.

3.2.2 The ability of rivers, streams and wetlands, and their associated flora and fauna, to cope with reduced summer flows and droughts has been greatly weakened by the impacts of groundwater abstraction on baseline flows. Pollution from surface water run-off and sewage effluent, together with and drainage and river modifications, have made matters worse. The impacts include:

(a) **A progressive desiccation of once boggy land in valleys and at the fen edge**. This has enabled the conversion of much land previously suitable only for seasonal grazing to arable cropping.

(b) **More frequent and prolonged reductions in flows of spring-fed streams**. For example, flows at Hauxton Mill are severely reduced compared with 30 years ago. There is now rarely enough water to sustain flows through the mill race. Historically, perhaps four mills were powered by water taken from Cherry Hinton Brook (Bullivant 2020). The Brook now suffers from low flows and may operate only '*at its low base rate flow more or less all year round*' (Mungovan 2017). In 1982, the citation for the Fowlmere Watercress Beds Site of Special Scientific Interest (now an RSPB Reserve) described it as '*a low area on the chalk where the most extensive springs in the county are to be found*' (Natural England 1982). Those springs now fail in dry years.

(c) **Declines in the flow and ecology of Nine Wells Springs, Hobson's Brook and Hobson's Conduit**. Over the period 1965-81, flows ranged between 70-80 litres per second in early spring and 20 litres per second in the autumn; since then, they have fallen below 20 litres per second for long periods. The springs dried up completely in August-September 2019 (Boreham 2020).

Substantial reductions in faunal diversity in Hobson's Brook between 1945-49 and 1969-72 have been attributed to greatly reduced flows and intensive arable farming (Gray 1974, 1977; Boreham 1990, 2020). Gray (1974) stated: '... *a stream with a hitherto full and vigorous biota has turned almost into a drainage ditch ...*'. Gray (1977) added: '*Should the climate of the first enquiry ever be restored, so that the Wells once more run to full capacity and adequate ground water renders irrigation superfluous, then it may be assumed that the life of the Brook, micro- and macro-fauna and flora alike, will regain all its pristine vigour*.

(d) **Local extinctions of rare invertebrates**. Nine Wells Springs was once a Site of Special Scientific Interest but was denotified in 1976 when the springs dried up, leading to the extinction of rare macro-invertebrates, including the relic aquatic flatworm *Crenobia alpina*. This species would have survived every drought at the springs for the 11,500 years since the last glacial period.

(e) **More frequent drying out of local wetlands**. Reduced river flows and a lowered water table increase the risk that important wetland sites such as Nine Wells Springs will dry out. Fulbourn Fen, Thriplow Meadows and Thriplow Peat Holes also all now dry out. Wicken Fen survives only because work has been undertaken to maintain high water levels. At Fowlmere, the RSPB battles the problem of depleted spring flows nearly every year. This once extensive wetland, which historically could not be drained, now relies on pumped water in dry years.

(f) **Losses of designated wetlands**. The Great Wilbraham River disappeared in the middle of the 20th century as a result of extensive Fen drainage and watercourse alteration. The feeder streams from its remaining Chalk spring sources were maintained almost only to supply the water mills at Quy and Lode. From well before 1930, abstraction from the local Chalk was already lowering the Fulbourn area aquifer. Teversham and Fulbourn Parishes together had over 400 hectares of designated wetland habitats in 1951. Now there are only two wetland Sites of Special Scientific Interest, covering some 90 hectares. Support provided by the Lodes Granta Groundwater Scheme from 1992 has failed to save the rivers. In 1997, the first Cambridgeshire river protection group was formed: the Wilbraham River Preservation Society. In March 2019 the Little Wilbraham River was dry (Hawkins 2011).

(g) **Losses of wetland plants**. There have been significant declines in the distribution of aquatic and bankside species, with many local extinctions. Preston *et al* (2003) found that some 35% of the wetland species in Cambridge have been lost since 1660, notably through the conversion of riparian commons into amenity grassland through the tipping of waste into ditches and hollows followed by levelling and resowing. The Cambridge Milk Parsley *Selinum carvifolium*, a very rare plant, now confined in Britain entirely to Cambridgeshire, holds on in just two or three county conservation wetland sites, with one recent local extinction. While land management changes have been major factors in these declines, low flows may also be important. Pollutants become more concentrated when flows are low and there have been disproportionate losses of aquatic species that cannot tolerate high nutrient levels in water (Preston *et al* 2003).

(h) **Degraded fisheries.** Many fish species cannot survive without good flows of clean water and healthy populations of freshwater plants and the invertebrates that depend on them. Burbot *Lota lota* is thought to have been extinct in the Cam since 1969. Brown Trout breed only where the Cam offers good quality water, a diversity of habitat and clean gravel to spawn upon. Cam fisheries are dominated by coarse fish that have less demanding ecological needs.

(i) **Increases in invasive species**. Losses of native species have been compounded by the spread of coarser vegetation and invasive species, encouraged by increases in nutrient levels as a result of pollution from farmland and sewage works. Aquatic species of concern include Floating Pennywort *Hydrocotyle ranunculoides*, Water Fern *Azolla filiculoides* and New Zealand Pigmyweed *Crassula helmsii* (all banned from sale since April 2014). Himalayan Balsam *Impatiens glandulifera* spreads very rapidly on banksides. At times Floating Pennywort has completely dominated long stretches of water, creating an impenetrable barrier to canoeists. Action has also had to be taken to prevent New Zealand Pigmyweed spreading into Cherry Hinton Brook; the dense mats of vegetation created by this species are difficult to eradicate.

(j) **Reduced dilution of pollutants**. When stream and river flows are reduced, there is less clean water available to dilute inputs of pollutants. These can come from point sources such as sewage treatment works, industrial sites and highway drains, and diffuse sources such as farmland and rural septic tanks. The damaging inputs include sediment, nutrients (nitrate and phosphate), pesticides, hydrocarbons, and endocrine disruptors leaching from plastic waste. Raw sewage can also enter river systems if sewage works become overwhelmed during rainstorms, as has happened episodically in the catchment. Three streams in the upper Cam and upper Rhee have been classified as of 'Poor' water quality by the Environment Agency. While three smaller streams are classified as 'Good', all the others, including the whole of the Lower Cam catchment, are classified only as 'Moderate' (Figure 7).

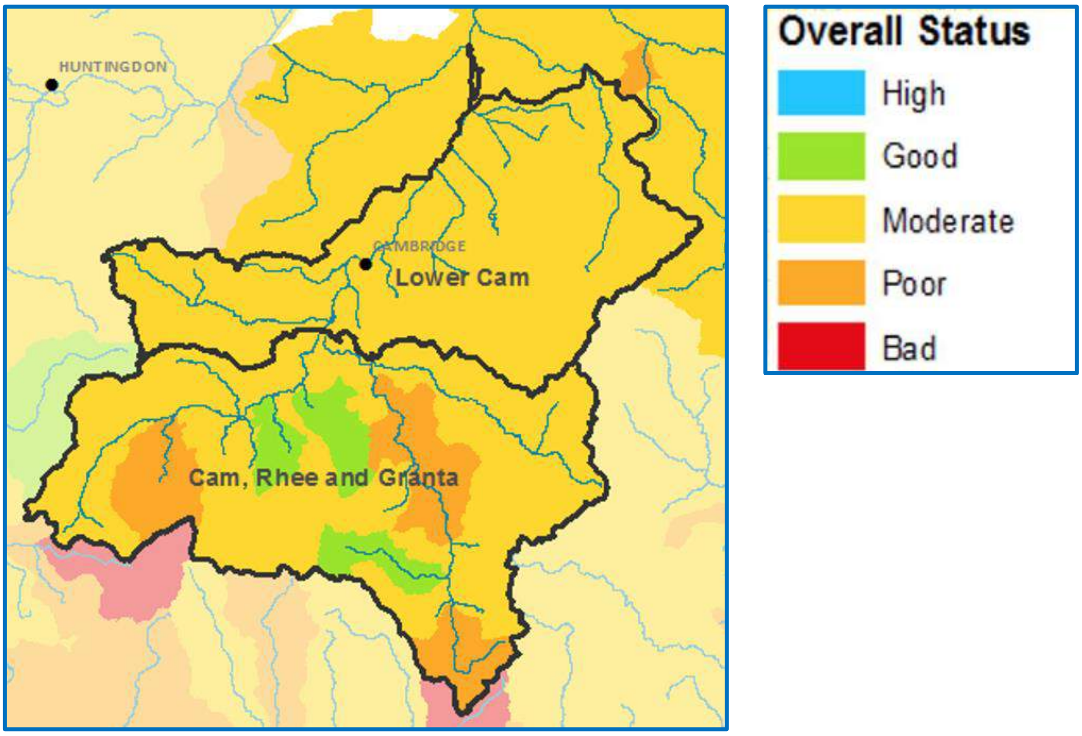


Figure 7: Water quality in the Cam Catchment in 2016. Source: Environment Agency.

(k) **Habitat modifications**. Some watercourses, particularly where they flow through urban areas, have been heavily modified over time: over-deepened, straightened, diverted, culverted, embanked and/or connected to surface water and industrial drains. The Cherry Hinton Brook is one such example; it has been so heavily modified that it no longer directly reaches the Cam (Mungovan 2017). This interference in natural processes compounds the impact of low flows. While much can be done to create better connections and improve channels to create optimal conditions for fish and other wildlife, such actions are of little value without adequate flows.

3.3 The problem is abstraction not lack of rainfall

3.3.1 To understand the significance of abstraction, as distinct from droughts and climate change, it is important to understand local rainfall patterns and how they affect river flows. Over the period 1900-2019, the mean annual and winter rainfall in Cambridge was 558 mm and 269 mm respectively (Stallard 2020) . The annual rainfall figure is low compared with the UK long-term average of 885 millimetres. The pattern of rainfall varies annually, seasonally and episodically (Figure 8) but the long-term mean annual rainfall has remained fairly constant to date.

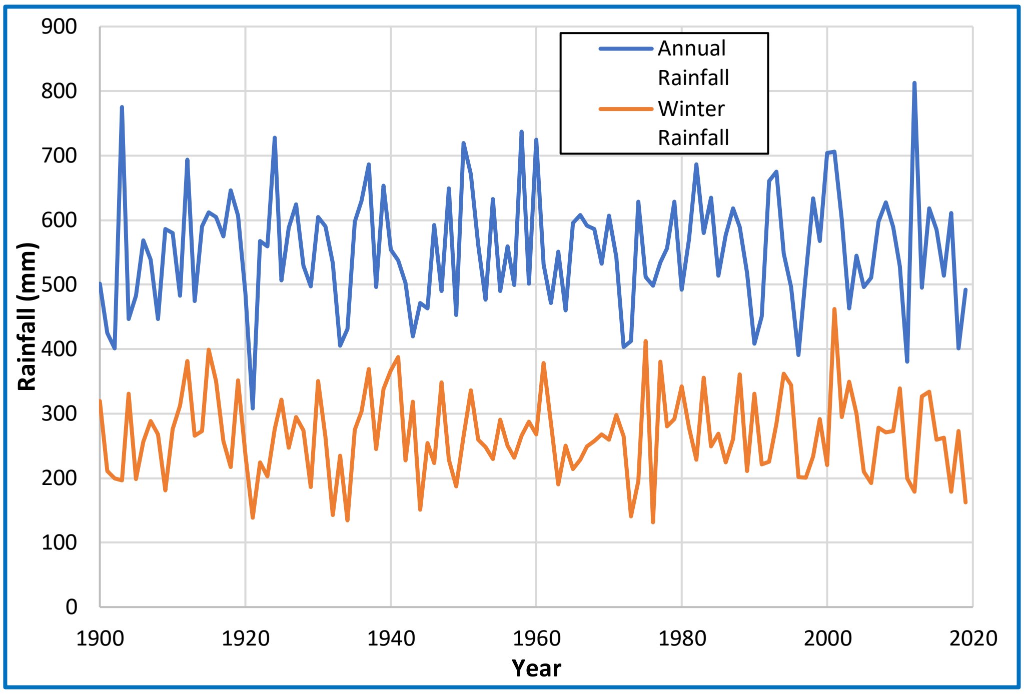


Figure 8. Annual and winter rainfall at the University Botanic Garden, Cambridge 1900-2019.

3.3.2 Spring and summer rainfall from April to September is largely taken up by plants and transpired back to the atmosphere. The proportion that percolates through the ground to reach the local Chalk aquifer may be as low as 5% (Hopkinson 1898). Autumn and winter rainfall from October to March is principally what recharges the groundwater. The health of the Cam Valley's groundwater therefore depends on, and is sensitive to, the amount of rainfall over this period. Figure 9 indicates a downward trend in winter rainfall from 290 to 250 mm between 1979 and 2019, but 250 mm is still close to the long term average of 269 mm over the period 1900 to 2019.

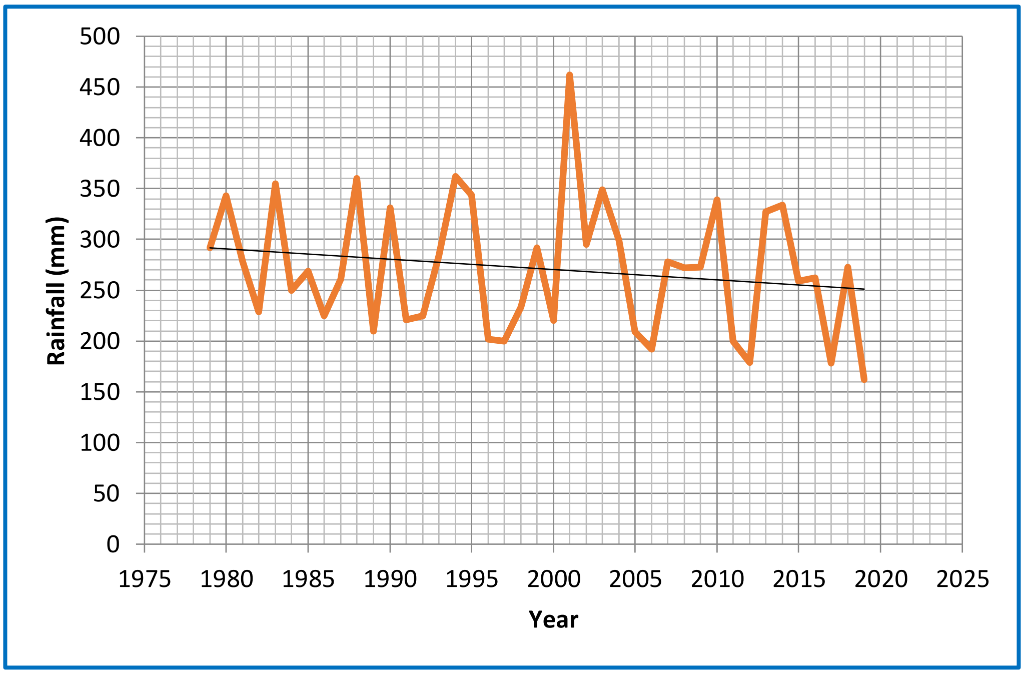


Figure 9. Winter (October - March) rainfall at the University Botanic Garden, Cambridge 1979-2019.

3.3.3 Median projections for the climate of Eastern England in the 2050s (Met Office 2019) are for a reduction in summer rainfall of 14% to 23% and an increase in winter rainfall of 7% to 11%. The results of a study modelling the impacts of climate change found that '*although total groundwater* *recharge is not likely to reduce and may increase, the recharge period could reduce from 5 months to 3 months. Taking into account drier soil moisture deficits and the implications of a shorter recharge window, the seasonal variability may have a more significant impact on resource availability with a greater risk of lower summer groundwater levels. Lower groundwater levels would result in lower base flows, therefore there is a potential risk of rivers becoming more vulnerable*' (Mansour & Hughes (2017) cited in Environment Agency 2020c).

3.3.4 Importantly, the slight trends in the annual and winter rainfall figures for Cambridge provide no substantial evidence as yet of the predicted changes in climate. The cause of the problems experienced by Cam Valley Chalk streams to date is not a reduction in rainfall due to climate change. It is not yet possible to say whether future climate change will worsen the position (more droughts) or improve it (more winter recharge). Either way, the system is not currently resilient enough to ensure that the environmental needs of our Chalk streams are met at all times.

3.3.5 The data for Cambridge show that annual rainfall has long been highly variable from one year to another. There have been several very dry or very wet years since 1900. Whether this pattern has changed significantly recently is unclear, although average temperatures have risen, and hotter summers inevitably add to the pressure on water resources. In the summer of 2019, the measured flow of the upper Cam at Dernford fell to 14% of its long term mean (Figure 10). The 2019-20 winter in Cambridge was relatively dry compared to the rest of the country with only just above average rainfall; Cam river flows were only 80% of the long-term average in March 2020.

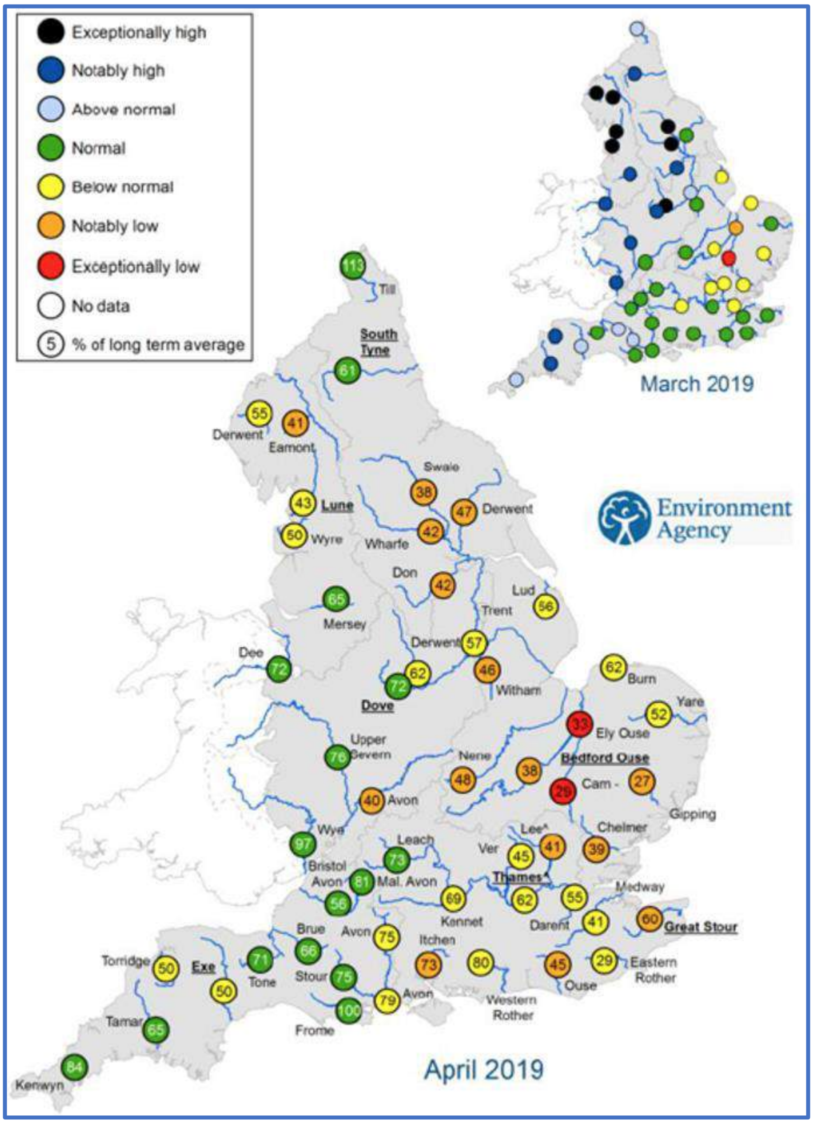


Figure 10. River flows March and April 2019. Source: National River Flow Archive.

3.3.6 The variability of rainfall from year to year underlines the need to ensure that Cam Valley groundwaters have the resilience to keep Chalk streams flowing at levels that protect the environment when winter recharge is low and/or summer droughts are more frequent, prolonged, and/or intense. Two or more consecutive winters of low winter rainfall pose a substantial risk to water supplies and the environment (Environment Agency 2015b; Stallard 2020).

3.3.7 Figure 11 shows, for the period 1962 to 2018, flows in the upper River Cam at Dernford near Sawston (orange line) and rainfall between the end of one drying period and the start of the next (i.e. the amount of rain wetting up the soil in winter) (blue line). The fluctuations of flow and rainfall often coincide. However, flow volumes have declined, notably since the early 1990s, while rainfall between the end of drying and the start of the next drying cycle shows no clear trend. The decline in flow can best be explained by the increasing levels of abstraction in the upper Cam.

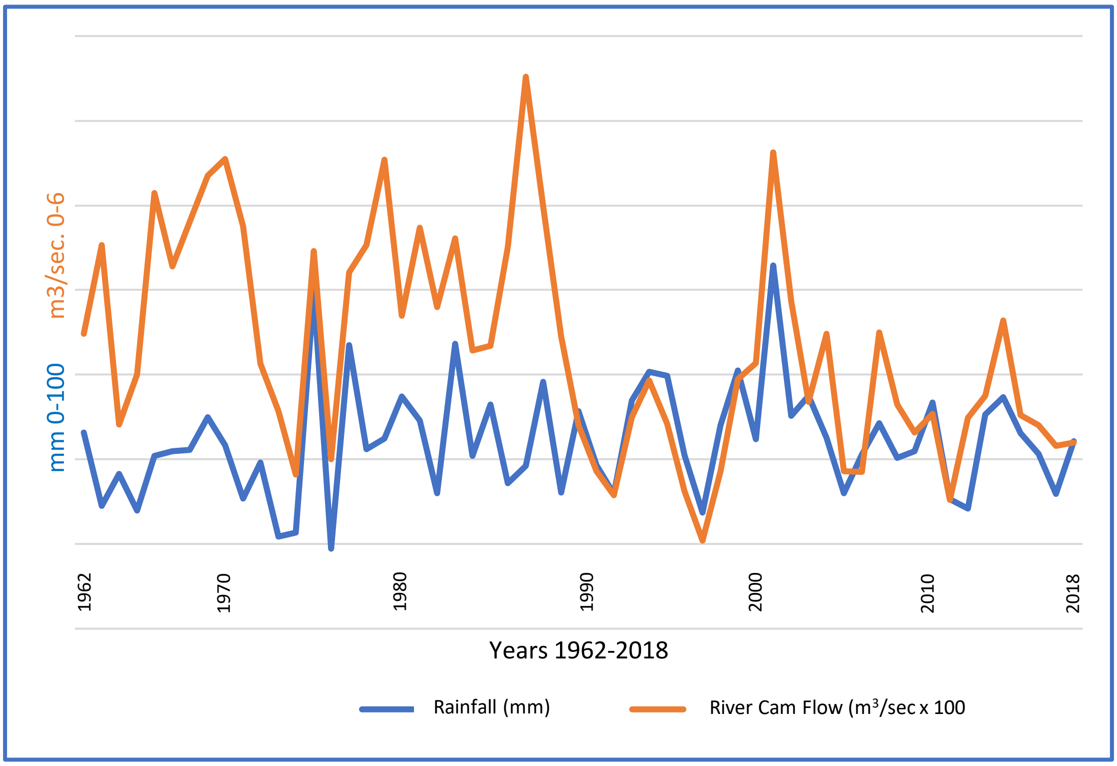


Figure 11. Changes in the amount of rain wetting up the soil in winter (in mm, blue) and the flow of the River Cam at Dernford (in m^3/sec x100) (orange). Source: Data from Centre for Ecology and Hydrology.

3.3.8 Soil moisture deficits, which reflect the difference between incoming rainfall and outgoing loss of moisture by evapotranspiration, are also affected by lowering of the water table by abstraction. Figure 12 shows monthly soil moisture deficits and surpluses for the years 1961-2019. The peaks are at the point in each year (around March) when the soil is at its wettest after the winter; the troughs are the point when the soil is at its driest (around September) at the end of the summer.

3.3.9 In about 24 (41%) of the 59 years, winter rainfall has not exceeded the previous deficit (from the Figure these are the years where the maximum deficit is of the order of 250 mm). The rainfall the following winter will then have to eliminate a deficit accumulated over two years before it starts to replenish the Chalk aquifer. This happened most recently in the winter of 2018/19. River levels were very low at Jesus Green Lock by July 2019 and parts of the Cam upstream dried out. The flow at Jesus Green Lock now, in May 2020, is almost as low as it was then. Last winter’s rainfall probably reached the Chalk aquifer only in February of this year. It has been dry since.

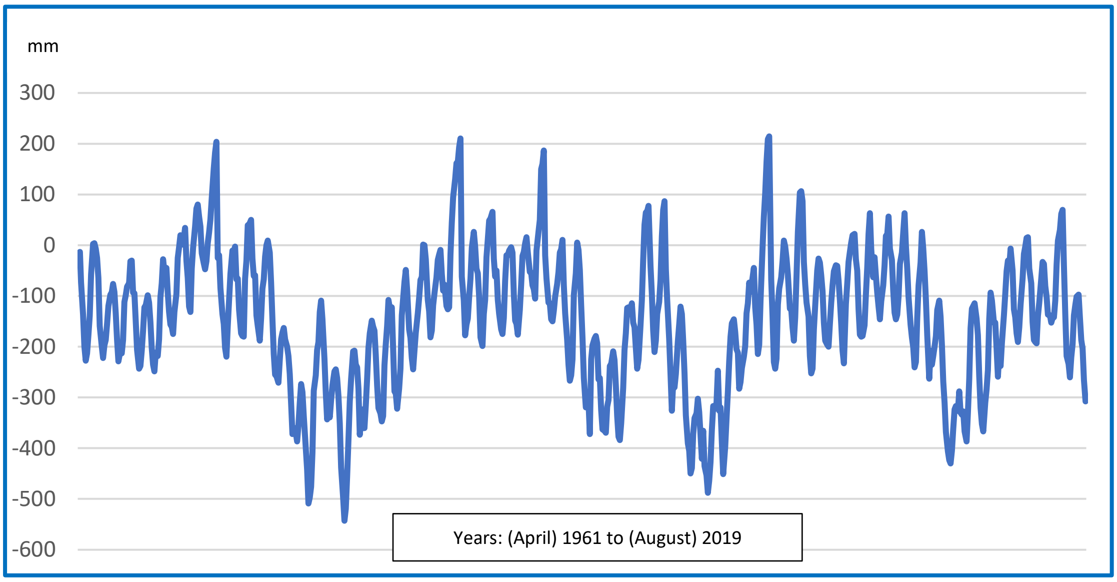


Figure 12. Monthly positive/negative Potential Soil Moisture Surpluses/Deficits (mm) 1961-2019. Source: R Evans. Rainfall data: NIAB (Cambridge). Daily evapotranspiration data: MAFF Technical Bulletin 26.

3.4 Groundwater support is not the answer

3.4.1 Groundwater augmentation schemes were introduced in the 1990s in response to the drought of 1976 and continuing concern about the environmental impact of low flows (Rushton & Fawthrop 1991). Overall, some 62% of the Chalk groundwater pumped is taken for public water supply. A further 20% annually is pumped from 14 boreholes, mostly in the summer, into augmentation schemes to offset the damaging effects of groundwater abstractions on Chalk streams. This huge volume is piped to about twice that number of 'spring heads'. The summer flows for such places as Wicken Fen's New River, the River Snail, the five Fen skirt Lodes, the Little Wilbraham River, the Hoffer Brook, the River Shep at Fowlmere, the River Mel, Bassingbourn's Wellhead Springs, Thriplow Meadows, and the Mill River are all supported by this pumped augmentation.

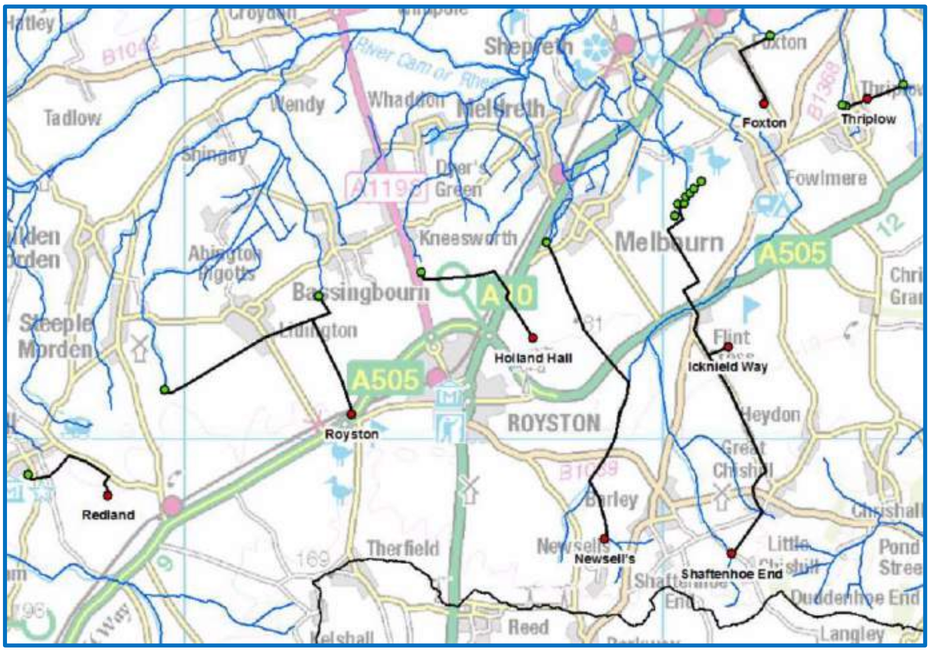
3.4.2 The schemes operating in the Valley, as described in the Cam and Ely Ouse Abstraction Licensing Strategy (Environment Agency 2017) with the recent addition of the Nine Wells scheme, are:

(a) **Rhee**: Eight Environment Agency boreholes support eight tributaries and three Sites of Special Scientific Interest: Ashwell Springs, Fowlmere Watercress Beds, and Thriplow Meadows (Figure 13). Some tributaries are supported every year, others only in droughts.

(b) **Lodes Granta**: Six Environment Agency boreholes support the Lodes and the River Granta at 10 locations (Figure 14). They mitigate the effects of abstraction in the catchment in dry periods.

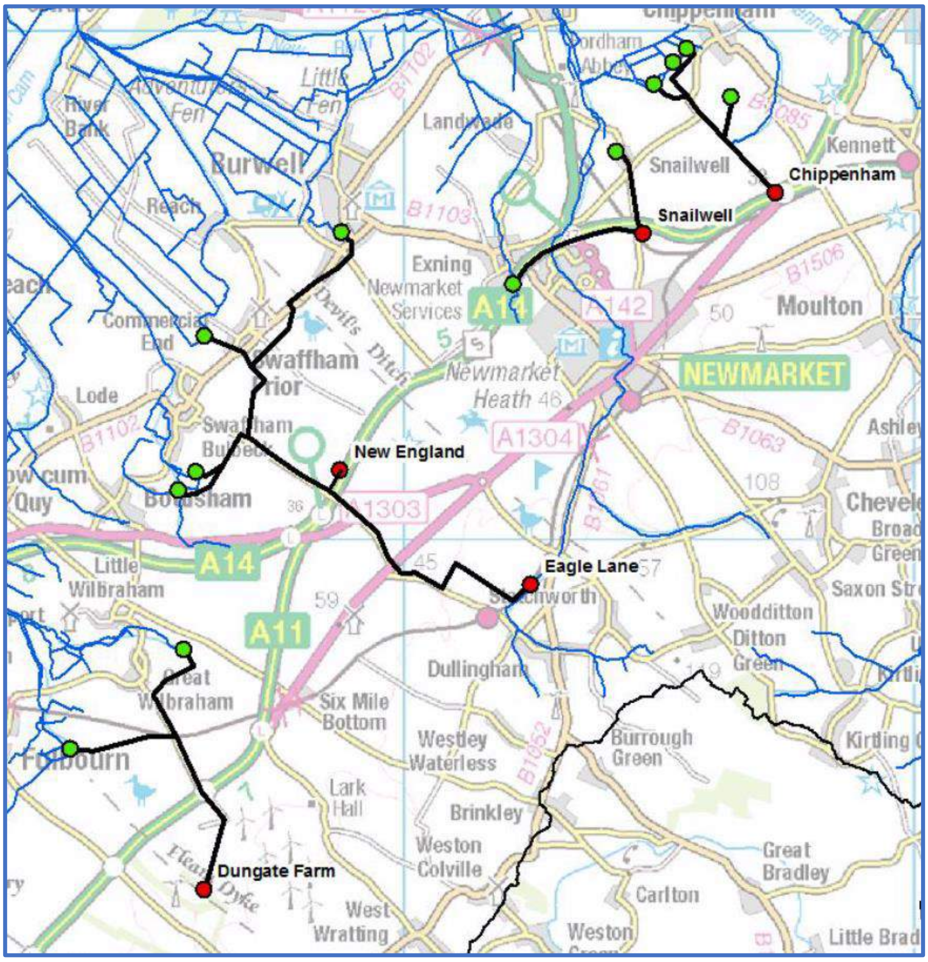
(c) **Other schemes**: Affinity Water support the River Cam and Ashwell Springs to mitigate the impact on the river and spring of their groundwater abstractions.

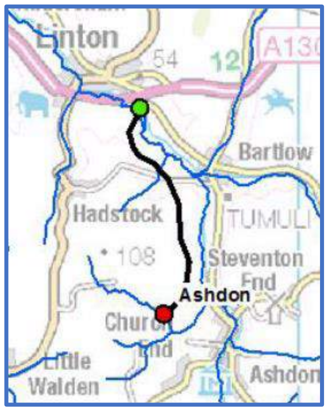
(d) **Nine Wells**: An augmentation scheme to support flows at Nine Wells (and hence in Hobson's Brook) was proposed 11 years ago when the impact of water abstraction at Babraham was first confirmed. Investigations started in 2016. Following various delays, it is hoped that the scheme will begin to actively support flows in Hobson's Brook in summer 2020.



Boreholes are shown in red (to the south) and 'spring heads' in green (generally to the north).

Figure 13. River Rhee Groundwater Support Scheme. Source: Environment Agency.





Boreholes are shown in red (to the south) and 'spring heads' in green (generally to the north).

Figure 14. Lodes Granta Groundwater Support Scheme. Source: Environment Agency

3.4.3 The Cam's Chalk streams are pale imitations of what they were even 20-30 years ago despite augmentation efforts. They would be drier or even completely dry for longer periods, over longer stretches, without this augmentation but it is not sustainable, for several reasons:

(a) **As the 'added' water comes from the same aquifer it is not a net addition:** The schemes 'rob Peter to pay Paul' by abstracting yet more water from the same aquifer to try to keep the rivers flowing. They simply replace depletion at the spring head with depletion at the site of the augmentation borehole, creating a downward spiral effect on the aquifer. These 'additions' are cosmetic fixes that do not address the real problem of chronic over-abstraction.

(b) **There may not be enough water to pump at the augmentation borehole.** For Fowlmere and the River Granta, there are concerns that the groundwater is simply not available for abstraction in the compensatory borehole to sustain the necessary flows. There is a risk that augmentation may simply cease, as happened at the Little Wilbraham River in 2015.

(c) **The added water is often insufficient to restore a proper flow to a river**. Too little water may be provided to enable the stream to run (e.g. at Lode Mill in recent years). In dry weather the pumped water may simply be lost through the bed of the stream into the underlying Chalk because the surrounding water table is too low (e.g. Little Wilbraham River).

(d) **The schemes do not necessarily deliver water when it is needed**: Promised real-time flow monitoring and telemetry to manage flows has not always been delivered. The lack of automation means that the successful operation of the schemes depends on someone personally observing low flows and ringing up to ask for more water to be pumped. In addition, if pumps fail, the receiving streams will lose the support they need.

(e) **The water delivered may be of an inferior quality, potentially damaging water life**. Pumped water may have different chemical characteristics to the receiving water and can warm up when conveyed by pipes, altering temperature profiles in the receiving water. The clear spring water that is pumped may not be sufficient to dilute pulses of treated effluent from sewage works, doing little to improve water quality (e.g. the River Mel is affected by discharges from Melbourn and Meldreth sewage treatment works).

3.4.4 The picture on page 2 of the River Granta at Stapleford in September 2019 illustrates that augmentation cannot be relied upon to compensate for the impacts of lowered water tables. In summer 2019, the River Granta was continuously augmented by water abstracted from the borehole at Ashdon north of Linton (see Figure 14), 15 kilometres upstream of the bridge at Stapleford. Despite this support, and the combined inputs of treated sewage effluent from the villages of Linton, Haslingfield, Abington and Babraham, the River Granta at Stapleford was still dry.

Recommendation 3: The Regional Plan must recognise that the ability of the Cam Valley's rivers, streams and wetlands, and their wildlife, to cope with reduced summer flows and droughts has been greatly weakened by the impacts of groundwater abstraction on baseline flows. The changes experienced are due not so much to climate change or periodic droughts but to over-abstraction over many decades, leading people wrongly to view low flows as the norm.

Recommendation 4: The Regional Plan must seek to remedy the full range of impacts caused by over-abstraction and the accompanying and growing pressures from population growth, intensive land management, built development and future climate change. It must recognise that the groundwater augmentation schemes tried to date are inadequate and that new approaches are needed to restore natural flows and develop alternative sources of public water supplies.

4. THE SOLUTIONS

4.0.1 To achieve our vision for the River Cam, and its many tributaries, of healthy water and wetland habitats that are rich in fish, birds, plants and other wildlife, we seek:

- Substantial reductions in groundwater abstraction from the Chalk.
- Investment in alternative sources of public water supplies.
- Investment in water reuse and aquifer recharge schemes.
- Investment in the harvesting of rainwater and recycling of greywater.
- A step-change in attitudes to water use through metering, leakage control and demand management.
- Significant reductions in water pollution from sewage effluent and run-off from farmland and built-up land, and investment in work to restore and improve riverine habitats.
- Improved resilience, not only for public water supplies but also for the environment.

4.0.2 We set out below the options that Water Resources East should consider in developing its Regional Plan. While this must focus on water *resources*, the water environment needs to be viewed as a whole. Actions on water resources will need to be complemented by further work on water *quality* and water *habitats* as part of the Anglian Region's River Basin Management Plan, and by the development of appropriate local planning policies (e.g. in the Greater Cambridge Local Plan).

4.1 Substantial reductions in groundwater abstraction from the Chalk

4.1.1 Many of the water abstraction licences in the Cam Valley were granted in the early 1960s when water seemed abundant, development pressures were modest, and little attention was paid to environmental impacts. Licences were granted regardless of availability, in perpetuity, for fixed quantities of water often far in excess of the amounts needed and used at the time (Risk Solutions 2015). These 'permanent' licences are understandably viewed as valuable assets by the water companies, farmers and other abstractors that own them. It can accordingly be difficult and expensive to seek reductions in licensed amounts and/or to terminate the licences.

4.1.2 Cambridge Water and Affinity Water hold licences to abstract and treat 90 megalitres of water per day on average from the Rhee, Cam and Granta (Table 1). Cambridge Water has licences for 60% of this total, Affinity Water 40%. The companies supply customers not only in the Cam Valley itself but also in Hertfordshire and Essex (Affinity Water's 'Central Region') and north and west of Cambridge towards St Ives and Ramsey on the edge of the Fens. Anglian Water also abstracts groundwater.

4.1.3 Over the 18-year period 2000-17, Cambridge Water and Affinity Water abstracted some 54 megalitres per day on average, 60% of their licensed total. As we showed in section 3, even this level of abstraction is a cause of significant environmental concern. The action needed on licences is not only to make paper savings, by removing over-generous allocations far in excess of what is currently taken, but importantly also to make significant reductions where necessary in the amounts abstracted now. Action is also needed on licences held by Anglian Water.

4.1.4 Defra's 2017 Water Abstraction Plan, includes a programme for 'Restoring Sustainable Abstraction'. This recognises that '*unsustainable levels of abstraction impact the ecology and resilience of our rivers, wetlands and aquifers*' and '*diminishes some of the most iconic catchments and important* *habitats in the country*.' These include the 220 or so internationally important Chalk streams in the UK that '*represent 75% to 80% of this habitat type globally*'. Defra's plan aims to '*use existing powers and approaches to address unsustainable abstraction so that around 90% of surface water bodies and 77% of groundwater bodies meet the required standards by 2021*.'

River	Company	Maximum licensed volume (megalitres)		Volume abstracted (megalitres)		Percentage abstracted
		Per year (A)	*Per day*	Per year (B)	*Per day*	(B/A x 100)
Rhee	Affinity Water	3,072	*8.4*	1,755	*4.8*	57%
	Cambridge Water	7,122	*19.5*	4,347	*11.9*	61%
Cam	Affinity Water	10,057	*27.5*	5,533	*15.2*	55%
	Cambridge Water	5,975	*16.4*	4,470	*12.2*	75%
Granta	Affinity Water	-		-		-
	Cambridge Water	6,576	*18.0*	3,533	*9.7*	54%
Total	Affinity Water	13,129	*36.0*	7,288	*20.0*	55%
	Cambridge Water	19,673	*53.9*	12,349	*33.8*	63%
	Total	32,802	*89.9*	19,637	*53.8*	60%

Table 1. Licensed quantities (fixed) and annual and daily mean abstracted amounts (megalitres) between 2000 and 2017 for the Rhee, Cam and Granta sub-catchments only. Source: Environment Agency.

4.1.5 The Cam and Ely Ouse Abstraction Licensing Strategy (Environment Agency 2017) states that the '*Groundwater unit balance shows more water has been abstracted based on recent amounts than the amount available. No further consumptive licences will be granted.*' It also provides for caps, reductions, or 'hands off' flow/level conditions to be applied when *time-limited* licences are renewed to reduce the risk of ecological deterioration and restore sustainable levels of abstraction.

4.1.6 The Licensing Strategy provides some reassurance as regards future licensing and *time-limited* licences but does not deal with the *permanent* licences under review as part of the 'Restoring Sustainable Abstraction' programme. Licences that allow abstraction to continue at times when environmental damage will result, which for some of them may be all the time, do not provide a valid starting point for future water resource planning: they must be reviewed and amended or terminated on the basis of today's understanding of current rainfall, potential changes in soil moisture deficits during the year, aquifer levels and the water needs of the environment.

4.1.7 The Environment Agency has assessed the need to reduce groundwater abstraction over an area that extends westward from the Cam towards Bedford. For this area, their model suggests '*reductions in groundwater abstraction, for all sectors, in the order of 55% of fully licensed rates*' (Environment Agency, in correspondence). The Environment Agency point out that all reductions in abstraction to secure Good Ecological Status under the Water Framework Directive are subject to a cost-benefit assessment and that the results of the assessment carried out for the last River Basin Management Plan (Environment Agency 2015a) were that '*the measures needed to get [the] entire aquifer system back to supporting good ecological status were disproportionately expensive*.'

4.1.8 The Environment Agency continue: '*...restoring the River Cam's or Granta's flow to natural conditions or to somewhere between natural and present levels will require significant reductions in abstraction for both public water and also other sectors including agriculture. Replacing this water is not a simple, cheap or quick solution and would likely result in the need for new reservoir storage, the treatment and movement of surface water from other parts of the country, which have their own environmental impact, as well as changes in personal consumption, pipe leakage, as well as growth and development. We are asking Water Resources East to consider the implications of more significant reductions in groundwater abstraction than are presently in their plans as part of the* *environmental ambition. This should allow a more informed debate about the measures that would be required to achieve these reductions and what the costs, financial and environmental, would be*.'

4.1.9 The Water Resource Management Plans of the two main local supply companies state:

(a) Cambridge Water: '... *in the main, continuing to use our existing sources is the most efficient way to operate over the next 25 years. But we will manage our environmental impact by reducing the volume of groundwater we take from our sources by approximately six million litres a day where necessary to manage the risk of causing deterioration to the environment*.'

(b) Affinity Water: '*Our Plan commits to reducing the amount of water we take from chalk catchments in our Central region. We will do this by reducing the amount of water we take from existing sources and avoiding any further development of new chalk groundwater options in our Central region. By doing so we are helping to protect natural water resources and the local environment within these vulnerable chalk catchments*.'

4.1.10 More radical approaches are needed to tackle the problem of lowered water tables. Simply cutting back licenced volumes by removing quantities that abstractors have not needed to use to date will do nothing to remedy current problems. The amount of water currently abstracted from the Chalk needs to be reduced substantially and permanently. At the same time, action is needed to find alternative sources of water, reuse wastewater, recharge aquifers, harvest rainwater, recycle greywater, and bring about a step change in attitudes to water use, as we discuss below.

Recommendation 5: The Regional Plan should seek the urgent review and amendment or termination as necessary of all groundwater abstraction licences affecting the Cam Valley based on today's understanding of current rainfall and aquifer levels and environmental needs for water. This must include real cuts in actual current abstraction, not just paper savings in licensed amounts. The necessary funds will need to be made available to support this process.

4.2 Investment in alternative sources of public water supplies

4.2.1 Transfer schemes are a tried and tested option for augmenting public water supplies. For example, since the 1970s, the Environment Agency's 'Ely Ouse to Essex Transfer Scheme' (EOETS) has transferred water at times of high flow from the Ely Ouse at Denver to Essex. Some of this is from the Cam, which provides on average 21% of the flow at Denver (Risk Solutions 2015). The water travels via the 'Cut Off Channel', pipelines and watercourses to rivers in Essex, from which it is abstracted. In a 'normal' year the EOETS supplies 7% of the demand in Essex; in a 'dry' year it can supply 15% to 35% (Environment Agency 2010). When the need to maintain minimum flows in the tidal River Ouse at Denver means that the EOETS cannot operate, it is supplemented by the Great Ouse Groundwater Scheme, which augments flows in the Little Ouse and Thet rivers.

4.2.2 Several proposals have been put forward to develop further water transfers from the north to the south of the Anglian Region. They include:

- Cambridge Water: To liaise with neighbouring companies to '*further explore the long-term resilience of water supplies in the region*.' The company's Resilience action plan (South Staffordshire Water Company 2019) adds: '*A resilient business will have a range of different, unconnected water sources, such as rivers and groundwater, each of which will have a different level of response to drought, heavy rainfall or pollution. It will also be able to satisfy demand from a different combination of these water sources*.'

- Affinity Water For its Central region, including the Lee and Stort catchments, which draw water from the Cam Valley: a '*new reservoir in Oxfordshire*', a '*transfer of water via the Grand Union Canal*', and an '*alternative strategic transfer solution from South Lincolnshire*.'

- [Anglian Water](): To establish a 'Strategic North-South Water Grid' to enable water transfers from Lincolnshire south to Essex (Figure 15). This would include a new 'Fenland Reservoir' able to supply some 42 megalitres per day (Anglian Water 2019, Table 5.2). This would be filled during high winter flows to store water for redistribution when needed.

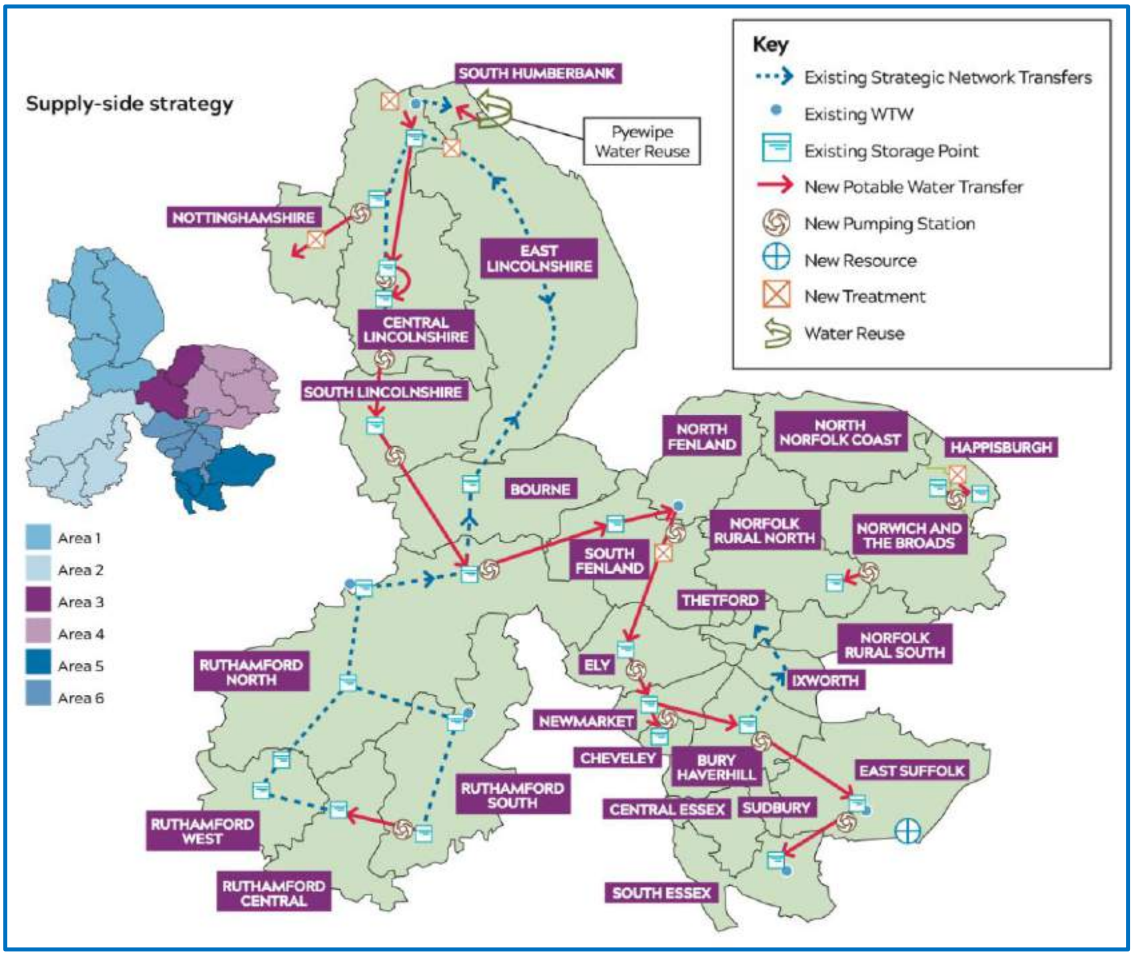


Figure 15: Anglian Water Supply-side strategy (including a North-South Strategic Water Grid) Source: Anglian Water 2019.

4.2.3 The proposed Strategic Grid would also link into a related proposal for a 'Future Fenland Adaptation Strategy' (Figure 16). This integrated package includes:

- '*New multi-sector reservoirs providing additional water supply resilience for water companies, farmers and the food industry.*

- *Downstream flood barriers or barrages to protect growth areas in the Fens, enabling key local infrastructure projects such as a rail connection from Wisbech to Cambridge and the dualling of the A47 to move forward.*

- *Open water channels to provide water storage, biodiversity, navigation and tourism, and further flood risk management benefits.*

- *The opportunity to collaborate to manage land and water across the Fens in a new and integrated way, seeking to secure the future of the peat landscape given its crucial role in carbon sequestration*.' (Water Resources East 2020).

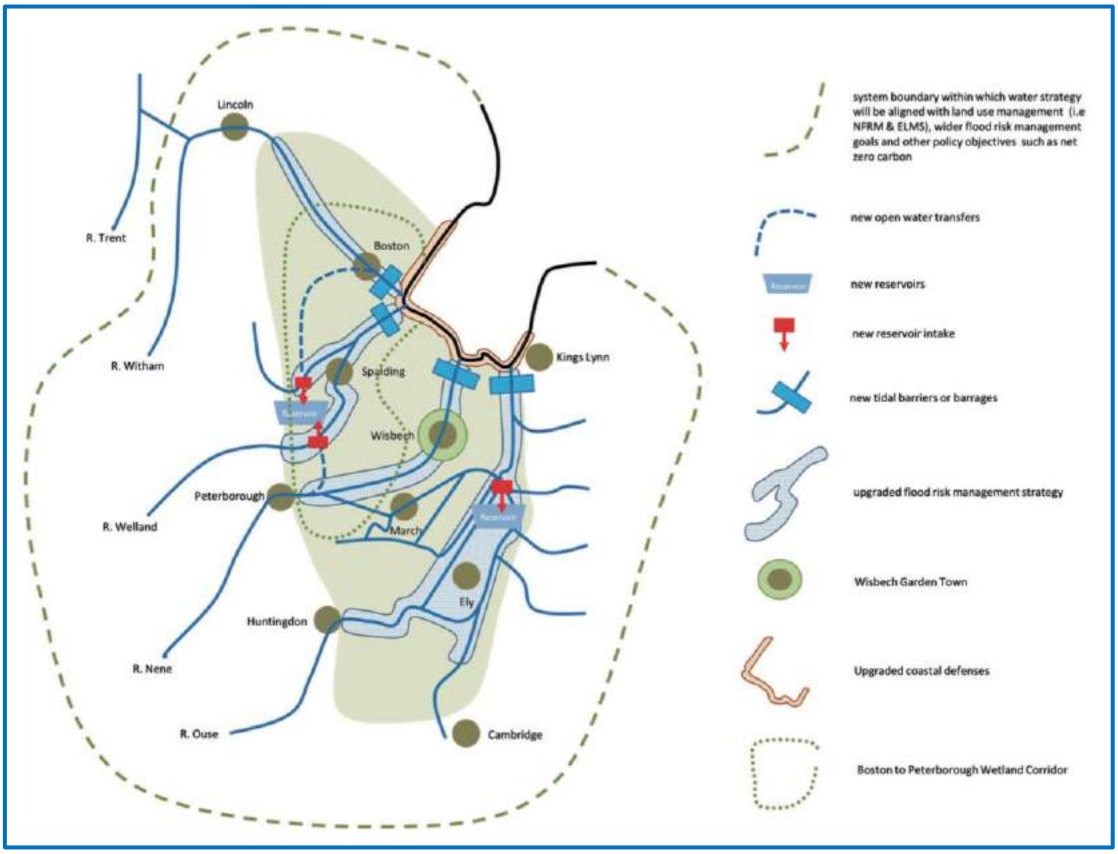


Figure 16. Future Fenland Adaptation Strategy. Source: Water Resources East (2020).

4.2.4 The extent to which these transfer proposals have taken into account the water needs of the Cam Valley is unclear. The Anglian Water proposal appears to be designed to benefit Suffolk and Essex, and the Fenland proposal to benefit land well to the north of Cambridge. Water Resources East should assess the opportunities that these schemes may offer to provide alternative sources of supply for the Cam Valley, to replace abstractions from the Chalk. If the schemes could assist, these opportunities should be built into their future detailed planning and design.

4.2.5 One radical option could be to apply to the Cam Valley an approach advanced by the *Chalk-Streams First* coalition to re-naturalise flows in Chalk stream catchments that drain to the south of the Chilterns (Figure 17). This exciting and ambitious proposal asks Affinity Water to:

(a) Cease all abstraction of groundwater from the aquifer that feeds the Chilterns' Chalk streams.

(b) Let flows in the streams recover, so that more water than at present flows downstream to the Lower Colne and Lea.

(c) Abstract water instead from the Lower Colne and Lea and store it as necessary in the Lower Thames reservoirs.

(d) Use existing pipe networks, to be further developed under Affinity Water's current 'Supply 2040' plan, to redistribute water from the reservoirs to the communities hitherto served by local abstractions.

4.2.6 Applying this approach to the River Cam would require a parallel set of interventions: closing boreholes in the upper reaches of the catchment so that Chalk streams can again flow unimpeded from their head springs through the landscape; capturing a proportion of these re-naturalised flows as surface water from the lower Cam and storing it in a new reservoir there; and redistributing that water through pipe networks to areas previously served directly from the boreholes.

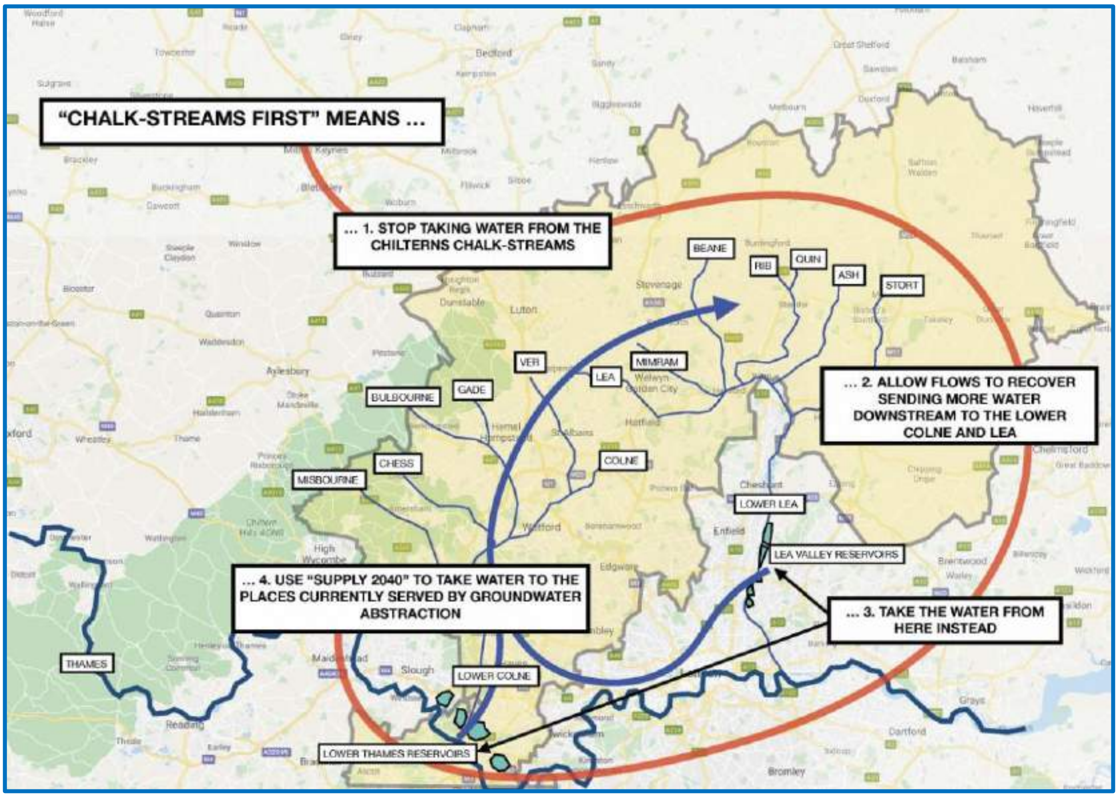


Figure 17. The 'Chalk-streams First' scheme proposal in summary. Source: Chalk-streams First coalition.

4.2.7 New north-south transfers, a 'Chalk-streams First' solution, or all these options in combination, may offer the greatest potential to augment local public water supplies and thereby reduce the pressure on groundwater abstractions from the Chalk. Such schemes would enhance the resilience of both water supplies and the environment. Importantly, they could also reduce the need to continue any transfers of groundwater into the Cam Valley that have adverse impacts elsewhere.

Recommendation 6: The Regional Plan should: assess the opportunities that proposed north-south water transfers may offer to provide alternative sources of supply for the Cam Valley, to replace abstractions from the Chalk; and assess how the approach set out by the *Chalk-streams First* coalition for the south Chiltern abstractions managed by Affinity Water could be applied to, and implemented in, the Cam Valley as an alternative or in combination with new transfers.

4.3 Investment in water reuse and aquifer recharge schemes

4.3.1 The idea of treating sewage effluent so that it is capable of being used to augment drinking water supplies, to irrigate crops, and to recharge aquifers, may seem unlikely but such technologies exist and have been widely used elsewhere (e.g. in the USA). The Langford Recycling Scheme, built in 2003 and operated by Essex & Suffolk Water, is an impressive example (House of Lords 2006; Lunn 2013). Up to 40 megalitres per day of treated sewage effluent that would otherwise be discharged to the sea is diverted to the Langford Scheme and treated to high standards (including nutrient removal and ultraviolet disinfection). The water is then released into the River Chelmer and abstracted at water treatment works three kilometres downstream to feed public supplies.

4.3.2 Schemes such as this could also be used to provide treated water to recharge the Chalk aquifer directly. It would be essential to avoid contaminating the groundwater with any residual pollutants such as heavy metals, pesticides and bacteria. Advanced technologies, such as ultra-violet irradiation, used widely to disinfect the final effluent from sewage treatment works that discharge to bathing and shellfish waters, should also be utilised.

4.3.3 There is also scope to reduce local pressure on some abstractions by using treated effluent for irrigating high value crops. Overall, the volume of wastewater produced in the Cam Valley is much greater than the volume abstracted by agriculture. The volume of wastewater varies little throughout the year (but may be the only source of some flows in dry periods, including stretches of the Cam in 2019). Any water not directly abstracted for irrigation would continue to be available for rivers and public supply. There have been some trials of this approach in the UK and the potential of this approach has been examined in a science review at EU level (Pistocchi *et al* 2017).

4.3.4 Neither Cambridge Water nor Affinity Water operate any sewage treatment plants. In the Cam Valley, Anglian Water provides this service. One new water reuse scheme is proposed in their current Water Resource Management Plan but this will be on the south bank of the Humber. This option should also be examined for sewage treatment works in the Cam Valley. It would in any case be desirable to upgrade treatment standards at all the sewage treatment works that discharge water to Chalk streams. Removing nutrients from their effluents would in particular help to improve water quality in the receiving rivers, especially when flows are low.

Recommendation 7: Water Resources East should evaluate the feasibility and cost of treating wastewater to high standards, at all sewage treatment works in the Cam Valley, so that it can be used for public water supply, to recharge the Chalk aquifer directly, and/or to irrigate crops in locations where the contribution of treated effluent to summer river flows is not critical.

4.4 Investment in the harvesting of rainwater and recycling of greywater

4.4.1 There is a strong view locally that planning permission for future development should be refused because only a finite number of people can be served in the Cam Valley by our groundwater resources in normal years, let alone a drought year. However, under the National Planning Policy Framework (MHCLG 2019), 'lack of water' is not an acceptable ground for refusal; instead, it is for the water companies to put the necessary water supply and wastewater infrastructure in place. The powers that are available to planning authorities include: requiring development to be phased and not occupied before the infrastructure is ready; and imposing planning conditions or obligations on developers to mitigate and/or compensate for any environmental damage.

4.4.2 Some recent developments include significant water harvesting and recycling schemes. At Eddington in Cambridge, a rainwater harvesting system has been installed alongside a conventional drinking water supply serving 3,000 homes (University of Cambridge 2020). This project, the largest of its type in the UK, aims to reduce the use of treated mains water from around 140 litres per person per day down to 80, with the supply of greywater making up the difference in demand. Our local authorities should require all new housing and business developments, where possible, to: harvest, store and re-use rainfall; include greywater recycling schemes; and manage and improve surface water run-off using sustainable urban drainage systems (SUDS).

4.4.3 Current work on the Greater Cambridge Local Plan includes an 'Integrated Water Management Study'. This will '*consider the sustainability of the growth being proposed in the Local Plan, the water infrastructure that will be required, and the measures needed to manage and protect the water environment*'. The Study will produce a baseline study, a detailed Water Cycle Strategy, and a Strategic Flood Risk Assessment. This provides an excellent opportunity to build into the Local Plan the policies needed to make Cambridge into a 'Water Sensitive City' (Wong & Browntake 2009).

Recommendation 8: The Regional Plan should ask local authorities to require all new housing and business developments, where possible, to harvest, store and re-use rainfall, to include greywater recycling schemes, and to incorporate sustainable urban drainage systems (SUDS), building on the good practice demonstrated in the Eddington development in Cambridge.

4.5 A step-change in attitudes to water use

4.5.1 Water that has been abstracted, stored, treated to drinking water standards and distributed through water mains to homes and businesses is a valuable high-quality resource. Yet water companies themselves lose significant amounts of water through leakage and water is squandered by its end users. Tap water, as an essential of life, has often been viewed as a free good, and only in recent decades as something to be paid for. At around £0.88 per 1,000 litres[1], its price contrasts markedly with that of petrol, also arguably an 'essential' for modern life, at £1,100 per 1,000 litres[2]. Locally, if water were also £1.10 per litre, we might all take greater care to safeguard it.

4.5.2 We consider that there needs to be an enduring step-change in attitudes to water use. This should include concerted action to reduce leakage, accelerated action to meter supplies, and an ambitious programme of demand management, with increasing levels of restriction being triggered by changes in groundwater levels. The aim should be to make Cambridge the 'No. 1' water-saving city, and the Anglian Region the 'No. 1' water saving region, in England.

Leakage control

4.5.3 The National Framework for Water Resources calls for '*planning to achieve leakage reductions of 50 per cent on average by 2050*'. Both our water supply companies promise action on leakage:

- Cambridge Water: '*By 2024/25, we will reduce total leakage on our network by 15% from 2019/20 levels [By 2 megalitres/day from 13.5 megalitres/day). We will achieve this transformational reduction through a combination of pressure management, innovation and active leakage control. We will also make further leakage reductions from 2025 to 2045*.'

- Affinity Water: '*We are committed to reducing leakage. In 2015, leakage was around 21% (189 megalitres per day) of the water we put into supply. By 2025 we plan to have reduced this to 15%. Our leakage ambition is set to achieve a 50% reduction in leakage between 2015 and 2045, resulting in 11% of water into supply being lost to leakage by 2045*.'

- Anglian Water: '*We aim to reduce leakage from a three year average of 182 megalitres per day in 2017-18 to 142 megalitres per day by [2025], a reduction of 22%. By 2045, we plan to reduce our leakage to 106 megalitres per day, a reduction of 42%*.'

4.5.4 These targets appear to be insufficiently ambitious, offering savings that are too small and too late. There should be greater urgency about leakage control with more demanding targets, for example to reduce leakage from 2020 levels by 50% by 2025, 75% by 2035 and 90% by 2040.

4.5.5 Reactive work to fix leaks should continue whenever they occur. There may also be a case for prioritising action to renew pipe networks in areas outside the Chalk, to the north and west of Cambridge Water's supply area, where water lost through leakage will be lost irrevocably. In contrast, water that percolates from leaks back into the Chalk provides a form of recharge and, if these leaks were to be fixed, there would be little net benefit to the aquifer.

Recommendation 9: The Regional Plan should set more demanding targets for leakage control by the water companies (e.g. a 50% reduction on current levels by 2025, 75% by 2035 and 90% by 2040) and prioritise the renewal of pipe networks outside Chalk areas where leakage will not contribute to the recharge of Chalk groundwater and will represent a net loss to the aquifer.

[1] Cambridge Water bill, January 2020. Charge £0.8739 per cubic metre (= per 1,000 litres)

[2] Unleaded petrol price at Elizabeth Way Petrol Station Cambridge, May 2020. Charge £1.099 per litre.

Metering water use

4.5.6 Installing a water meter enables customers to monitor usage and brings about savings in water consumption of 9-20% (Save Water Save Money Ltd 2020). Cambridge Water plans to '*encourage an additional 500 households a year to switch to a water meter ... This will give us a level of roughly 90% of customers with a water meter by 2044/45 [from 70%]. We are looking at options for 'smart meter' devices that would help customers monitor and control how much water they use – something our customers said would be useful to them*.' Affinity Water is also '*Installing more water meters in homes and businesses and upgrading these to smart meters by 2045*.' Anglian Water has greater ambitions and expects its smart metering programme to save 13 megalitres per day by 2025 and 51 megalitres per day by 2045.

4.5.7 More and faster action is needed to retrofit meters where they do not already exist. Customers should be equipped with smart meters that provide a constant visible readout (without having to log into a computer), to help them save water. Targets should be more demanding. For example, at least 90% of supplies should be metered by 2025, and 50% of households and businesses should have smart meters by then, with 100% coverage for both being the target by 2030.

Recommendation 10: The Regional Plan should set more demanding targets for metering programmes (e.g. to meter at least 90% of supplies by 2025, and equip 50% of households and businesses with smart meters by then, with 100% coverage for both being the target by 2030).

Managing demand for water from households and businesses

4.5.8 All water companies have Drought Plans to help them manage demand during droughts. Their actions are based on 'drought triggers', including rainfall, reservoir storage, and groundwater levels. The options available to them include:

- Campaigns through public messaging to encourage voluntary reductions and supply-side measures (e.g. to enhance abstraction at existing sources or standby sources).
- Temporary use bans (TUBs), commonly referred to as 'hosepipe' bans.
- Non-essential use bans (NEUBs) that affect businesses as well as households.
- Supply side Drought Permits and Orders enabling abstraction beyond what would normally be permitted.
- Emergency Drought Orders (e.g. standpipes, emergency abstractions).

4.5.9 All the water companies have targets to reduce average daily water use per person:

- Cambridge Water: From 145 litres/person/day to 137 litres by 2025 and 129 litres by 2045.
- Affinity Water: From 152 litres/person/day to 129 litres by 2025 and 110-120 litres by 2045.
- Anglian Water: From 137 litres/person/day to 130 litres by 2025 and 120 litres by 2045.

4.5.10 Household water consumption is dominated by water use in bathrooms (68%), where toilet flushing and showering account for almost 50% of the household total. Nearly a quarter of household water (22%) is used in kitchens, and the remainder (10%) outside (Figure 18).

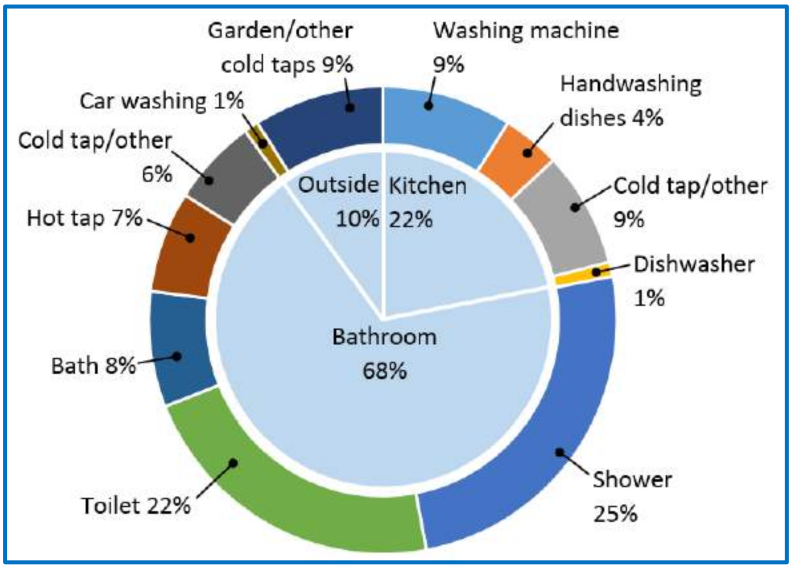


Figure 18: Breakdown of typical domestic water consumption.
Source: Stallard (2020) from data provided by the Energy Saving Trust.

4.5.11 The companies actively encourage people to save water. Cambridge Water's current Pledge 15 campaign, supported by a leaflet, seeks a daily household reduction of 15 litres. Past interventions have included offering free water butts and water-saving visits. Affinity Water offers a range of tips and free water-saving items. Anglian Water is asking customers to save up to 20 litres of water per person per day. These efforts are welcome but they lack urgency.

4.5.12 One problem is that householders often have little idea themselves of just how much water they are using. Until smart meters are in place, more information should be provided in water bills. Cambridge Water bills show the volume of water used in cubic metres and the number of days between meter readings but do not give a daily use figure. Adding this information for the household, and then showing what this total means if the household comprises 2, 3, 4 or 5 people, would improve awareness and help reinforce the Company's efforts to save water.

4.5.13 Important water-saving ideas, which should become part of normal day-to-day practice, are set out below (Table 2). If adopted and sustained by many thousands of people across the Cam Valley, these actions, particularly those that reduce water use in bathrooms, could be valuable. Businesses and public bodies could take similar actions (e.g. one urinal can use up to 170,000 litres of water each year, while now well-proven waterless urinals use none (Waterless 2020)). However, such actions are unlikely to be an effective solution, in themselves, because they are entirely voluntary.

How to save water, and the Cam

- Don't flush every time you pee
- Reduce quantity of water in WC cisterns; if dual flush, use the lesser flush when appropriate.
- Fit aerators to taps.
- Have brief showers instead of baths.
- Don't run the tap when brushing teeth.
- Use a bowl when washing-up and only use the dishwasher and washing machine when full.
- Install water butts with drain downpipe connectors
- Wash the car with a bucket and sponge, rather than a hose.
- If your water supply is not metered, apply to have a free smart meter installed.
- Act promptly to repair or replace any leaky appliances, dripping taps or overflowing cisterns

Table 2. Water saving tips. Source: Cam Valley Forum

4.5.14 Cambridge Water has made hardly any use of temporary use bans, non-essential use bans and Drought Permits and Orders. The measure that most often signals that water supplies are under threat is the temporary use ban, or hosepipe ban, but the company uses these only once every 20 years on average, in contrast to Anglian Water and Affinity Water, which both use them once every 10 years (Figure 19). Given the relatively limited water resources available to Cambridge Water, especially when compared with Anglian Water, this appears to be anomalous.

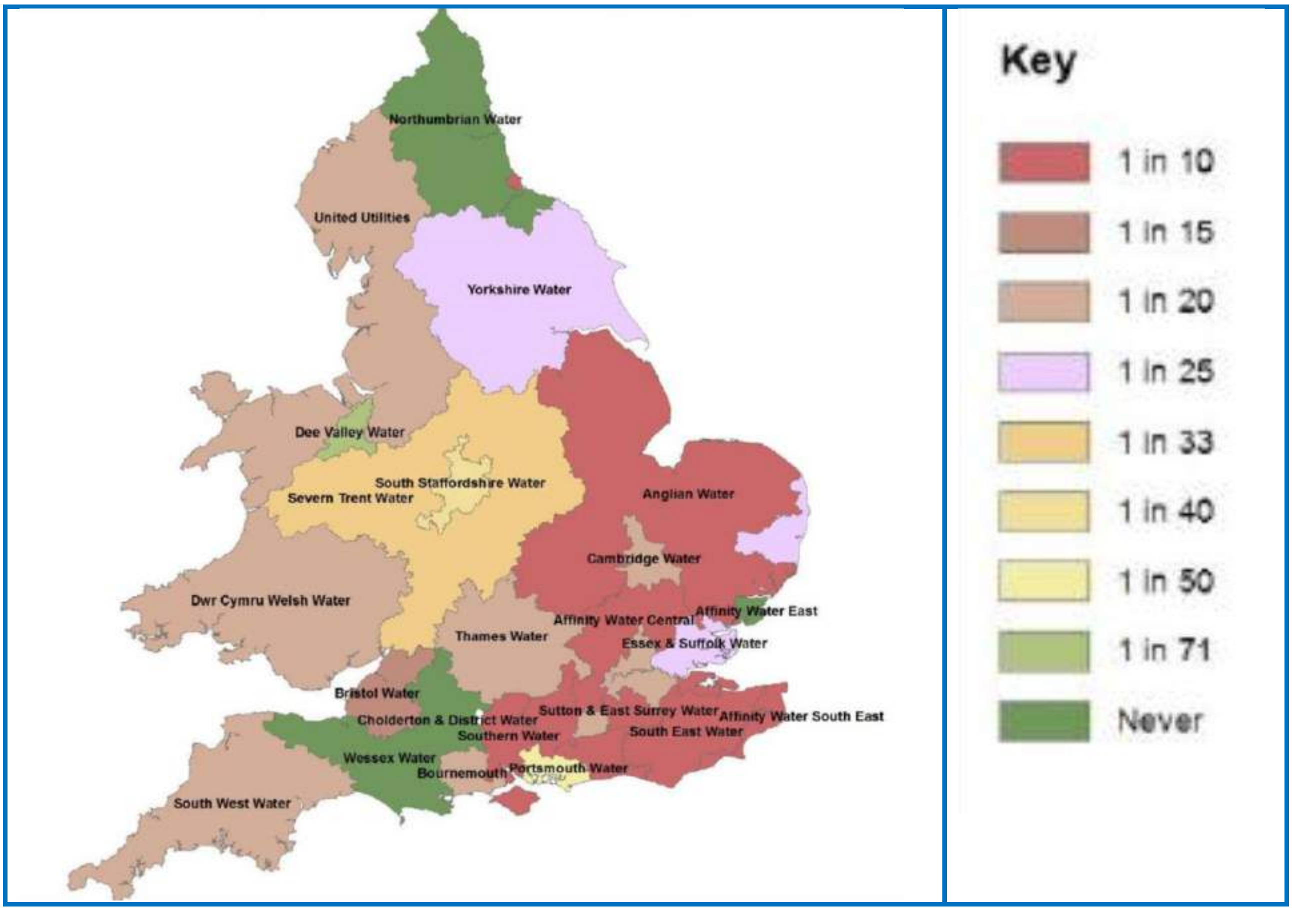


Figure 19. Levels of service for Temporary Use Bans ('hosepipe bans') 2016.
Source: Based on Figure 3.5 provided by Atkins UK in Water UK (2016).

4.5.15 A more resolute approach is needed: demanding baseline savings at all times and further reductions as groundwater levels fall below key 'trigger' points. Experience from another water-stressed city, Cape Town, is relevant here. At one point towards the end of its 2015-18 drought, the city was expected to run out of water and sought to limit water use to 50 litres per person per day.

4.5.16 Under a new Water Strategy (Cape Town Government 2019), demand is now managed through baseline regulations (Cape Town Government 2020a). These restrictions are progressively tightened as necessary (Table 3). Level 1, which currently applies, has a target of 120 litres per person per day. For much of 2019 the target was 105 litres (Level 3). The restrictions target the use of hosepipes, sprinklers in gardens and sports fields, swimming pools, car washes, and water features. Water pressure is halved at level 3 and reduced still further under emergency measures.

4.5.17 The restrictions are widely promoted and highly visible. Water levels in the six key supply reservoirs are published weekly (Cape Town Government 2020b). There are also progressive tariffs linked to the targets for water use at each Level; increasingly higher charges apply as consumption rises. In the UK, any suggestion that the price of water should rise appears to be anathema to politicians. This is short-sighted; the UK could usefully learn from other countries that see tariffs as an important tool to encourage wise use of water and discourage profligacy.

Restriction measures	Restriction Level				
	Water wise	Level 1	Level 2	Level 3	Emergency response
Watering: hosepipe / sprinklers	Allowed (before 0900 or after 1800)	1 hour (Tuesdays and Saturdays)	1 hour (Saturdays)	Not allowed	Not allowed
Watering: drippers/drip line/soaker hose or bucket / watering can	Allowed	Allowed	Allowed	1 hour (Tuesdays and Saturdays)	Not allowed
Sports fields / parks (sprinklers)	Allowed	1 hour (Tuesdays and Fridays)	1 hour (Tuesdays)	1 hour (Tuesdays)	By exemption only
Swimming pools	Allowed subject to conditions (e.g. must have a cover)	Allowed subject to conditions	- Topping up allowed subject to conditions - No filling / refilling	- Topping up allowed subject to conditions - No filling / refilling	No topping up No filling
Car washing (privately)	Allowed	Bucket or high pressure/ low volume cleaner	Bucket only	Not allowed	Not allowed
Informal car washes	Allowed	Bucket or high pressure/ low volume cleaner	Bucket only	Bucket only	Not allowed
Commercial car washes	Allowed	Allowed	Allowed	Allowed	Not allowed
Water features	Allowed	Allowed	Not allowed	Not allowed	Not allowed
Other	(e.g. no hosing down of paved areas with potable water)	-	-	-	Additional emergency restrictions may be determined
Targeted water pressure (bar)	>2.4	>2.4	>2.4	>1.2	>0.5
Dam level trigger points	>80%	70%-80%	60%-70%	45%-60%	<45%
Water use target per person per day		120		105	100-70-50

Table 3: Cape Town restrictions on use of municipal drinking water. Source: Cape Town Government (2020b)

4.5.18 Other actions taken during the drought to save water (Parks *et al* 2019) included:

(a) **Installing water management devices in supply pipes to enforce daily limits** on water use; once the limit has been reached, the water is reduced to a trickle until the following day.

(b) **Reducing water pressure in municipal pipes**, not only saving water but also decreasing losses through existing leaks and the frequency of further leaks.

(c) **Publishing maps of water use** showing which households in affluent areas were achieving reduced daily water consumption targets

(d) **Equipping over 350 schools with smart water meters** to encourage and monitor water savings.

(e) **Introducing mobile applications**, for example to 'gamify' the experience of water saving.

(f) **Establishing business forums to encourage voluntary water savings** and sharing of good practice, and imposing strict limits on agricultural quotas for water.

4.5.19 Defra issued its Consultation on measures to reduce personal water use in July 2019. This covered a wide range of options. The Government's conclusions on the consultation are awaited. If they are demanding enough, these should also be taken into account in developing the Regional Plan.

Recommendation 11: The Regional Plan should seek to bring about an enduring step-change in attitudes to water use by securing support for ambitious programmes of demand management along the lines of that adopted in Cape Town. The aim should be to make Cambridge the 'No. 1' water-saving city, and the Anglian Region the 'No. 1' water saving region, in England.

Recommendation 12: For the Cam Valley, a comprehensive demand management plan should include:

(a) Defining a minimum baseline of mandatory restrictions on household and business use of water to be applied at all times.

(b) Defining further restrictions to be imposed as a matter of course at least in the four months from May to August every year (e.g. a ban on household use of sprinklers and hosepipes, including high-pressure hoses used to clean driveways and patios).

(c) Agreeing groundwater level 'trigger' points at which progressively more demanding restrictions on household and business use of water will apply.

(d) Rolling out smart water meters in homes, schools, businesses, hospitals and public buildings to enable continuous tracking of water use and encourage savings supported by effective training and incentives for building managers to reduce consumption.

(e) Actively reducing water pressure as groundwater 'trigger' points are reached.

(f) Installing water management devices in pipes supplying those customers whose use of water regularly exceeds guideline targets.

(g) Working with voluntary groups and the media to communicate the importance of water and water-saving messages to households and businesses.

(h) Learning from other countries about the costs and benefits of introducing progressive tariffs, linked to water supply 'trigger' points, to discourage profligate use of water.

***

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