CHALK-STREAMS FIRST

A Permanent and Sustainable Solution to the Chilterns Chalk-Streams Crisis

Supported by a coalition of

The Rivers Trust, The Angling Trust, WWF UK, The Wild Trout Trust & Salmon and Trout Conservation

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This paper was written on behalf of the above organisations by Charles Rangeley-Wilson in consultation with John Lawson
An earlier draft (V1) was independently reviewed by Colin Fenn.

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Chalk-Streams First is a radical, new idea for a scheme aimed at the early “re-naturalising” of flows in the Chilterns chalk-streams. It is based on the principle of allowing the chalk-streams first use of water that is currently abstracted directly from the chalk aquifer, but with a potentially small net loss to regional water supply.

The Chilterns is an Area of Outstanding Natural Beauty and its chalk-streams are internationally rare riverine eco-systems that should be the jewel in the Chilterns’ crown (most of the world’s chalk-streams are English and those in the Chilterns have been – historically – amongst the most celebrated). However, since the mid-20th century abstraction of water from the Chilterns aquifer that feeds these chalk-streams has greatly denuded their natural flows, causing the “Chilterns Chalk-Stream Crisis”: chronic, unnaturally low-flows and unnaturally extended drying.

A coalition of conservation organisations The Angling Trust, The Rivers Trust, Salmon & Trout Conservation, The Wild Trout Trust and WWF UK proposes that the Chilterns chalk-stream crisis should be resolved by almost complete cessation of chalk groundwater abstraction in the upper parts of the Colne and Lea valleys. This would allow re-naturalisation of the chalk-stream flows and is simply the right thing to do.

Replacement supplies for the towns and villages currently served by groundwater abstraction would come from connection to Thames Water’s London supplies instead. These would now have the benefit of the enhanced chalk-stream flows and thus increased availability of water for abstraction from the lower

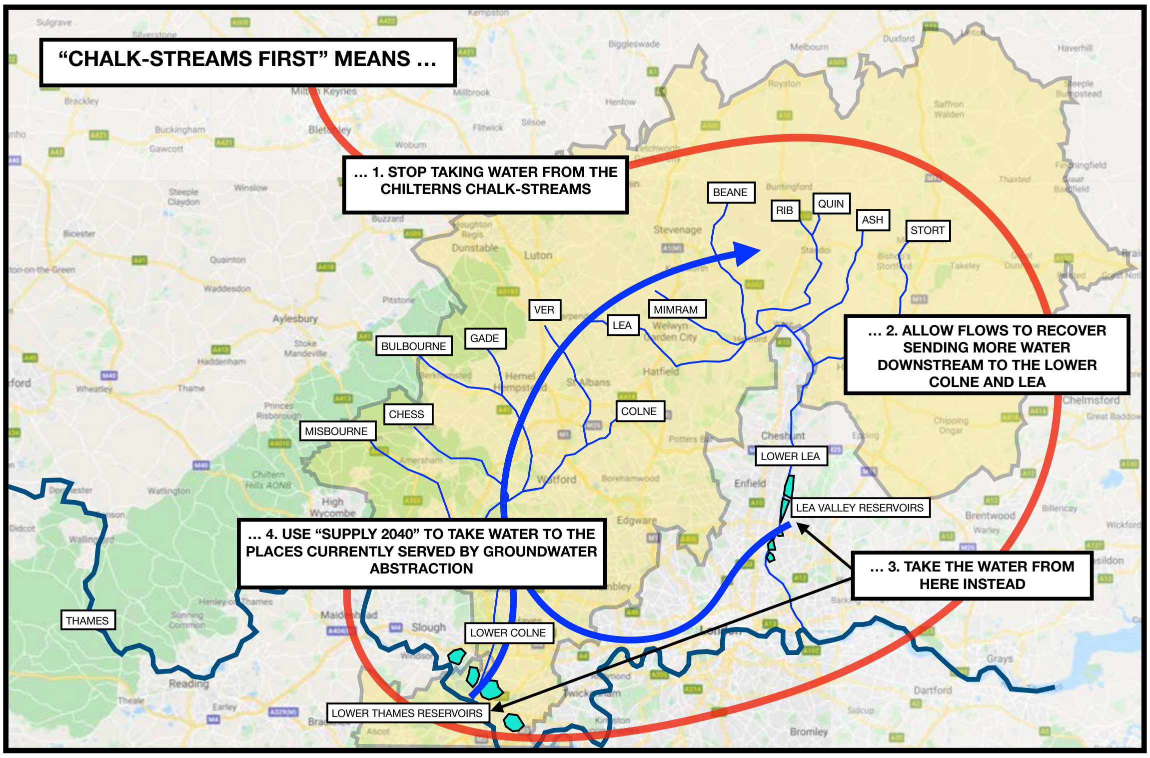


Figure 1. The Chalk-Streams First scheme in summary.

Rivers Thames and Lea. Consequently, overall loss of regional water resources would only be in the region of 15% of the reduced chalk groundwater abstraction. The concept is illustrated in Figure 1.

Chalk-Streams First would be enabled by the supply infrastructure project called “Supply 2040” which is already in Affinity Water’s plans and is an integral part of other strategic schemes for water-resources allocation. The coalition proposes that Supply 2040, enhanced where necessary, should be brought forward to 2030 **to allow early re-naturalisation** of the chalk streams. Taking account of chalk stream flow recovery, the scheme would not be dependent on a major new source for London and the small replacement resource required could come from some of the smaller resource developments already in Thames Water's plans.

OFWAT has given the green light for a major Strategic Review of water resources in the south-east which will look at a variety of strategic supply and storage schemes including Abingdon reservoir and the Severn-Thames Transfer. A solution to the Chilterns chalk-stream crisis should be a fundamental and high-profile part of the investigations.

The Chalk-Streams First coalition commissioned an independent pre-feasibility report into the potential of the Chalk-Steams First scheme as expressed in an earlier draft of this paper: that report, undertaken by Colin Fenn, is available for inspection on this link: https://www.dropbox.com/s/311ylzhmhewic62/CF%20Review%20of%20CSF%20paper%20200124%20copy.pdf?dl=0

The authors of this Chalk-Stream First paper have subsequently edited and re-written parts of it in the light of the report's findings and to the best of their ability within the limited time and resources available. The report highlighted a number of shortcomings in terms of the detail of the evidence base and broadly speaking recommended that these be addressed through the more detailed investigations.

The Chalk-Streams First coalition wholeheartedly accepts and agrees with this advice and emphasises that the primary goal of this paper is to promote a thorough investigation of the idea as part of OFWAT's Strategic Review of water resources in the South East.

Overall the independent pre-feasibility report finds that the Chalk-Streams First proposal is sufficiently sound as to merit these more extensive investigations.

From the report's Key Findings:

> "My key conclusion is that the draft Chalk-Streams First proposition, as put, identifies a feasible and a viable solution to the problem of chronic flow depletion in the internationally-rare and precious chalk-streams of the Chiltern Hills; it being to allow flows in the upstream chalk streams of the Chilterns to run unreduced by abstraction, with water being taken from the correspondingly enhanced flows in the downstream Colne and Lee, and as needs may be from a range of other less-environmentally fragile sources to meet the needs of demand centres in the Chilterns, using Affinity Water's already planned 'Supply 2040 scheme."

Note on the technical evidence used in this paper

In this paper, the **Chalk-Streams First** coalition has presented some technical evidence to justify the need for a new approach to solving the Chilterns chalk-stream crisis and the effectiveness of the 'Chalk-Streams First' proposal. In particular, evidence is presented for:

• The scale of chalk-stream flow reduction arising from abstraction for water supplies

• The need for the problem to be addressed for the Chilterns region as a whole, rather than by 'Sustainability Reductions' that are specific to a particular valley or river

• The insufficiency of the Sustainability Reductions to date and currently planned future reductions

• The likely magnitude of the chalk-stream flow increases arising from a large scale regional reduction in borehole abstraction and the consequent yield increase for London's water supplies

The technical evidence presented in this paper has used whatever data are currently available to the Chalk-Streams First coalition and the limited technical resources available. With these limitations, it is not intended as a comprehensive technical justification for the Chalk-Streams First proposal.

However, the coalition believes that the evidence presented is sufficient to justify a much more comprehensive investigation of Chalk-Streams First to be undertaken as part of Ofwat's planned £465 million strategic resource investigations.

The Chilterns Chalk-Streams Crisis

The Chilterns chalk-streams feed mainly into two sub-catchments of the River Thames: the River Colne and the River Lea, or Lee (see Figure 2 below). The Colne chalk-streams are the rivers Misbourne, Chess, Bulbourne, Gade, Ver and upper Colne. The Lea chalk-streams are the rivers Mimram, Beane, Rib, Quin, Ash, Stort and upper Lea. These are all within the Affinity Water Area. The River Wye and the Hambledon Stream flow into the Thames and are in the Thames Water Area

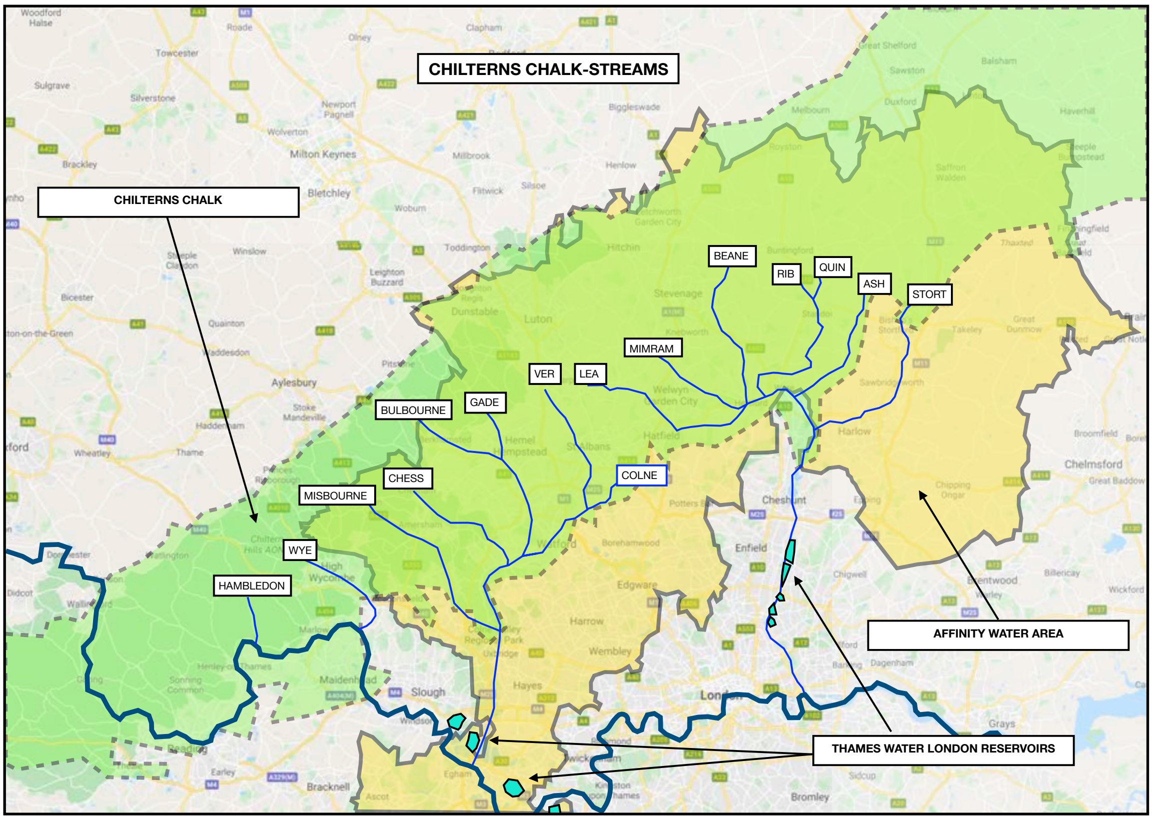


Figure 2. The Chilterns chalk-streams in relation to the River Thames and London's water supply reservoirs.

All these rivers suffer from low flows and often run dry (see Figure 3 below). This has caused a long-running controversy over the causes and possible solutions. Flows do vary seasonally and upper reaches of chalk-streams do dry under natural conditions. Changes in land-use and rainfall patterns as a result of climate change may be having an impact too, but this paper will show that the fundamental cause of *lower than natural* flows is groundwater abstraction.

Figure 3: the Rivers Chess and Beane in May 2017 - the time of year when chalk-stream base-flows are usually close to their highest. See: https://blogs.wwf.org.uk/blog/habitats/rivers-freshwater/englands-rivers-gone/

Although this fact is now generally acknowledged, as is evidenced by the recent Sustainability Reductions (reductions in abstraction designed to alleviate chronic low-flows), the Chalk-Stream First proposal is for a much more substantial reduction to very low levels, or ideally a complete cessation, of groundwater abstraction to allow a complete re-naturalisation of the Chilterns chalk-streams with only a marginal net loss to public water-supply.

In the problem (that abstraction causes low flows) lies the solution: reducing abstraction to very low levels or ceasing it altogether allows maximum "flow-recovery" and flow-recovery allows the water to be taken for public supply further down the catchment: hence Chalk-Streams *First*.

This Chalk-Streams First paper includes:

1. A simplified model of how chalk-streams work, the importance of base-flow in overall river flows and how base-flows are determined by Groundwater Levels.

2. Evidence for the interconnectivity of the whole Chilterns aquifer, suggesting that a sustainable solution to the Chilterns Chalk-Stream Crisis should be regional in scale and not conducted valley by valley.

3. An explanation of the importance of winter or "effective" rainfall in determining the groundwater levels which underpin base-flows throughout the year.

4. Evidence which suggests that there is no long-term trend-change in the total amount of winter rainfall, although there is perhaps evidence of increased volatility in recent years.

5. A summary of the past and present scale of abstraction, including an acknowledgement of the recent positive moves towards implementing Sustainability Reductions.

6. An analysis of what is currently planned in terms of future Sustainability Reductions.

7. A brief review of the UK TAG guidelines for acceptable anthropogenically-caused flow reductions in chalk-streams, suggesting that in spite of the important positive steps towards Sustainability Reductions taken recently, under current plans abstraction in the Chilterns chalk valleys is and will remain far too great a negative burden on this precious natural resource.

8. An alternative, radical and sustainable solution to the Chilterns Chalk-Streams Crisis – the Chalk-Streams First proposal – for allowing complete re-naturalisation of flows in the Chilterns chalk-streams with a potential net loss to supply of as little as 15%.

The value and essence of the Chalk-Streams First proposal is that flows can be restored to their natural profile by moving abstraction downstream, with big environmental gains and small net reductions in the amount of water available for abstraction at a catchment scale, with the means to achieve that end (a supply infrastructure network called Supply 2040) being in train. While there will be financial cost implications, these may not be considerable once the environmental gains are factored in.

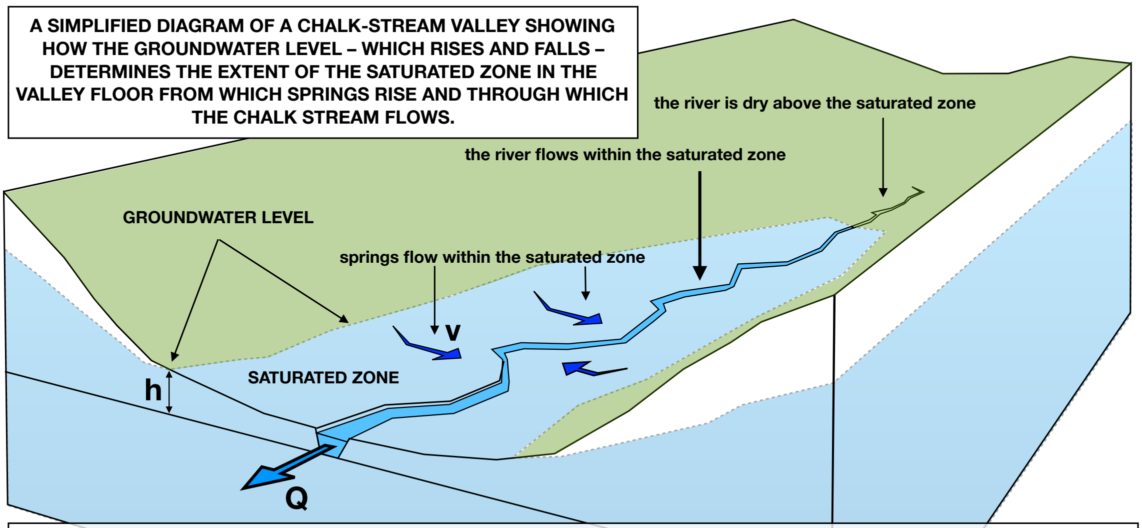
1. A Simplified Model of a Chalk-Stream & the Relationship Between Groundwater Levels and Base-Flows

The geology and hydrology of chalk valleys are complex and will vary locally and regionally so that no two chalk-streams are *exactly* alike. However, despite the hydrogeological complexities, flow in chalk streams generally follow a very simple pattern, whereby river flows are almost entirely driven by groundwater levels in the surrounding valley as shown in Figure 4.

The diagram represents a simplified ‘typical’ chalk-stream valley**, and shows how a chalk-stream flows within the saturated zone of the valley floor. The upper boundary of that zone – what is commonly called the “spring-line”, although this term is potentially misleading – moves up and down the valley according to groundwater levels – the level to which the ground is saturated with water.

Simply put – above the ground-water level the valley is dry and the river does not flow. Below it, the valley is saturated and the river flows.

The level of the groundwater, therefore, determines both the length of the river (the saturated zone extends higher up the valley as the groundwater height increases) and the gathering intensity of the flow (Q).



In theory the river flow (Q) is proportional to the height (h) of the groundwater level above the river bed, so that

$$Q = ah^{2.5}$$

(where (a) is a constant determined by the shape of the valley and transmissivity of the chalk and will vary from one valley to the next)

If (h) is the average height of the groundwater level above the valley bottom, elementary hydraulics shows the velocity flow (v) from the spring sources in the valley upstream is proportional to $h^{0.5}$

Assuming a V-shaped valley, the area of the exposed fissures is proportional to h^2

Therefore, the baseflow (Q) in the river from the springs upstream is proportional to $h^{0.5} \times h^2 = h^{2.5}$

In simple terms this means that a 10% increase in the height of the groundwater above the valley bottom amounts to a 25% increase in flows.

Figure 4. Simplified mechanics of chalk-stream flows.

**No two rivers are exactly alike and there are various ‘types’ of chalk-stream too: some, like the Dorset Frome, rise from older rocks like greensand and then flow over chalk further down the valley; some, like the Fontmell Brook, are scarp-face streams, and having risen at the base of the generally steeper, north-west facing chalk escarpment, flow over older rocks and clays; some rise from chalk that was heavily impacted and overlain by the glaciers of the last glacial maximum – the Yorkshire and Lincolnshire chalk-streams for example. Some are heavily influenced by originating from or flowing through deep deposits of peri-glacial drift – like Norfolk’s River Nar; while others – generally the “classic” type of chalk-stream (illustrated above) known as “slope-face” streams, rise from chalk and flow for long distances over chalk. All these variations will impact the flow regime of a given river, the way the river responds to direct rain, ‘quick-flow’ through heavily fissured chalk or sands and gravels, and the degree to which the aquifer base-flow underpins these other flows. Base-flow varies from one river to the next, but the “classic” chalk-streams of the Chilterns have a high base-flow, although this is likely to have have been altered (lowered) by modern land-use and development, meaning a higher proportion of rainfall runs-off into the rivers than was once the case. The concept of base-flow is important, however, as with all chalk-streams, base-flow is the foundation of the flow regime in the river.

Figure 5 (below) shows the clear correlation between all the river flows and the groundwater level at Amersham Road, Little Chalfont, despite the considerable distances between the various recording stations, as shown in Figure 6 (page 7). Note: flow scales vary for each plot, GWL scales the same for each plot.

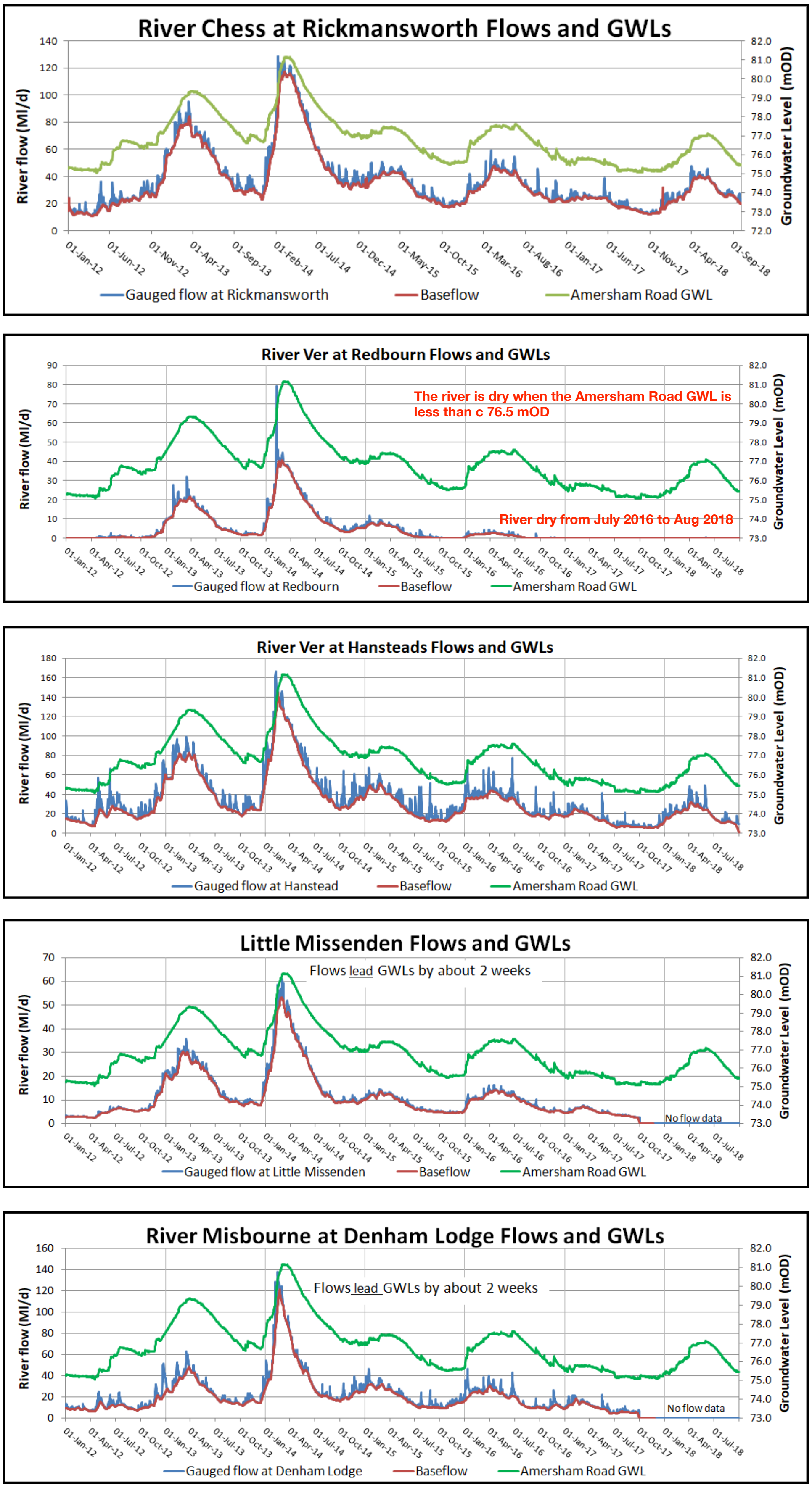


Figure 5. Relationship between flows in the Chess, Ver and Misborne and the Amersham GWL.

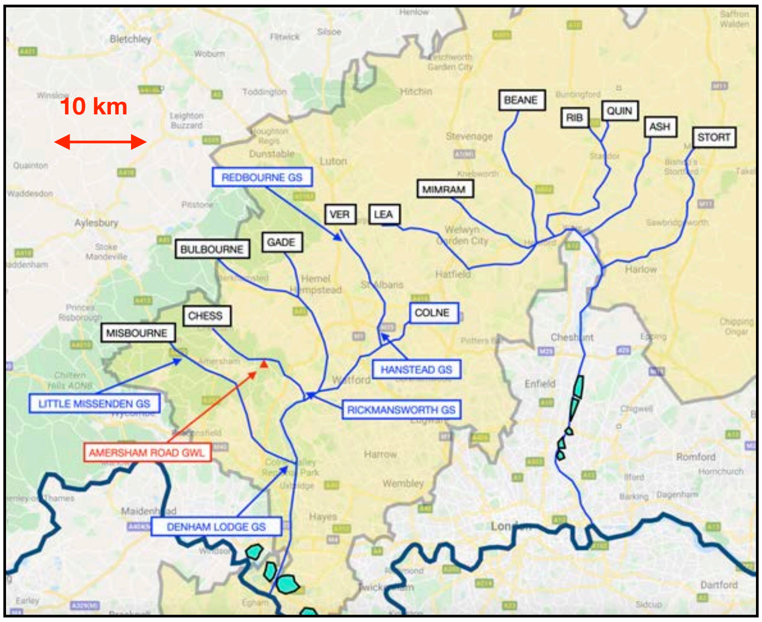


Figure 6. Locations of the river flow gauging stations and Amersham Road GWL shown in Figure 5.

There are some differences in timing of the peaks and troughs of flows and groundwater levels, with the river flows tending to lead the groundwater levels by about 2 weeks. This seemingly illogical difference in timing (if groundwater levels drive river flows), is explained by the slower responsiveness of groundwater levels in the high ground between valleys where the chalk is less fractured (eg at the Amersham Road borehole), compared to the more open fissures in the valley sides and bottoms. Nevertheless, the strong relationship between river flows and groundwater levels can also be seen in scatter plots of all the groundwater levels and river flows at the various locations shown in Figure 7. At each gauging station, the base-flow can be seen to comply well with the theoretical relationship, $Q = ah^{2.5}$, (explained in Figure 4).

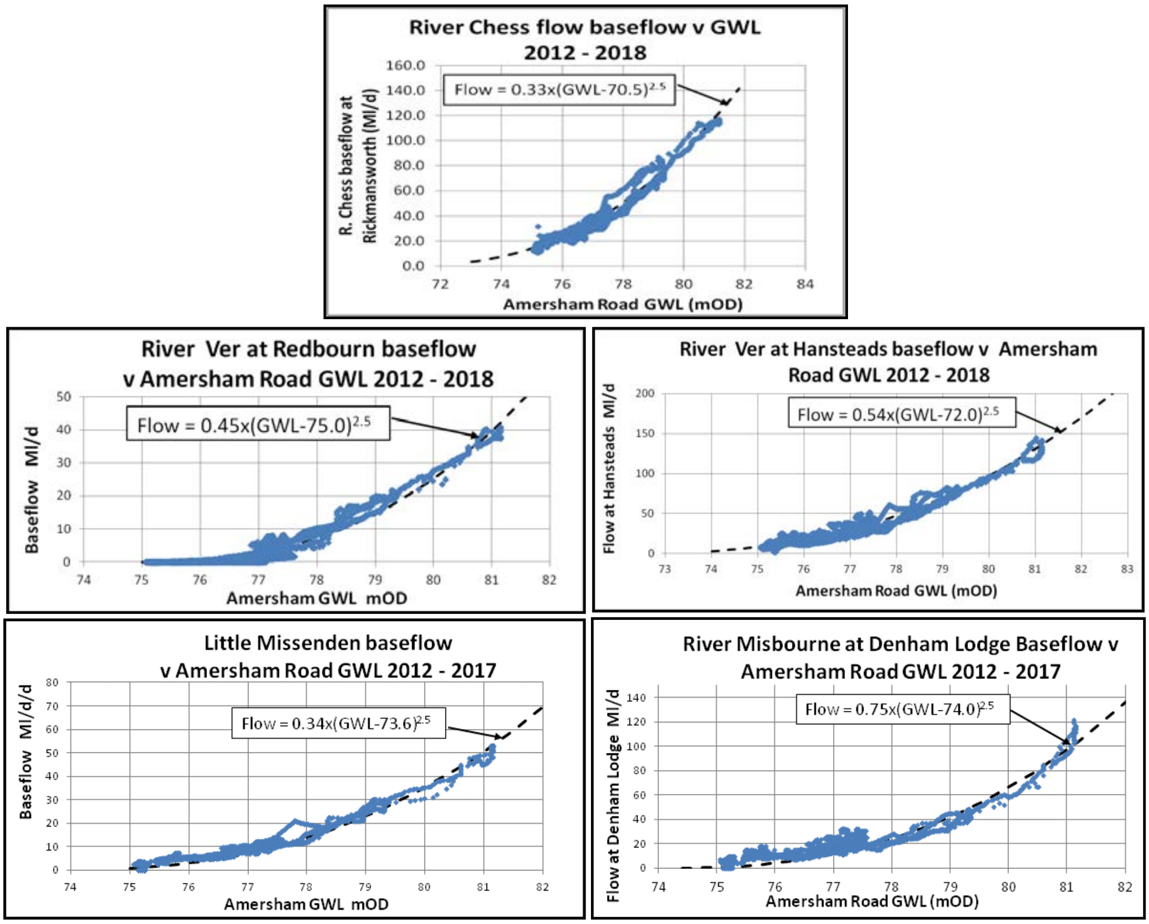


Figure 7. Recorded daily river base-flows vs Amersham Road GWLs 2012 - 2018. Note that there is a slight hysteresis in the annual cycle of flow and groundwater changes, with flows being higher relative to the groundwater levels when they are both rising than when they are falling.

2. The Interconnectedness of the Chilterns Aquifer

This relationship between groundwater levels and flows, although apparently crude and over-simplified, is borne out by long-term flow and groundwater level data. The flows at each location shown in Figure 5 above are related to recorded groundwater levels at Amersham Road, Little Chalfont, at distances of up to 15 km from the locations of the measured flows. This also suggests that there is strong connectivity between adjacent chalk valleys.

Additional evidence that the groundwater levels of the Chilterns aquifer are strongly interconnected across the river valleys is provided by the fluctuations in the Lilly Bottom and Amersham Road GWLs which are 20 miles apart, as shown by the chart and map in Figure 8.

The Chilterns aquifer therefore appears to behave like a body of water whose surface level AOD – or the groundwater level – fluctuates and *that fluctuation determines the river flows* in all the chalk valleys of the Chilterns region. It is appreciated that this evidence for the inter-connectivity of the regional aquifer and the various chalk streams is based thus far on the limited data currently available to the Chalk-Stream First coalition. Nevertheless, it justifies further investigation into the good-sense basis for a *regional* approach to the re-naturalisation of the rivers proposed by Chalk-Streams First.

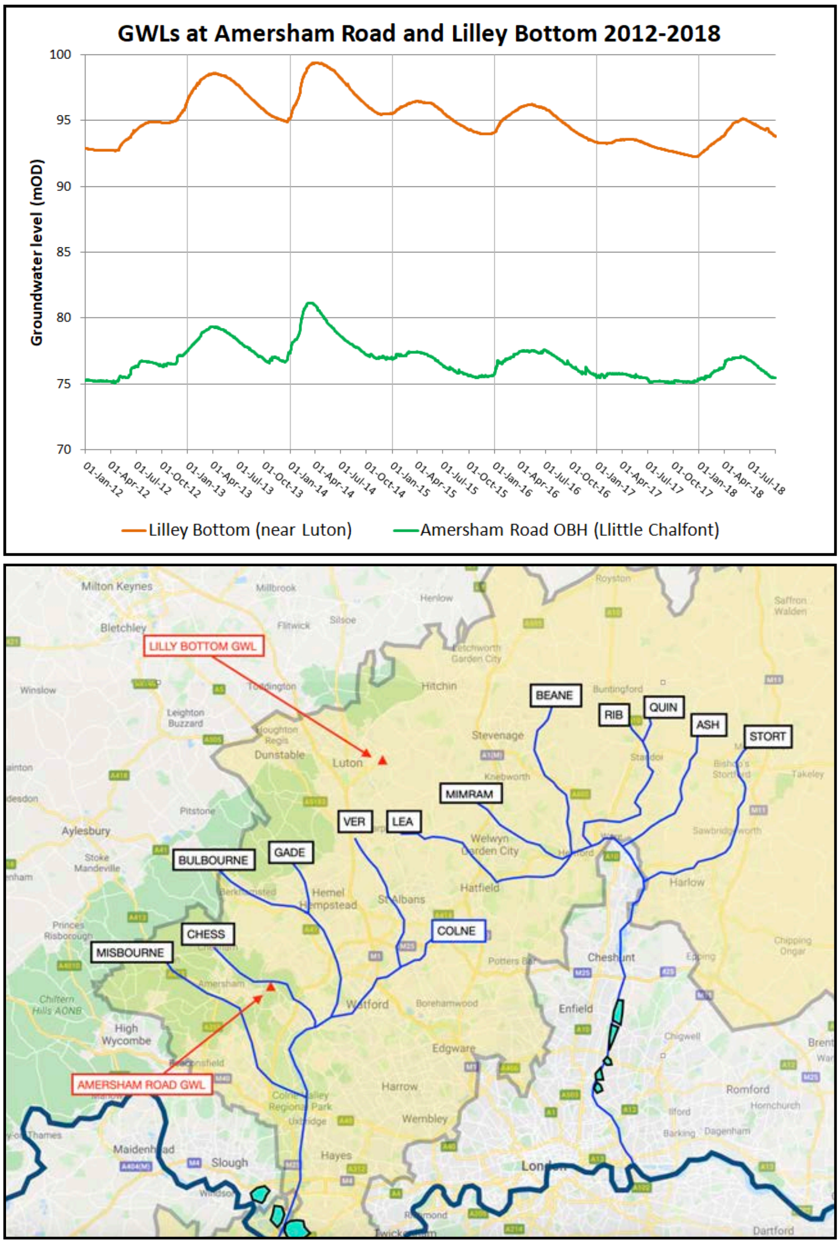


Figure 8. Evidence of the inter-connectivity of the regional aquifer showing mirrored fluctuations in GWLs at Amersham Road and Lilly Bottom, which are 20 miles apart.

3. The Importance of Winter Rain or “Effective Rain”

Groundwater levels and therefore river base-flows are heavily dependent on winter rainfall. Summer rainfall, is mostly absorbed by vegetation and has little effect on summer base-flow.

The two charts in Figure 9 show the strong links between winter rainfall (taken at Heathrow to the south-west) and groundwater levels and river flow. Groundwater levels in the spring (March / April / May) are determined by winter rainfall (the preceding November to March); river base-flows at the start of summer are largely determined by groundwater levels at the end of spring; from then on base-flows generally recede and do not pick up again until late autumn when rainfall once again gets through to the aquifer.

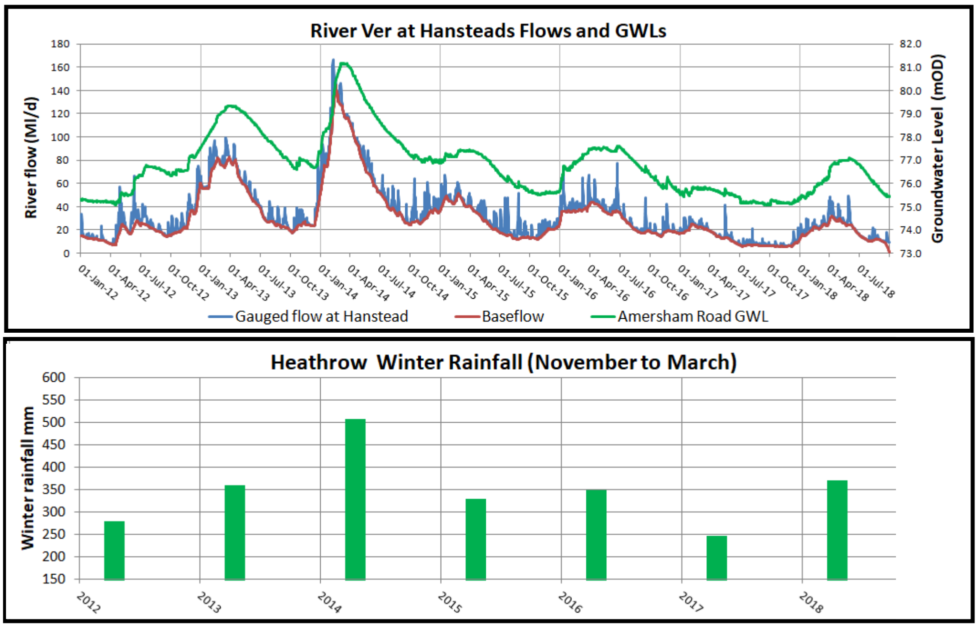


Figure 9. The relationship between total flows in the River Ver and winter rainfall at Heathrow.

The charts in Figure 10 also show the dependency of summer base-flows on the rainfall in the preceding winters. After wet winters, groundwater levels and river flows are high in spring and remain relatively high as groundwater levels fall during the following summer and autumn. Conversely, dry winters lead to low groundwater levels and river flows in the spring, followed inevitably by very low flows in the following summer and autumn.

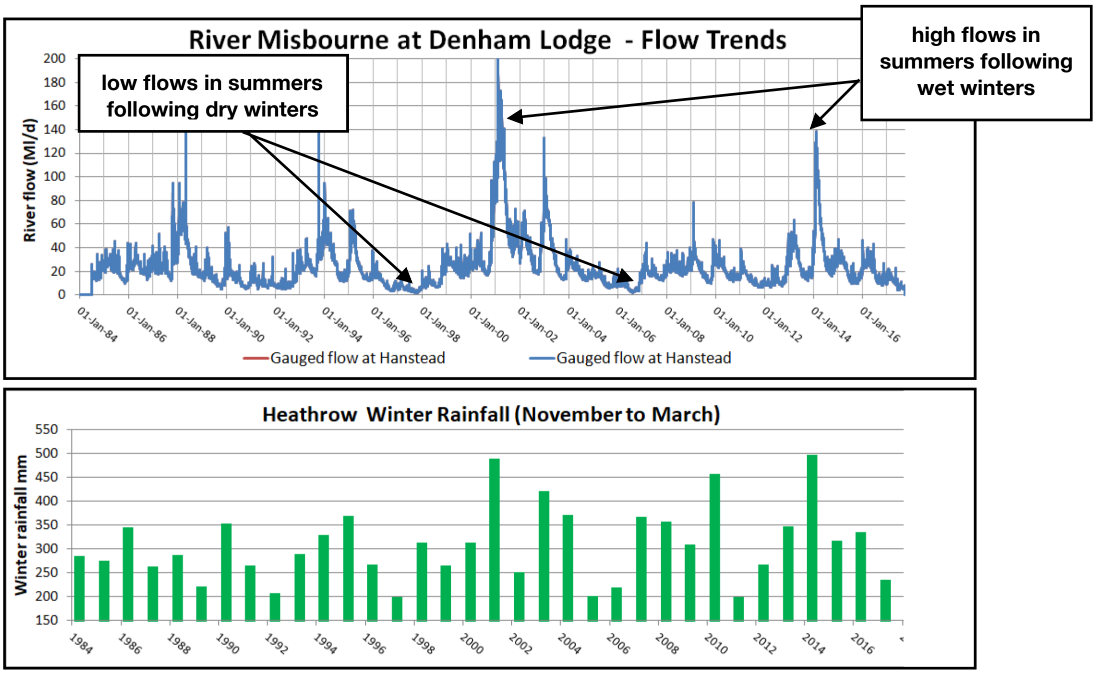


Figure 10. The relationship between total flows in the River Misborne at Denham Lodge and winter rainfall at Heathrow 1984 to 2018.

4. No Long-Term Change in Winter Rainfall Patterns

Climate change is sometimes cited as one of the possible causes of low flows in chalk-streams, or at least as being a contributory influence: for example Radio 4 Costing the Earth, "Dry Me a River" Wednesday 13th Nov 2019. The evidence to date does not support this.

Climate change may indeed present significant and various challenges to chalk-streams, particularly in combination with abstraction and with changing land-use. Volatility in rainfall patterns, storm run-off and increasing temperatures pose major threats to the health of chalk-streams, while robust, natural flows are – if anything – increasingly vital for the restoration and preservation of that health.

However, the data thus far doesn't show any long-term changes in the *amount* of winter rainfall – even if there might be changes in the patterns and intensity – and as shown above it is the cumulative amount over time which underpins groundwater levels and therefore base-flows.

The red line on the Figure 11 below shows the rolling 5 year average winter rainfall at Heathrow. There is no indication of any downward trend in winter rainfall since the early 1960s. If anything, there appears to have been a slight increase in winter rainfall over this period.

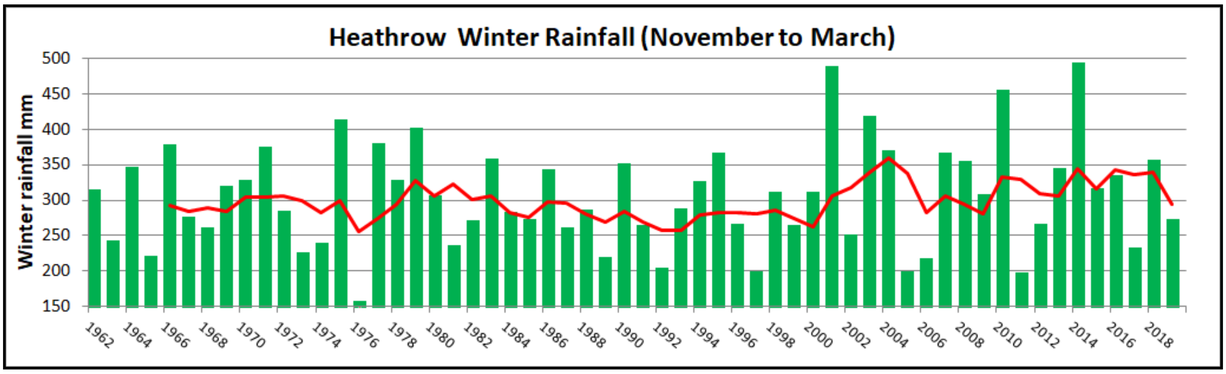


Figure 11. The rolling 5 year average of winter rainfall at Heathrow.

Looking back further to the middle of the 19th century, the total amount of winter rainfall appears to be generally increasing. The blue line in Figure 12 below represents winter rainfall since about 1760, with a steady climb since 1860. There is a clear upward trend in winter rainfall superimposed on apparent cyclical highs and lows at roughly 30 year intervals. In contrast, summer rainfall, the purple line in Figure 12, appears to be generally falling. However, as summer base-flows on chalk-streams are minimally affected by summer rainfall, the trend in climate change should, if anything, result in an increase in groundwater levels at the start of summer and therefore an increase in the levels of summer base-flows.

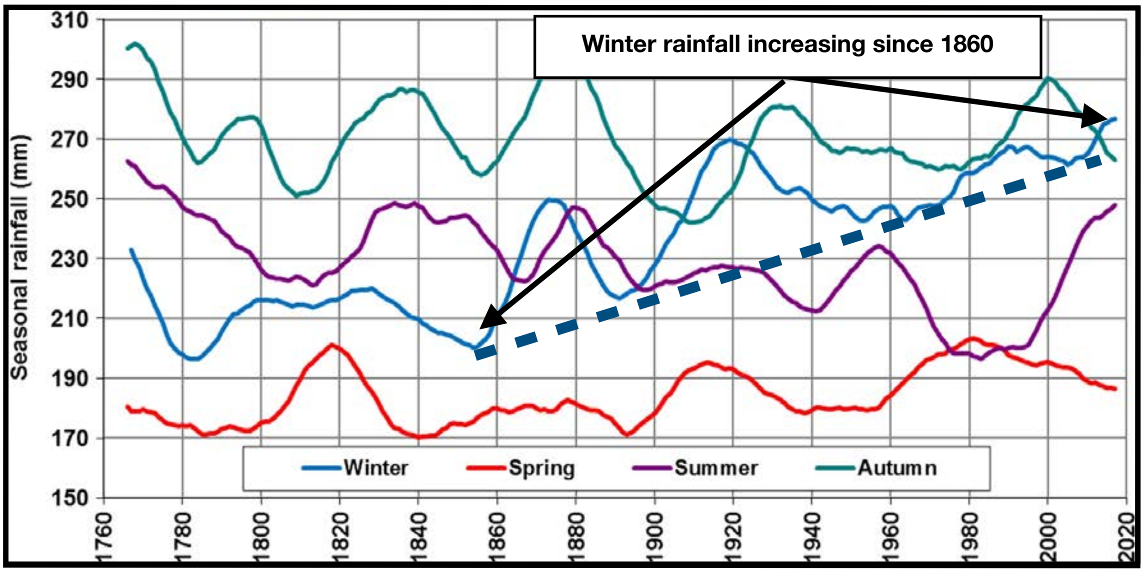


Figure 12. Trends in seasonal rainfall in England and Wales since the mid-18th century

5. The Past & Present Scale of Abstraction

Figure 13 below shows low flows in the River Chess since the 1970s. During that time average low flows have fallen by two thirds from 30 Ml/d to 10 Ml/d. This is likely to be mainly the consequence of rising abstraction, for example an increase of about 7 Ml/d between 1999 and 2005 to compensate for reductions in the Bulbourne catchment. This is one example of how Sustainability Reductions, if not conducted on a regional scale, may run the danger of not yielding the hoped-for results (because the aquifer is a regional entity) and also of passing the problem on to somewhere else.

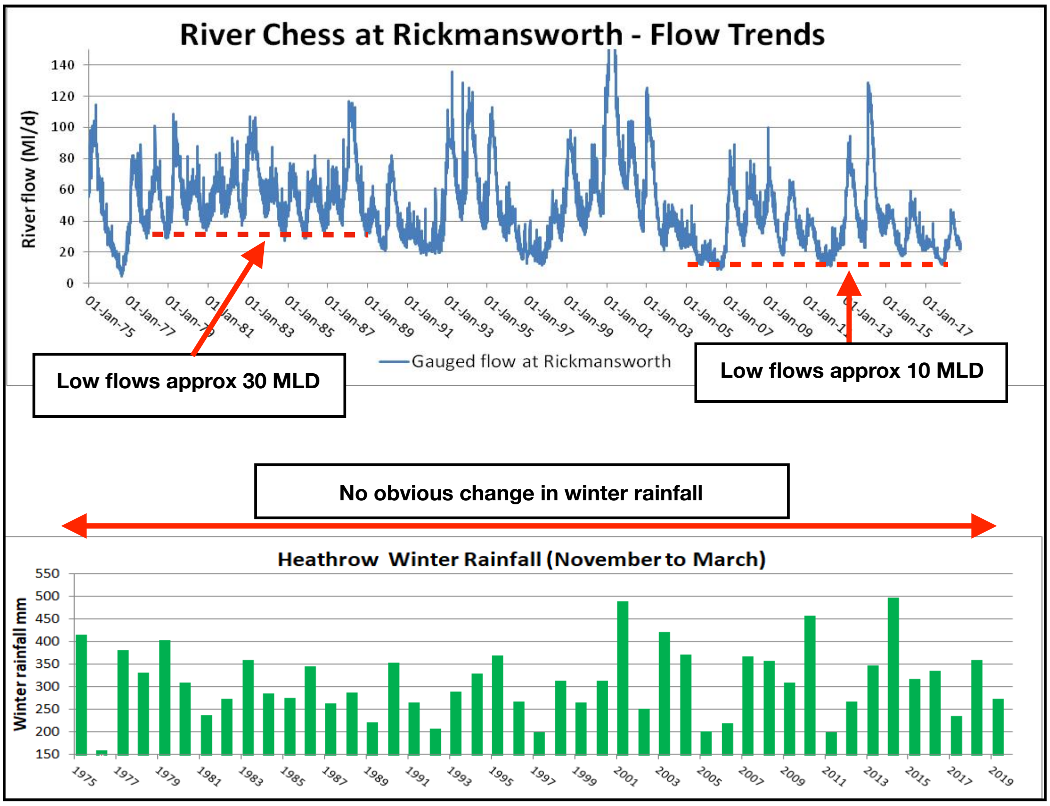


Figure 13. Declining low flows in the River Chess since the 1970s

As stated on Page 4. the impact of abstraction on flows is now generally acknowledged. As we have seen the regional aquifer acts as a reservoir and the fluctuation of the surface level of that aquifer, the groundwater level, must be a function of inflows (to the aquifer) minus outflows (from the aquifer).

In simplified terms, the major *inflow* of water into the aquifer is from rainfall infiltration through the chalk (there may be sometimes be inflow from the river but ultimately all the water in the aquifer derives from rainfall).

The major *outflows* are river flow and daily borehole abstraction. Again it is worth noting that there will be additional smaller outflows such as groundwater outflow beneath the valley and into adjacent valleys, evaporation and transpiration, but setting those aside in order to highlight the primary behaviour:

• if river base-flows are determined by groundwater level and …

• groundwater levels are determined by rainfall – minus river flows and abstraction …

… then it is inevitable that *over the long-run* abstraction will lower groundwater levels and thus diminish river base-flows by an amount that is *proportional to* and *nearly equivalent on average to the amount of water abstracted* (although again it is worth pointing out that the effect on flows is complicated by time lags within the non-uniform aquifer and will vary according to the time of year).

The total groundwater abstraction from just the Ver / Gade / Chess / Misbourne tributaries of the Colne catchment is currently approximately 82 - 85 Ml/d. This is a lower total than in the past because of recent Sustainability Reductions (reductions in abstraction to restore flows). The amounts abstracted in the past and today are shown in Figure 14 below.

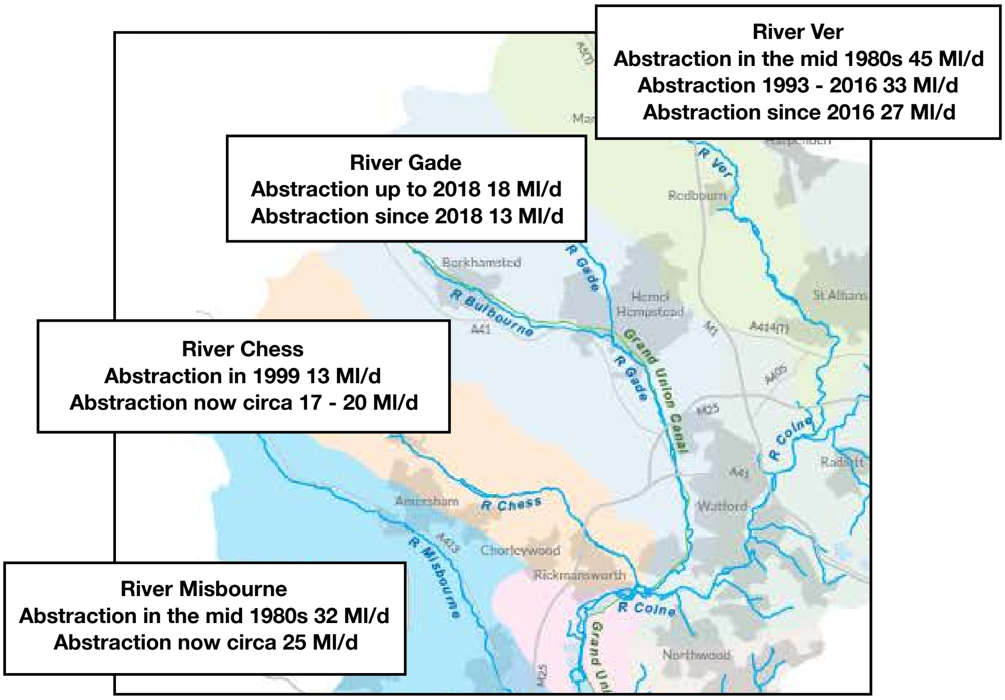


Figure 14. Abstraction from the Upper Colne tributary valleys.
These figures are approximations only, prepared to the best knowledge of the Chalk-Streams First coalition.

85 Ml/d is hard to conceptualise and this may be one of the reasons why abstraction has remained such an intractable issue for so long. One megalitre is a million litres or 1000 cubic metres. Over a year the abstraction amounts to 31 million cubic metres and would fill the whole of the Queen Mother reservoir, London's largest reservoir.

6. Recent and Planned Sustainability Reductions

There have been substantial Sustainability Reductions in recent years, as shown for example in the Ver valley where current abstraction is circa 27 Ml/d, about half the level of the 1980s. Abstraction in the Ver valley had climbed four-fold from less than 10 Ml/d in the 1940s to a peak of almost 50 Ml/d in the 1980s. Abstraction during that time was a very high proportion of the annual aquifer re-charge, and in some years abstraction exceeded re-charge of the aquifer, as shown in general terms in Figure 15. Even now 27 Ml/d would exceed the valley recharge in long droughts such as 1964/65 or 1975/76.

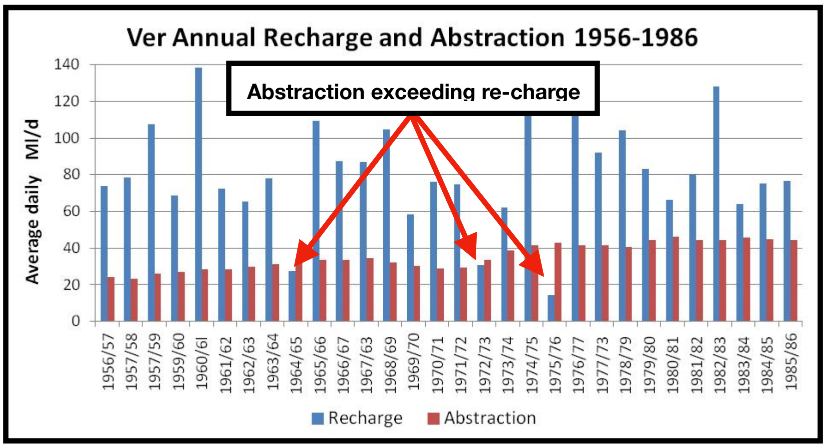


Figure 15. Growth in abstraction in the River Ver valley from 1865 to 1985

Full details of current abstraction rates and Sustainability Reductions in the Ver and other chalk valleys were not available for preparation of this paper, so unfortunately a proper analysis of the effectiveness of the Sustainability Reductions to date was beyond the scope of the authors. A detailed analysis of the impact of Sustainability Reductions should be a high priority for further investigation of the Chalk Streams First proposal – including analysis of:

1) the impact, thus far, on downstream flow-recovery and

2) the possibility that Sustainability Reductions may be less effective if not conducted on a regional level (see ref the interconnectedness of the aquifer, Page 7 above, and the example of post 2005 increases in abstraction rates on the Chess following reductions on the Bulbourne in the Ver catchment).

Affinity Water's planned Sustainability Reductions within the 2025 WRMP are shown in Figure 16 below.

Colne chalk-stream reductions by 2025	Lea chalk-stream reductions by 2025
River Ver – 9 Ml/d **River Chess – 6.4 Ml/d** **River Misbourne – 2 Ml/d**	**River Mimram – 5.7 Ml/d** **Upper Lea – 10.2 Ml/d**

Figure 16. Affinity's planned Sustainability Reductions in the upper Colne and Lea

7. UKTAG Guidelines for Acceptable Flow Reductions

Acceptable % reductions from natural flow is chalk-streams taken from UK TAG guidelines are shown in Figure 17 below.

Table 31: Water resources standards for rivers and Good Status

Types	Season	Flow > QN60	Flow > QN70	Flow > QN95	Flow < QN95
		(% change allowed from the natural flow)			
A2 (headwaters), C2, D2	April –Oct	20	15	10	7.5
	Nov –March	25	20	15	10

Figure 17. UKTAG acceptable flow reductions in headwater chalk streams

These define environmentally acceptable limits to anthropogenically caused flow reductions as % figures above which it is likely that environmental damage will be caused. Obviously the further above the limit one goes, the greater the damage.

Assuming that average annual natural flow equates to the annual re-charge, UK TAG figures suggest that the abstraction in a given valley should not exceed 5 to 10% of the valley recharge. This would mean, for example:

• for the River Ver, with an average recharge of 78 Ml/d, acceptable abstraction should be 4 to 8 Ml/d as opposed the 27 Ml/d currently abstracted.

• for the River Misbourne, with an average recharge of 61 Ml/d, acceptable abstraction should be 3 to 6 Ml/d as opposed the 25 Ml/d currently abstracted.

UK TAG guidelines alone suggest that, in spite of recent Sustainability Reductions, the Chilterns chalk-streams are still being heavily over-abstracted.

Abstraction in the River Ver, for example, would have to come down by at least 70% from 27 to 8 Ml/d to fall in line with UK TAG guidelines. In the current plans the reduction will be in the order of less than half of this at 33% from 27 to 18 Ml/d.

Abstraction in the River Misbourne would have to come down by at least 76% from 25 to 6 Ml/d and yet in the current plans reductions will be in the order of only 8% from 25 to 23 Ml/d.

Affinity's Planned Sustainability Reductions, whilst they are a move in the right direction, fall far short of what is truly needed.

8. A RADICAL AND SUSTAINABLE SOLUTION

In order to effect real change and to adequately restore flows to within UK TAG guidelines we need a radically different system, one that replaces the groundwater abstraction with water taken from outside or downstream of the chalk valleys.

OPTIONS UNDER INVESTIGATION

Affinity's latest Water Resource Management Plan shows a number of options are under investigation, including Abingdon Reservoir, Severn-Thames Transfer, Minworth Transfer. These options are to be investigated in more detail in the £460 million Strategic Investigations, approved by Ofwat.

But what account has yet been taken of the *additional flows* in the upstream reaches of the Colne and Lea (which can be abstracted downstream to supply London) that will result from the planned or potential future Sustainability Reductions or indeed of other strategic schemes to supply water to South East England, as shown in Figure 18?**

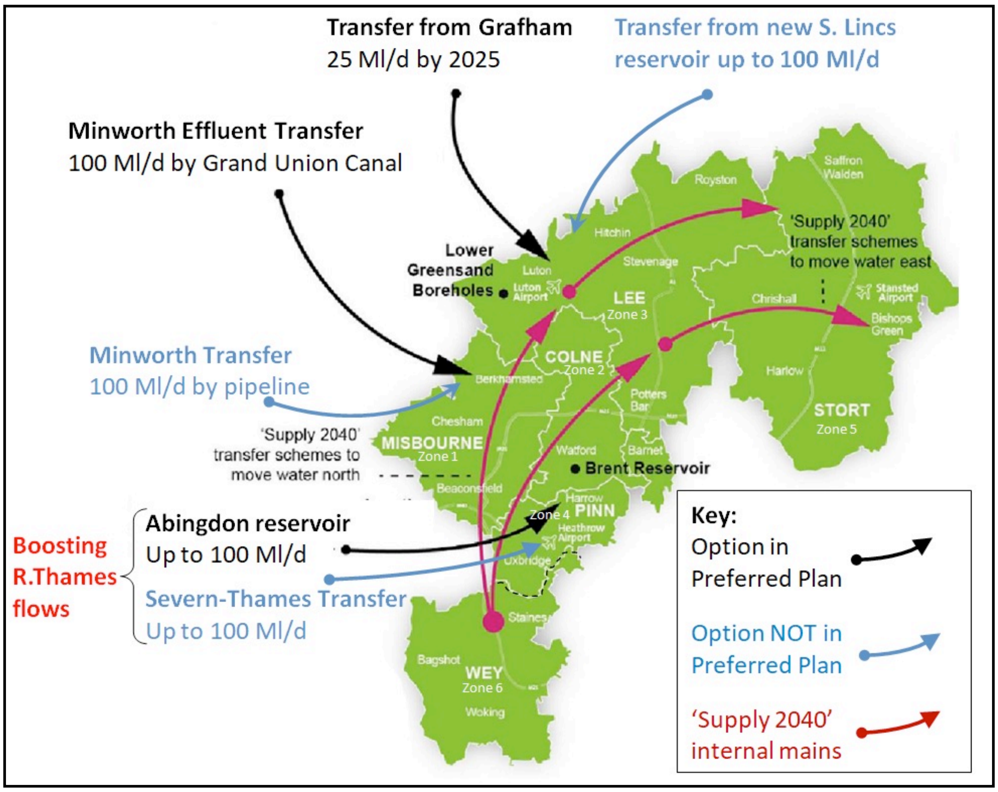


Figure 18. Strategic water resource schemes in Thames Water and Affinity Water WRMPs

Going beyond this to the heart of the Chalk-Steam First proposal, what about the additional flows that would result from a RE-NATURALISATION of river flows resulting from a 100% reduction of groundwater abstraction throughout the Chilterns chalk-streams?

As we have shown, chalk-stream flows are directly related to groundwater level. And abstraction lowers groundwater. Any reduction in abstraction must therefore lead to an increase in flows: this is called "flow-recovery". In the current range of strategic options under consideration the downstream resource benefits of upper chalk-stream flow-recovery should be carefully investigated.

CHALK-STREAM FLOW-RECOVERY RESULTING FROM ABSTRACTION REDUCTION

Recent regional groundwater modelling of flow-recovery on two different chalk-streams, the Kennet in Berkshire and the Tarrant in Dorset, showed flow-recovery resulting from reduction in abstraction amounting to an average of between 81 and 90% of the reduction in abstraction as shown in Figure 19.

** For example, the 25 Ml/d of reduced abstraction enabled by the transfer from Grafham will increase the flow available in the lower Colne and Lea for supplying London by about 20 Ml/d. That 20 Ml/d could be used to enable a further reduction in abstraction of 20 Ml/d from from the chalk aquifer, with no net loss to London's supplies.

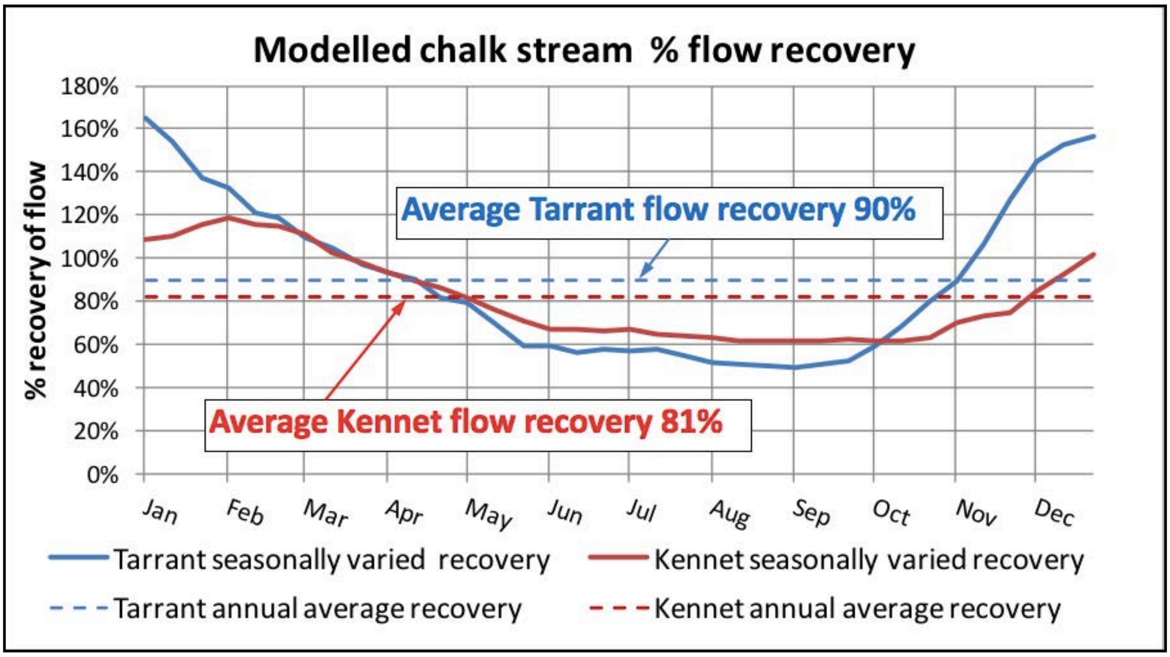


Figure 19. Modelled annual flow recoveries from Sustainability Reductions in the Rivers Kennet and Tarrant

These are annual flow recovery profiles taken from recent regional groundwater modelling by the Environment Agency and Wessex Water for the Rivers Kennet (2010) and Tarrant (2019) respectively. Whilst recognising these rivers are not in the Chilterns, they have similar hydrology, so the high levels of flow-recovery are likely to be replicated in the Chilterns.

Detailed analysis of flow-recovery data in the Chilterns should be a vital part of the investigation of the Chalk-Streams First proposal and should include modelling of flow-recovery using the Chilterns regional groundwater model, combined with modelling the resulting yield gain for London in Thames Water's WARMS2 model.

In other words for every 100 Ml/d not abstracted in the Chilterns we might expect to see additional flows of between 81 and 90 Ml/d in the lower Rivers Colne / Thames and Lea available for supplying London.

Flow-recovery in the winter re-charge period of November to March is considerably higher than in the summer, but the timing of the recovery is largely immaterial because the extra flow would be stored in London's reservoirs**. In functional terms in the Chalk-Streams First scheme the available storage in London's storage reservoirs in droughts replaces storage in the aquifer.

In normal years, assuming an annual average flow-recovery of 85%, somewhere between the two figures above, and applied to flows on the River Colne, currently planned Sustainability Reductions of 17.4 Ml/d will increase flows in the Lower Colne by circa 15 Ml/d (even a low estimate of 50% flow recovery would still yield very worthwhile gains in the order of 8.7 Ml/d).

But a 100% reduction of the current total abstraction of the Colne chalk-streams of circa 85 Ml/d would – assuming 85% flow recovery – increase flows in the Lower Colne by 72 Ml/d (or a still worthwhile 42.5 Ml/d if recovery rates proved as low as 50%)

The same would hold of the Lea chalk-streams. The additional water would flow to the Thames Water surface-water abstraction points for the storage reservoirs on the Thames and the Lea where the water could be added to the overall London supply network as shown in Figure 20.

** It should be noted that the droughts which really threaten London's supplies are those which last for more than 12 months, for example the droughts of 1933/34 and 1975/76. It may well be that the % figure of flow recovery drops during these events, leading to a higher net loss to supply, albeit with a maximum possible benefit to chalk-streams at a time of high stress – the opposite of what currently happens. However, the degree of flow-recovery in the lower Rivers Colne and Lea during long-term droughts and the consequent yield gain for London's supplies would be an important part of a more detailed investigation into the viability of Chalk-Streams First.

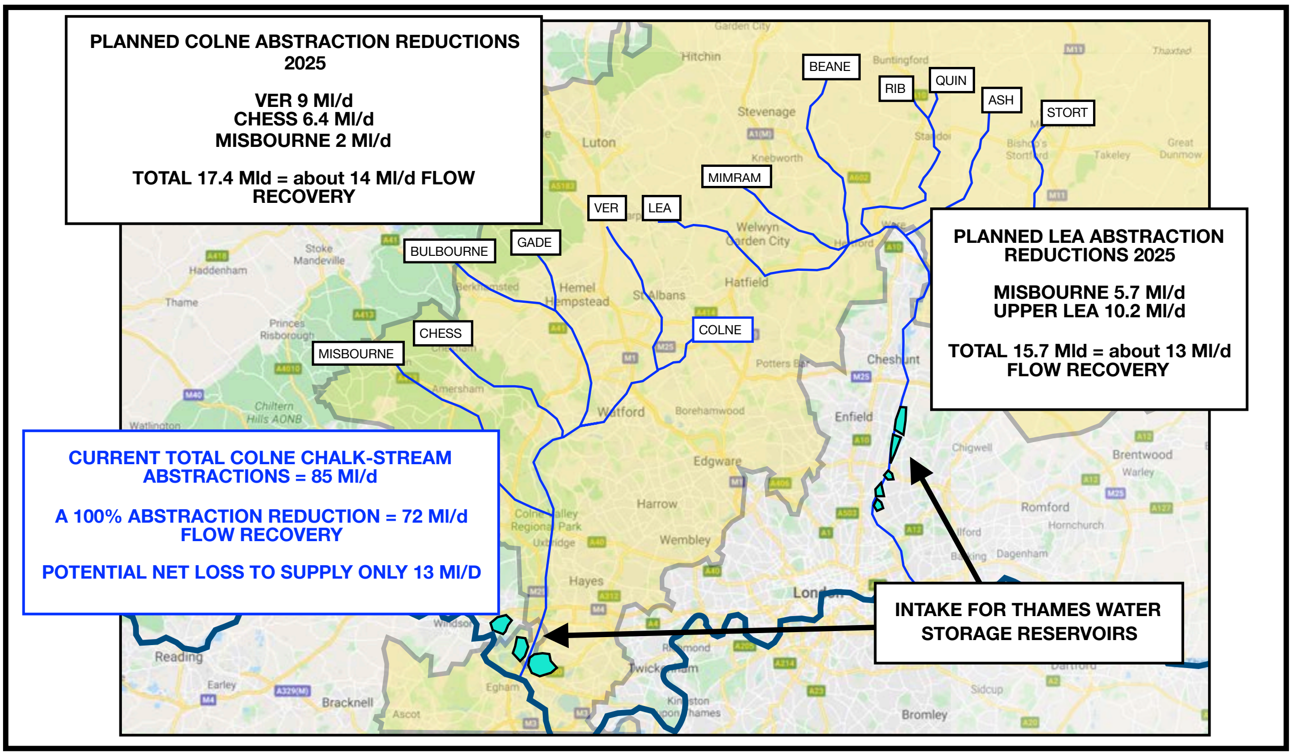


Figure 20. Flow-recovery in the Colne and Lea, available to supply London and the south-east based on an estimate derived from modelling on the Rivers Tarrant and Kennet. Detailed assessment of the flow-recovery and yield increase for London's supplies will be a crucial part of the investigations of the Chalk-Streams First proposal.

In other words not only would a 100% reduction in abstraction amount to a complete re-naturalisation of flows in the Chilterns chalk-streams, the re-naturalisation can be achieved with little impact on overall regional water resources, because about 85% of the replacement supply would come from increased river flows in the lower Rivers Thames and Lea resulting from the chalk stream flow-recovery.

THE VITAL ROLE OF THE "SUPPLY 2040" PIPE NETWORK IN STRATEGIC OPTIONS

Under this proposal water currently pumped out of the ground in the Chilterns – to supply towns and villages in the Chilterns – would flow downstream to the lower Lea and Colne as shown in Figure 21.

The towns and villages in the Chilterns currently supplied by groundwater abstraction in the Chilterns would be supplied instead by a pipe supply network that is already included in Affinity Water's planning – from AMP7 onwards: this network is called "SUPPLY 2040".

SUPPLY 2040 is driven firstly by the need to move water north to the Chilterns from Affinity Water's surplus area south of Egham – in order to compensate for current Sustainability Reductions – and secondly by the need to move water from either a future Abingdon Reservoir or Severn-Thames transfer scheme, or both and thirdly by the need to accommodate various other potential strategic supply-schemes.

SUPPLY 2040 is a vital component of ALL the strategic supply options currently under consideration. It's construction is already time-tabled, as shown in Figure 21, and costed (although the capacity of some parts of the network might need additional bolstering to accommodate the Chalk-Streams First proposal).

SUPPLY 2040 could, therefore, be also be used as a means to quickly and cost-effectively deliver substantial, if not total, reductions in groundwater abstraction in the Chilterns with no loss of supply to areas currently supplied by groundwater abstraction and with only a small net effect on London's supplies after allowing for flow recovery. Additional flow in the chalk-streams resulting from a reduction in or cessation of groundwater abstraction would be available as surface water at the Thames Water abstraction points on the Rivers Lea and Thames, as shown in Figure 22.

For the River Wye, re-naturalisation could be achieved in a similar fashion, although being in Thames Water's supply area, it would be more difficult to connect to the Supply 2040 network.

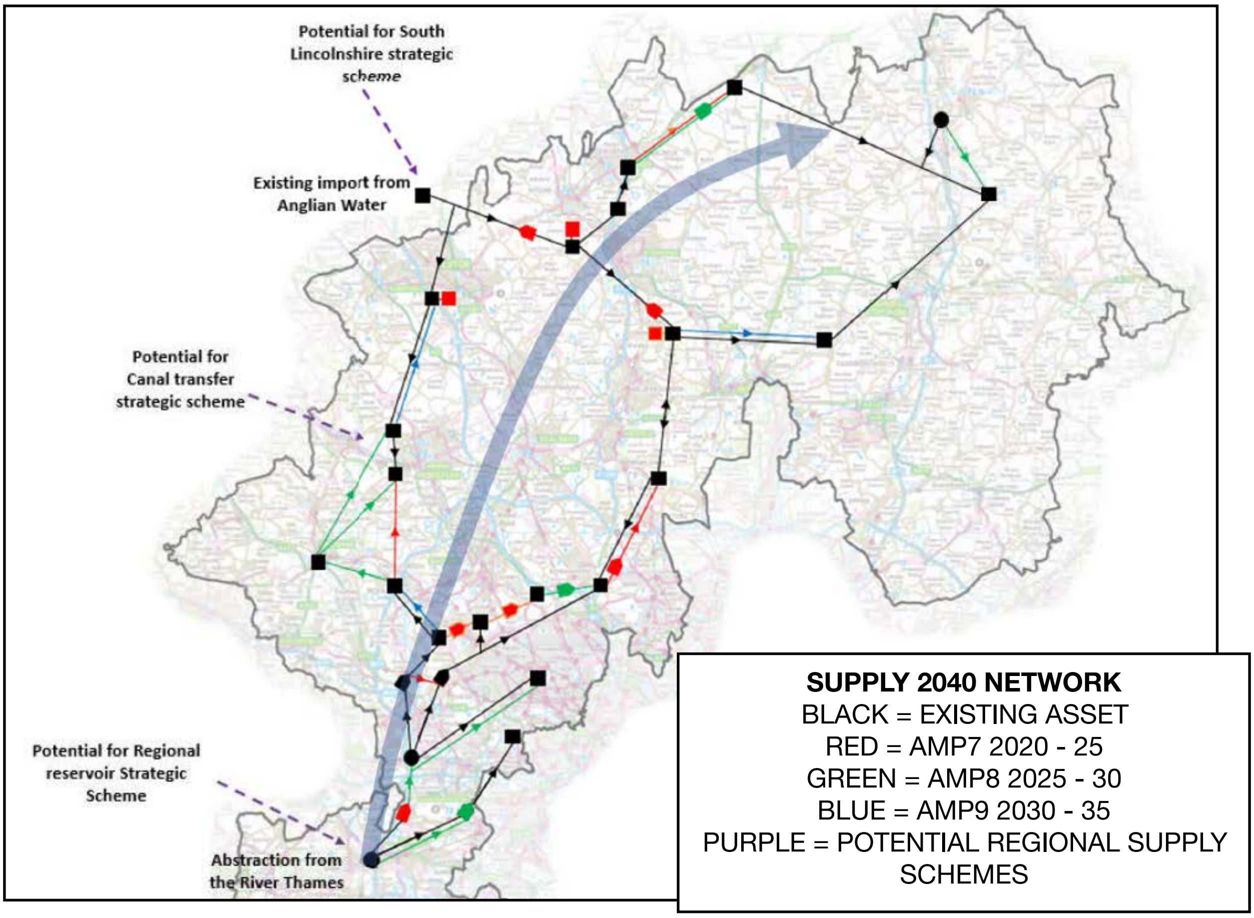


Figure 21. Affinity Water's planned SUPPLY 2040 pipe network

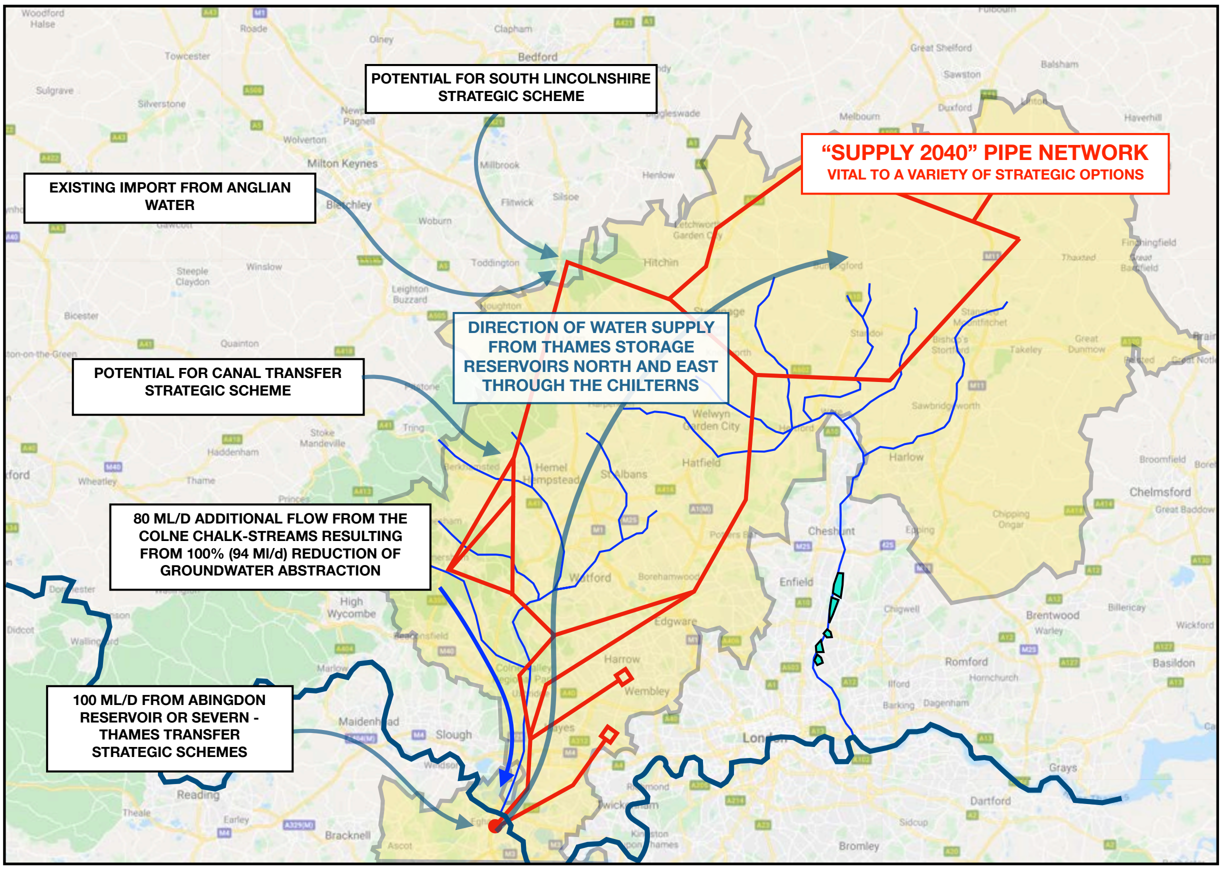


Figure 22. Use of SUPPLY 2040 to relieve chalk abstraction and the potential replacement sources

USING THE UNIQUE OPPORTUNITY THAT SUPPLY 2040 PROVIDES
CHALK-STREAMS FIRST PROPOSES THAT WE…

- **STOP** GROUNDWATER ABSTRACTION IN THE CHILTERNS

- USE **FLOW-RECOVERY** TO TAKE THE WATER TO EXISTING SURFACE WATER ABSTRACTION POINTS ON THE LOWER LEA AND THAMES INSTEAD WITH **ONLY A NET 15% LOSS TO SUPPLY**

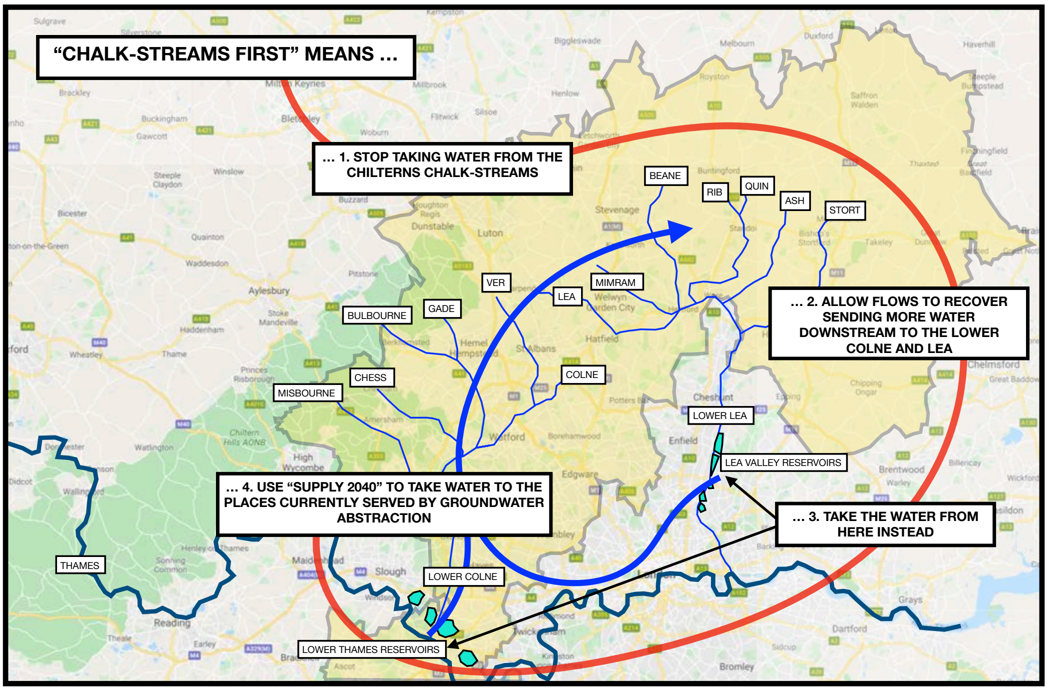
- **USE SUPPLY 2040 NETWORK** TO TAKE WATER TO PLACES CURRENTLY SERVED BY GROUNDWATER ABSTRACTION

- **RECOVER THE NET 15%** THROUGH ANY OR ALL OF THE FOLLOWING, ALL WITHIN AFFINITY AND THAMES WATER STRATEGIC PROPOSALS

AFFINITY WATER'S SOUTH OF EGHAM SURPLUS
ALL LONDON LEAKAGE SAVINGS
ALL LONDON DEMAND REDUCTIONS
LONDON EFFLUENT RECYCLING OR DESALINATION
DIDCOT POWER STATION LICENCE RELEASE
OXFORD CANAL TRANSFER SCHEME
SEVERN - THAMES TRANSFER SCHEME
ABINGDON RESERVOIR

- GIVEN THAT IT IS RELATIVELY AFFORDABLE AND POTENTIALLY QUICK TO DELIVER **BRING "SUPPLY 2040" FORWARD TO BECOME "SUPPLY 2030"**.

It's high time we put CHALK-STREAMS FIRST



A SOLUTION TO THE CHILTERNS CHALK-STREAM CRISIS SHOULD BE A FUNDAMENTAL AND HIGH-PROFILE PART OF THE STRATEGIC WATER PLAN FOR THE SOUTH EAST AND AN INTEGRAL PART OF OFWAT'S £460 MILLION PROGRAMME OF INVESTIGATIONS INTO STRATEGIC WATER RESOURCES.