RIVER LARK CATCHMENT APPRAISAL

Defining the problem of the Larks poor ecological health and pathways to improvement

The River Lark Catchment Partnership

love every drop anglianwater

NORFOLK RIVERS TRUST

The Riverfly Partnership

ENVIRONMENTAL SUSTAINABILITY

Catchment Based Approach

The Rivers Trust

Environment Agency

A clear solution for farmers CATCHMENT SENSITIVE FARMING NATURAL ENGLAND

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Notice

This document has been prepared by Norfolk Rivers Ecology working in close collaboration with River Lark Catchment Partnership. The document has 39 pages including the cover.

Document history

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Disclaimer

This Report has been prepared by Norfolk Rivers Ecology working in close collaboration with River Lark Catchment Partnership, with all reasonable skill, care and diligence within the terms of the contract of engagement with Anglian Water Services Ltd on behalf of the CamEO Catchment Partnership and taking into account the resources devoted to it by agreement with the Client. The material in this report reflects best judgement in light of the information available at the time of preparation.

Photos

Unless otherwise credited photos used in this report are provided by Sam Hurst and or Norfolk Rivers Ecology.

Contact

Sam Hurst – sam@norfolkriverstrust.org

Norfolk Rivers Trust, Unit 7B Bayfield Brecks, Holt, Norfolk, NR25 7DZ

norfolkriverstrust.org

Contents

Executive Summary

The river Lark flows for 57km from its headwaters in on the eastern edge of the Newmarket ridge in Suffolk, to its confluence with the river Great Ouse near Littleport, in Cambridgeshire. The catchment covers an area of south of Bury St. Edmunds, flowing north west to Mildenhall. Here the Cut-off channel, a flood relief channel can divert water north to prevent flooding of Mildenhall and the low-lying fenland downstream. Below Isleham the Lark enters the South Level fenland drainage area, a pumped system, where water from the surrounding land has to be lifted into the embanked river. This report is primarily concerned with reaches of the Lark upstream of the cut-off channel that has the potential to support chalk stream ecology,

The Lark and its tributaries above Mildenhall can be categorised 3 hydrological types;

1. Ephemeral winterbournes (Lark above Bury St Edmunds, Linnet, upper Cavenham stream, Kennet-Lee Brook)
2. Perennial chalk streams (Culford stream, lower Cavenham stream and Tuddenham Mill stream)
3. Perennial main chalk river - baseflow from groundwater provides year-round flow. Considered to be from below Fornham lock/Sheepwash bridge (B1106) next to the remains of Fornham Park Lock

The environmental drought of 2018-19 had a significant impact on river flow and highlighted the fragility of the Lark's ecology in the face of mounting human and environmental pressures. The Lark is a historically degraded river but retains the potential to support flourishing chalk river ecology. The River Lark Catchment Partnership (RLCP) has been successful in delivering river habitat restoration projects through the Catchment Based Approach (Caba) however any ecological improvement is limited by both poor water quality and the impact of abstraction on natural flow. It is hoped that through this catchment appraisal the issues impacting the Lark can be better defined and communicated to key stakeholders in order to develop an action plan that will deliver outcomes to benefit the river Lark.

Acknowledgments

With thanks to all the members of the River Lark Catchment Partnership (RLCP)that have contributed to this document and Anglian Water Services (AWS) for funding its production. Specific thanks to; Ian Hawkins (Riverfly/RLCP), Geoff Brighty (Environmental Sustainability Associates Ltd), Andrew Hinchley (RLCP), James Stephens (RLCP), Becks Mundy (CSF NE),Jessie Leach (Rivers Trust), Sam Westwood (AWS), Chris Gerrard (AWS), Rob Clapham (EA), Natalie Wren (EA), Rob Bakewell (EA), Nina Birkby (EA).

The Lark – one of England’s Chalk rivers

The river Lark is one of only 200 chalk rivers, a globally rare habitat that is capable of supporting an array of iconic species such as brown trout, kingfisher and water vole. What makes chalk rivers so special is the exceptional quality, temperature and consistent flow that supports a unique aquatic ecosystem. The water gains these properties when Rainfall infiltrates the soil and enters the porous, fissured chalk bedrock that underlies the catchment. The chalk rock or aquifer acts as an underground reservoir with water emerging into the base of the river or from natural springs that feed its winterbourne ephemeral upper tributaries. It is the historically clean and plentiful water stored in the chalk that gives life to the Lark, its people and its economy.

Photo 1: Example of pristine chalk stream habitat – River Test, Hampshire. Clear water, gravel bed, water crowfoots (Ranunculus penicillatus). Photo credit: Mike Blackmore.

In recent decades the impact of unsustainable abstraction, modification and pollution have reduced much of the Lark and its tributaries to chalk streams name only. Only short stretches show glimpses the keystone species of plant, invertebrate and fish species that the river is capable of supporting. The continued growth and intensification of the Lark valley increases the pressures on the fragmented ecology, making it less resilient to climatic events. If greater effort is not made now to safeguard the Lark the opportunity to restore one of the region’s most valuable asset could be permanently lost.

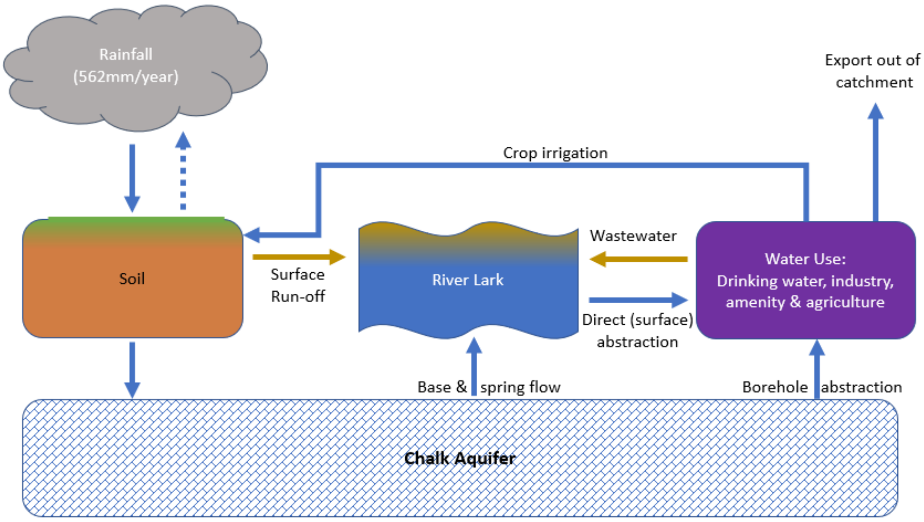


Figure 1: Hydrological model of water movement in the Lark catchment

1. Present health of the Lark Catchment

The Environment Agency (EA) classifies surface waters (rivers) and groundwater health by sub-, according to the EU Water Framework Directive (WFD), classifying them from High to Bad status. The WFD's aim was to for all surfaces waters to achieve good ecological status by the end of the 1st six-year RBMP cycle in 2015, although provision was made for a further two cycles up to 2027. The WFD has been adopted by UK legislation and goals have been incorporated into the 25 year environment plan.

1.1 Environment Agency Assessment

1.1.1 Surface water

At present, none of the Lark's surface waterbodies achieves good ecological status and none meet good chemical status*. Overall and ecological health of the river Lark catchment waterbodies has declined slightly from 2015 to 2019, likely in part to the environmental drought of 2018-19, and reflecting the wider national stagnation of river health.

* Note: Changes to the number chemicals tested for in 2019 (nationally) resulted in all of England's rivers failing to meet good chemical status.

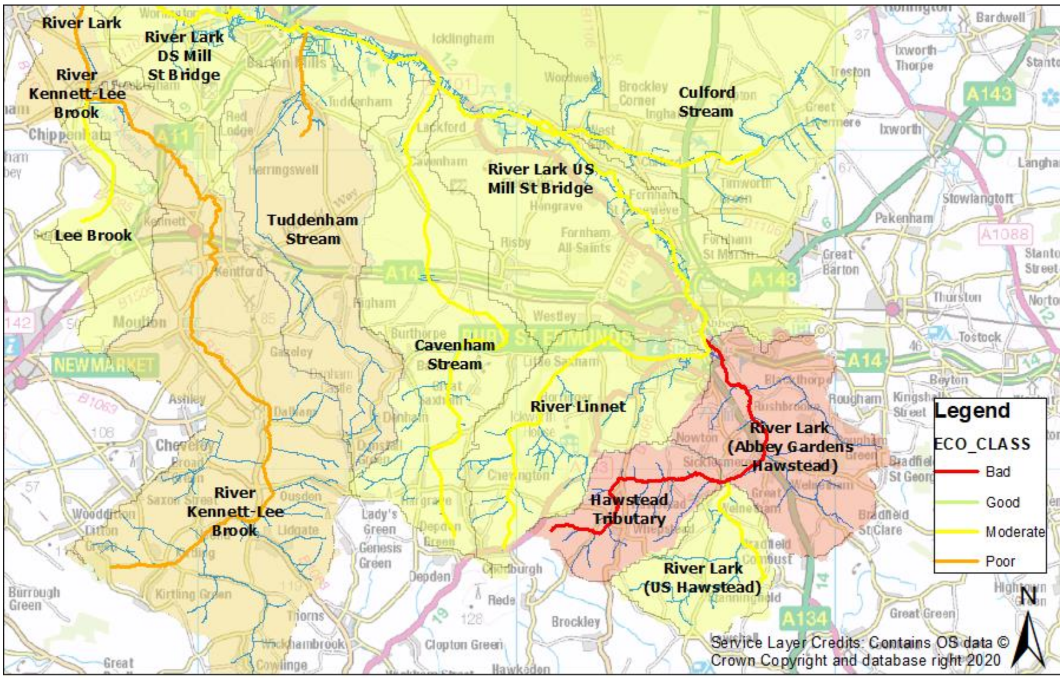
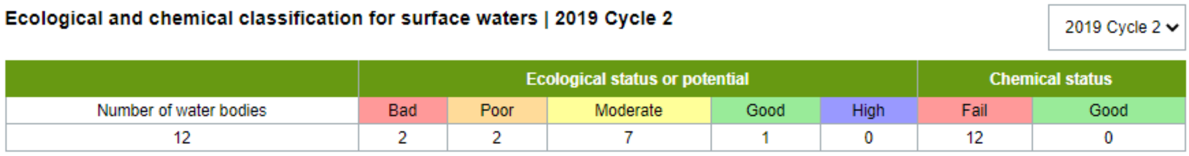


Figure 2: Overall river waterbody status 2019. Source: Environment Agency.

Table 1 Lark waterbody WFD status.



Ecological and chemical classification for surface waters | 2019 Cycle 2

2019 Cycle 2

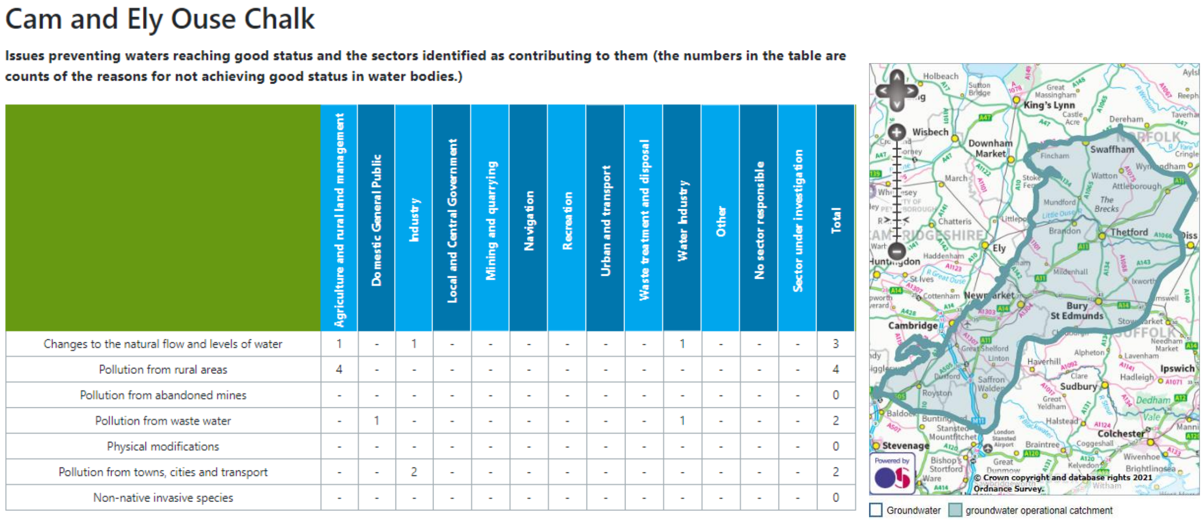
	Ecological status or potential					Chemical status	
Number of water bodies	Bad	Poor	Moderate	Good	High	Fail	Good
12	2	2	7	1	0	12	0

Source Environment Agency catchment data explorer website

1.1.2 Groundwater

The chalk bedrock underlying the river Lark catchment is part of the same geological formation running north east from the white cliffs of Hampshire to north west Norfolk. The Lark groundwater unit therefore forms part of the wider Cam & Ely Ouse (CamEO) chalk aquifer groundwater unit. The EA describes the groundwater flow as “usually rapid and fracture flow dominant” making it especially vulnerable to pollution on the surface. The aquifer is classified as of Poor status overall, Poor chemical status and Poor quotative status.

Table 2 Issues preventing the wider Cam& Ely Ouse chalk groundwater from reaching good status.



Cam and Ely Ouse Chalk

Issues preventing waters reaching good status and the sectors identified as contributing to them (the numbers in the table are counts of the reasons for not achieving good status in water bodies.)

	Agriculture and rural land management	Domestic General Public	Industry	Local and Central Government	Mining and quarrying	Navigation	Recreation	Urban and transport	Waste treatment and disposal	Water Industry	Other	No sector responsible	Sector under investigation	Total
Changes to the natural flow and levels of water	1	-	1	-	-	-	-	-	-	1	-	-	-	3
Pollution from rural areas	4	-	-	-	-	-	-	-	-	-	-	-	-	4
Pollution from abandoned mines	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Pollution from waste water	-	1	-	-	-	-	-	-	-	1	-	-	-	2
Physical modifications	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Pollution from towns, cities and transport	-	-	2	-	-	-	-	-	-	-	-	-	-	2
Non-native invasive species	-	-	-	-	-	-	-	-	-	-	-	-	-	0

Source Environment Agency catchment data explorer website

Anglian Water have identified high levels of Nitrate in the groundwater sources at a number of their supply boreholes within the Lark catchment. It is not possible to establish if this a legacy effect from historic excess nitrogen fertiliser application or more recent losses, but on the free draining Breckland soils leaching of pollutants can be rapid. This presents an immediate risk to public drinking water supplies but may also a longer-term risk to river water quality where connectivity to groundwater remains high.

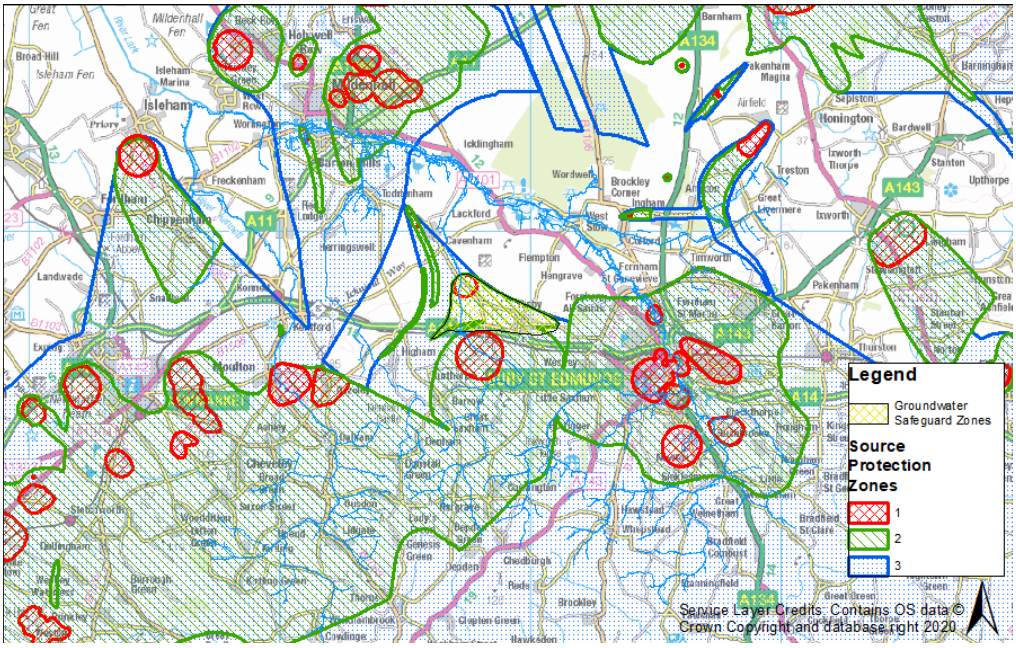


Figure 3: SPZ 1= 50 day travel time for any point below the water table to borehole. 2 = 200 day. 3 = Source catchment area.

1.2 Hydrology and Flow

Assessing the baseflow data from gauging stations on the River Lark allows for the investigation of key phenomena: for example, patterns in the impacts of dry periods or trends of increasing flow frequency. The analysis in this section draws from historic and live data from the Centre of Ecology and Hydrology (2021) showing flow analysis at two gauging stations: Fornham St Martin (Golf Course) and Temple (Icklingham), respective station IDs 33070 and 33014 (Figure 1). This study focuses on the just the Temple and Fornham St Martin gauging stations since they have available flow data up to 2021 (whereas the Isleham only records to 1986).

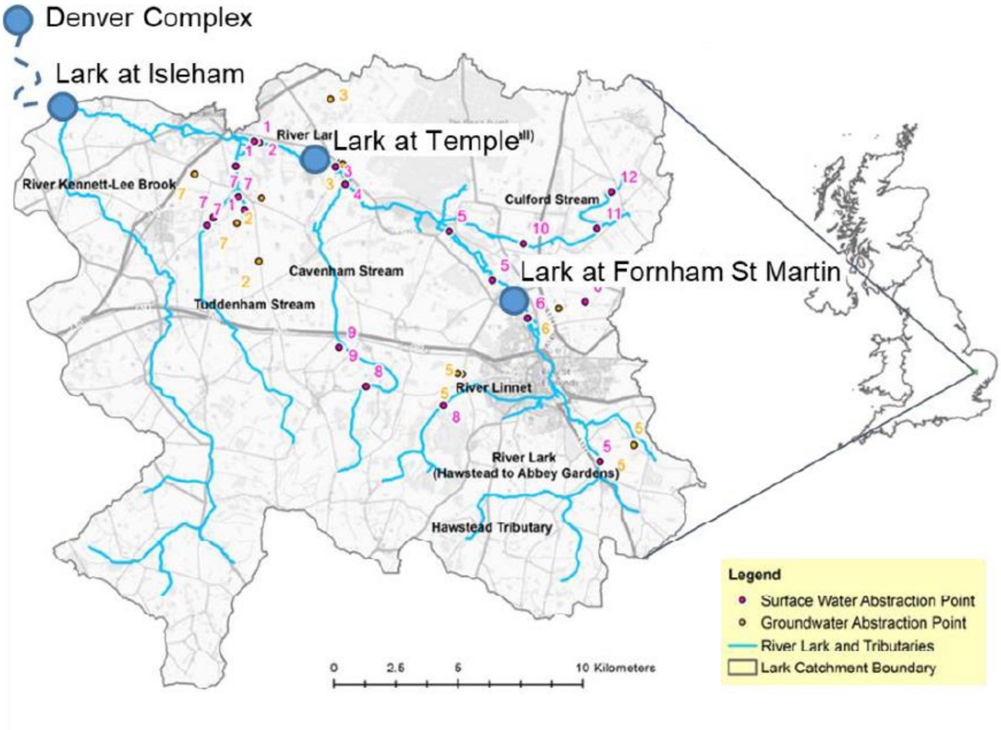


Figure 4: River Flow gauging stations relevant to the Lark catchment (Cranfield University, 2020).

1.2.1 Ephemeral / perennial flows within the Lark catchment

The source of flows has a significant impact on flows and water availability: specifically, whether the streams are ephemeral or perennial. A study by the Environment Agency (1999) identified that specifically for chalk streams, under *natural* conditions:

> *Depending upon the onset of autumn/winter rains, stream discharge tends to increase in December, associated with a rainfall-induced rise in shallower sections of the aquifer, and continues to increase until March or April. Through this time spring flow at the perennial head increases in strength, whilst springs along the ephemeral 'winterbourne' section reactivate after lying dormant through the summer months. Flows then decline steadily through the summer and autumn until the shallow aquifer is again bolstered in the winter by percolating autumnal rainfall (ibid.).*

This combination of perennial input from aquifer with ephemeral patterns throughout the main River Lark and its tributaries seems a likely scenario for the Lark catchment. However, it is crucial to understand the *unnatural* high levels of exploitation in the aquifer in the upstream catchment, causing significant separation from river flow and potentially even indicating the streams are likely to no longer be perennial (Environment Agency, 1992). Furthermore, the discharges from the small sewage treatment works (STWs) upstream of Bury St Edmunds do not discharge a sufficiently high amount to sustain a reliable baseflow, since the river has been dry in Bury St Edmunds over the significant periods of prolonged drought. These two factors indicate the streams are more likely to be mainly ephemeral (fed by rainwater). Environment Agency confirms that the Cavenham stream and River Kennett-Lee Brook are ephemeral (Environment Agency, 2014).

1.2.2 Flow data analysis

The Fornham catchment is 110km^2 and for Temple 272km^2, from flow data recorded at the respective gauging stations, the high flows correlate well with the relative catchment areas (Centre for Ecology & Hydrology, 2021). However, when looking at periods of low flows there is not as clear a correlation – this is likely due to the effluent inputs and confluences downstream of Fornham, which also skew mean flow statistics (ibid.).

See Figure 2 for a summary of the flow analysis at the two gauging stations between 1985-2019. By comparing the flows for Fornham and Temple over time, insight can be gathered from the impact of low flows between the two stations in drought periods.

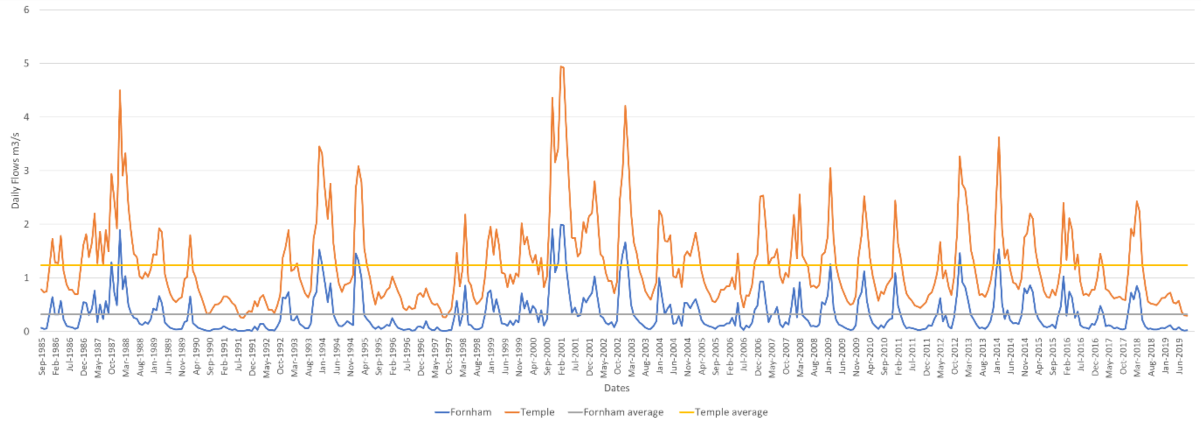


Figure 5:Average monthly flows at Fornham and Temple gauging stations on the River Lark 1985-2019, showing additional overall average lines (Centre for Ecology and Hydrology: 2021)

Figure 4 indicates that there does not appear to be trends in increasing frequency / severity of low flows over time in the record. Figure 5 shows that at the Temple gauging station, the lowest recorded flow in 2019 was 0.243 m3/s. The lowest flows on record since 1985 occurring in 1991 and 1997 were 0.165 and 0.167 m3/s respectively.

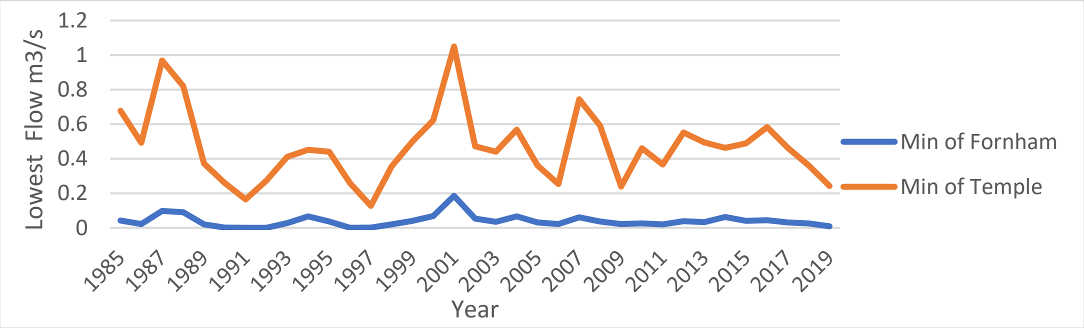


Figure 6:Drought and lowest flows per year comparison 1985-2019 for the Fornham and Temple gauging stations (Centre for Ecology and Hydrology: 2021)

1.2.3 Treated effluent contributions to flow

The daily effluent discharge flow record for Fornham WRC over the last ten years from July 2010 onwards shows that the discharges have been consistently between 100 and 180 l/s with a range more tightly between 100 and 120 l/s during the dry stretches. The record for West Stow WRC shows discharges ranging between 4 and 14 l/s with the dry flows always sitting between 4 and 5 l/s.

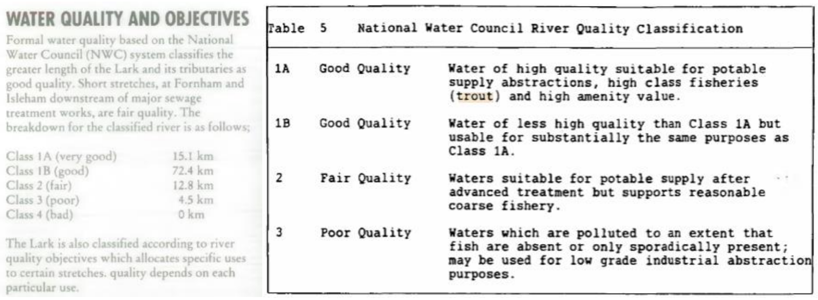
The table below shows the contributions of these effluent flows on the flow recorded at Temple WRC:

Summer recession		Flow at Temple	CWC Effluent m3/s	Net Flow	
2010	2nd Aug	0.460	0.118	0.342	74%
2011	24th Oct	0.367	0.123	0.244	66%
2012	19th Sept	0.585	0.125	0.460	79%
2013	11th Sept	0.494	0.127	0.367	74%
2014	28th Sept	0.463	0.115	0.348	75%
2015	22nd July	0.488	0.125	0.363	74%
2016	14th June	0.584	0.123	0.461	79%
2017	25th June	0.462	0.106	0.356	77%
2018	2nd July	0.360	0.120	0.240	67%
2019	27th Aug	0.243	0.107	0.136	56%

1.3 Water quality

1.3.1 Historical Context

The opening of the Sugar beet factory in Bury St. Edmunds in 1924 saw a dramatic decline in water quality in the perennial lark, with nutrient rich effluent causing extensive growth in sewage fungus downstream each winter during the “campaign”. This culminated in 1926-7 when a release of waste water from the factory lagoons “causing a six-mile section of the Lark to become completely deoxygenated” and prompted an investigation by the Ministry for Agriculture and Fisheries (Sheail, 1993). Post-war Improvements in the treatment of industrial and sewage effluent post war and construction of the present sewage works Fornham St Martin in 1968 undoubtedly lead to improvements in water quality downstream of Bury St Edmunds. However, in 1992 it was acknowledged that “The water quality does not meet NRA objectives. The lack of dilution flow in the river during drought conditions exacerbates the problems” (Barker, 1992).



WATER QUALITY AND OBJECTIVES

Formal water quality based on the National Water Council (NWC) system classifies the greater length of the Lark and its tributaries as good quality. Short stretches, at Fornham and Isleham downstream of major sewage treatment works, are fair quality. The breakdown for the classified river is as follows;

Class 1A (very good)	15.1 km
Class 1B (good)	72.4 km
Class 2 (fair)	12.8 km
Class 3 (poor)	4.5 km
Class 4 (bad)	0 km

The Lark is also classified according to river quality objectives which allocates specific uses to certain stretches. quality depends on each particular use.

Table 5 National Water Council River Quality Classification

1A	Good Quality	Water of high quality suitable for potable supply abstractions, high class fisheries (trout) and high amenity value.
1B	Good Quality	Water of less high quality than Class 1A but usable for substantially the same purposes as Class 1A.
2	Fair Quality	Waters suitable for potable supply after advanced treatment but supports reasonable coarse fishery.
3	Poor Quality	Waters which are polluted to an extent that fish are absent or only sporadically present; may be used for low grade industrial abstraction purposes.

Figure 7:1992 NRA assessment of Lark water quality (pre WFD)

Cessation of discharges of trade effluent from British Sugar in 2006 and Greene King in 2004 should have improved water quality, although there is some evidence that the cumulative loss of 5,136m^3/day to the flow through Bury St. Edmunds has exacerbated the impact of drought, with a negative effect on the ecology.

Table 3: Key WFD water quality elements classification 2019. Source EA catchment data explorer

Waterbody_ID	**Waterbody Name**	**Ammonia**	**Dissolved Oxygen**	**pH**	**Phosphate**	**Temperature**
GB105033042920	Lark (US Hawstead)	High	Good	High	Moderate	High
GB105033042930	Hawstead Tributary	High	Good	High	Poor	High
GB105033042940	Lark (Hawstead to Abbey Gardens)	High	Good	High	Poor	High
GB105033042950	Linnet	High	Bad	High	Poor	High
GB105033043030	Culford Stream	High	High	High	High	High
GB105033043000	Cavenham Stream	High	High	High	High	High
GB105033043051	Lark (Abbey Gardens to Mildenhall)	Good	Poor	High	Moderate	Good
GB105033043010	Tuddenham Stream	High	High	High	Poor	High
GB105033043052	Lark downstream of Mill Street Bridge	High	High	High	Moderate	High
GB105033042970	Lee Brook	High	Good	High	Poor	High
GB105033042990	Kennett-Lee Brook	High	Good	High	Moderate	High
GB105033043020	Kennett - Lee Brook	High	High	High	High	High

The volume of the discharge from Fornham WRC relative to river flow is apparent in the impact on key water quality elements (bar pH) in the river between Abbey Gardens and Mildenhall. Smaller AWS WRC's also have a large influence on water quality on upstream waterbodies. During the 2018/19 drought final effluent has been observed to be the sole source of water; Lark (US Hawstead), Hawstead Tributary, Lark (Hawstead to Abbey Gardens, Linnet, upper Cavenham Stream and Kennet- Lee Brook. The bad status of the Linnet for dissolved oxygen is attributed to low flows at its sample point (Raingate street bridge), supported by observations the Linnet was dry for large periods in 2018/19.

1.3.2 Phosphate

The EA classification of water quality on the tributaries on the river Lark shows excess phosphate is the primary reason for failure in 7/12 waterbodies. The excess phosphate also impacts on dissolved oxygen levels as it contributes to eutrophication through excess emergent plant, algal and bacterial growth. Phosphate enters watercourses from water recycling centre discharges, agricultural run-off and urban run-off/misconnections.

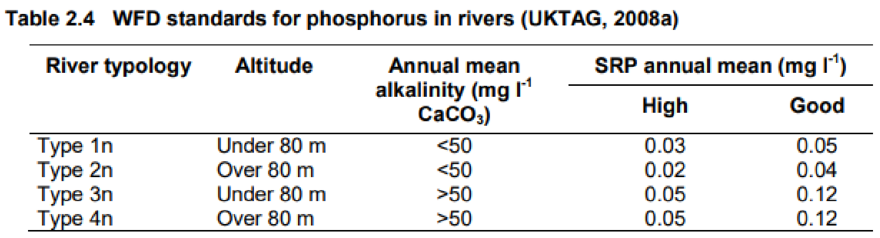
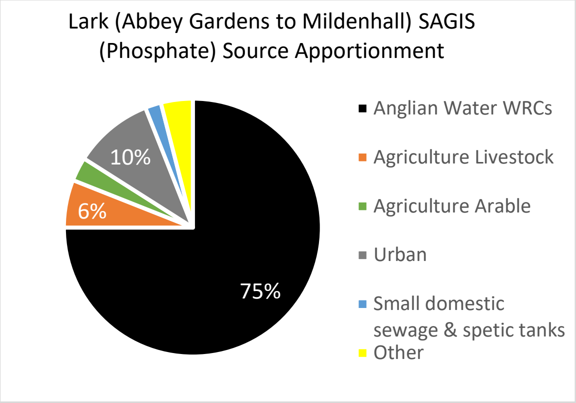


Table 2.4 WFD standards for phosphorus in rivers (UKTAG, 2008a)

River typology	Altitude	Annual mean alkalinity (mg l^{-1} CaCO$_3$)	SRP annual mean (mg l^{-1})	
			High	Good
Type 1n	Under 80 m	<50	0.03	0.05
Type 2n	Over 80 m	<50	0.02	0.04
Type 3n	Under 80 m	>50	0.05	0.12
Type 4n	Over 80 m	>50	0.05	0.12

Figure 8: Annual mean Soluble Reactive Phosphate targets set out by WFD.
Source: Review of phosphorus pollution in Anglian River Basin District EA&NFU 2012

Source apportionment models (such as SAGIS) are used to predict the relative shares of river phosphate (and other pollutants) based on known values i.e. average WRC discharge volume and phosphate level. These are used to determine the level of reduction required by each sector on their "fair share."



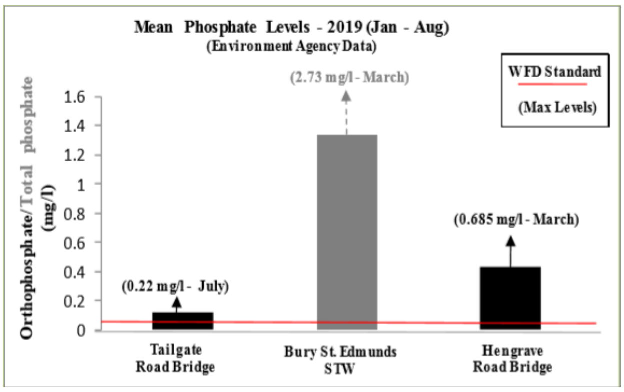


Figure 9: Source apportionment modelling by sector EA data 2017. Figure 10: *Phosphate concentrations upstream, Fornham WRC discharge and downstream.* Source: Dr Cyril Bennett MBE

Conventional water recycling centres remove roughly 50% of the phosphate from the influent but the retro-fitting of phosphate removal technologies greatly increases this, depending on the system and existing level of treatment. By the end of 2024 the only WRCs in the catchment without some level phosphate removal will be Rougham WRC, Fornham WRC and Mildenhall WRC where it is assessed as not cost-beneficial or not technologically possible to meet the required standards.

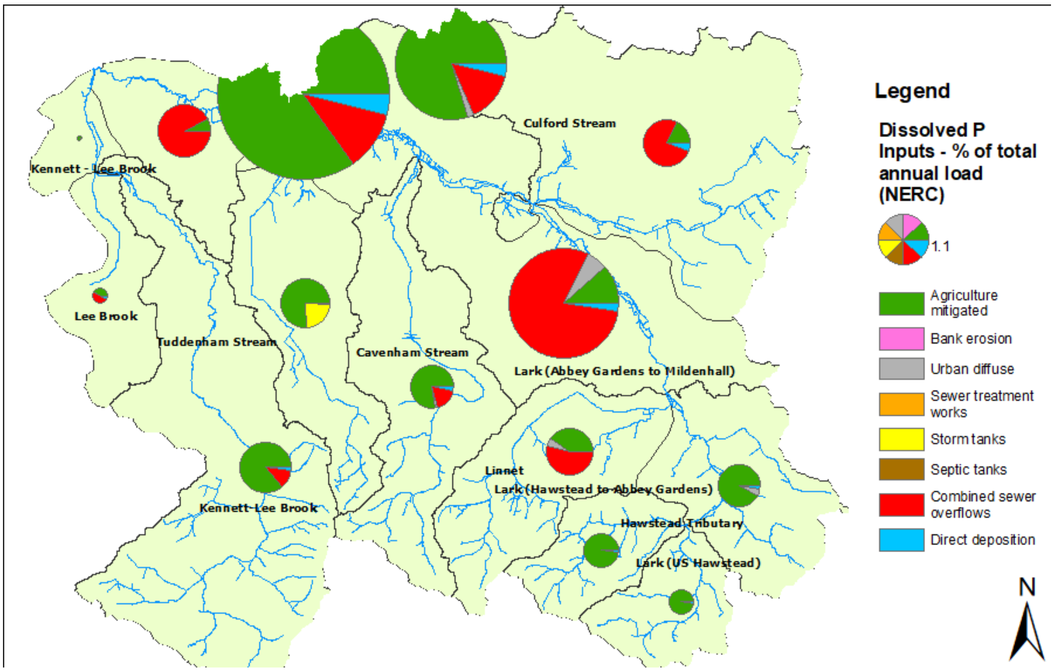
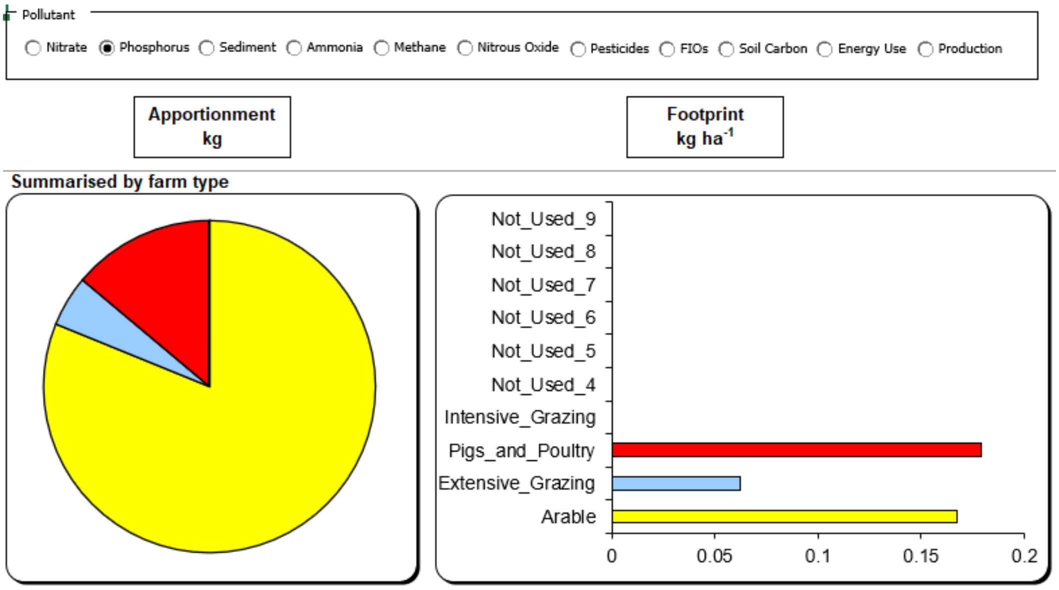


Figure 11: Dissolved sources of Phosphate - Caba catchment data package 2019

Agriculture contributes to phosphate load through the addition of mined rock phosphate, livestock manures, AD digestate and sewage sludge (biosolids) as fertiliser. Once applied phosphate binds strongly with soil particles and consequently its input to watercourses is primarily through surface run-off and poor slurry/manure management. Field/ tile drainage can also release fine sediment and phosphate, under certain conditions, such as where excess applications have built up soil phosphate indices to a high level. Being a predominantly arable catchment, it is unsurprising that phosphate losses from cropped land is modelled as to be responsible for the majority of agricultural phosphate input, with outdoor pigs being another prominent source (in the absence of free-range poultry).



Pollutant

○ Nitrate ● Phosphorus ○ Sediment ○ Ammonia ○ Methane ○ Nitrous Oxide ○ Pesticides ○ FIOs ○ Soil Carbon ○ Energy Use ○ Production

Figure 12: ADAS farmscoper catchment tool showing phosphorus losses by farm type in the Lark catchment.

1.4 Ecology

Like terrestrial environments river ecology is dependent on healthy populations of aquatic plants (macrophytes) and algae, that provide the food and habitat for invertebrates and fish species. Submergent plant species such as water-crowfoots (*Ranunculus penicillatus ssp. Pseudofluitans*), starworts (*Callitriche spp*) and greater water-moss (*Fontinalis antipyretica*) should be dominant in chalk streams, where low sediment loads and fast flowing water allow sunlight to reach river bed (Hatton-Ellis & Grieve, 2003). These oxygenate the water, as well as provide habitat and food for the smallest invertebrates that form the prey of macroinvertebrate species of mayflies (*Ephemoptera*) such as *Baetis Vernus*, Stoneflies (Plecoptera) and Caddis flies (Trichoptera). It is these invertebrates in both larval (aquatic) and adult (flying) forms that are the basis for the diet of brown trout (*Salmo trutta*) and other coarse fish species.

Table 4: Environment Agency WFD classification 2019

Waterbody ID	Waterbody Name	Fish	Invertebrates	Macrophytes and Phytobenthos
GB105033042920	Lark (US Hawstead)	NA	Moderate	Good
GB105033042930	Hawstead Tributary	NA	Bad	NA
GB105033042940	Lark (Hawstead to Abbey Gardens)	Bad	Good	Poor
GB105033042950	Linnet	NA	Moderate	NA
GB105033043030	Culford Stream	NA	Good	Moderate
GB105033043000	Cavenham Stream	Good	Good	High
GB105033043051	Lark (Abbey Gardens to Mildenhall)	Moderate	Good	NA
GB105033043010	Tuddenham Stream	NA	Good	Poor
GB105033043052	Lark downstream of Mill Street Bridge	NA	High	NA
GB105033043020	Kennett - Lee Brook	Poor	High	NA

1.4.1 Aquatic plants (macrophytes) and algae (phytobenthos)

Starwort is present on a number of the water bodies with high water quality, such as the Culford Stream, and on the Lark in the perennial Lark in restored sections at West stow. Water-crowfoot (*Ranunculus penicillatus)* has also been observed at the curved lock (2016) at in the same restored section of river but is scarce/absent in most of the waterbodies. The dominant species in the perennial Lark is Bur-reed (*Sparganium erectum*), which has encroached on the central channel to the detriment of other submerged oxygenating species. This indicates both nutrient enrichment, sedimentation and the low velocity of the canalised main river. Floating algal blooms of common duckweed have also been observed to exploit excess nutrient in low flow conditions and further deoxygenating the water column and exacerbating diurnal swings.

Photo 2: Left- channel choked with bur-reed. Credit RLCP. Photo 3: Right - Starwort and fools watercress on Culford stream.

Benthic algae and diatoms (phytobenthos) are a community of photosynthesising algae that take their nutrients form the water column, often acting as the base of the aquatic trophic pyramid. The Lark frequently suffers blooms of benthic algae that smother bed substrate and is indicative of high nutrient conditions. Blooms have been noted in many sections of the Lark downstream of Bury St Edmunds, already lacking in friable gravels, which impact on invertebrate habitat, oxygen levels, and fish spawning. The sources of nutrient input are primarily WRC discharges (as discussed), however blooms at Compiegne way also point to urban misconnections entering from surface water sewer system outfalls between Eastgate street bridge and St Saviours (Tesco).

Photo 4: Left -Benthic algal bloom covering bed downstream of Compiegne way in Bury St Edmunds Aug 2020.
Photo 5: Right – Benthic algae smothered with silt covering river bed at Hengrave Aug 2020. Credit Ian Hawkins.

1.4.2 Invertebrates

Invertebrate populations are one of the best indicators of river health and water quality as different species have varying tolerances to dissolved oxygen levels, pH and pollutants, such as ammonia, phosphate and sediment. Unlike water quality sampling that provides a snapshot at a particular time, invertebrate populations can be used to reflect a more continuous record of water quality. Different scoring systems have been developed to this end with different strengths and weaknesses.

Upper Lark and ephermeral tributaries

Low flow, phosphate, sediment, signal crayfish and lack of habitat are cited as the primary reasons for poor invertebrate scores in these waterbodies (Birkby, 2020). These headwaters often have reaches with the most intact habitat, and smallest influence of effluent discharges and have been shown to support locally rare stonefly species *(Brachyptera risi)*. If improvements in flow and water quality can be made they can play an important role in the recolonisation and resilience of invertebrate communities I the perennial Lark through downstream drift.

Abbey Gardens to Mildenhall

The invertebrate communities are indicating that the current state of water quality is far from healthy, therefore preventing further deterioration as a result of this extra loading is critical. No further deterioration is also a requirement under the Water Framework (Mattingley, 2019)

Protracted low flows recorded between 1990 and 1993, and from 1995 onwards, caused a marked decline in LIFE (F) macroinvertebrate composition on the Lark. Baseline LIFE (F) scores recorded at Fornham between 1989 and 1997 were very low, and only ranged from 5.2 to 6.0 (Balbi, Extence, & Chadd, 1999). LIFE values enumerated at individual sites will be further influenced by the quantity and quality of instream habitat available for invertebrate colonization. In this context, it is of interest to note that, even during periods of relatively high flow, LIFE (F) scores at Fornham on the channelized River Lark (Figure 6c) were poor compared with family derived scores obtained at all times from other chalk stream sites on the Kennet (Figure 7c) and Waithe Beck (Figure 5a). This variability may be explained by a number of factors, including geological and structural differences between disparate rivers, the latter being strongly influenced by past and present engineering practices and policies.

In 2016 Ian Hawkins released 9 million blue-winged olives (*Serratella Ignita)* into the Lark at West stow following the extensive river restoration, however these are absent from recent river-fly surveys of this stretch. It is possible that an undetected chemical pollution event or the increased influence of the discharge from Fornham WRC during the 2018/19 drought prevented the re-establishment of this species. High phosphate and suspended sediment levels in this waterbody are almost certainly a contributory factor given the established relationship between these and mayfly egg mortality.

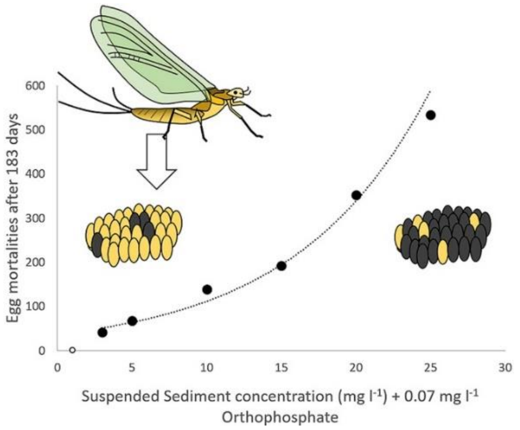


Figure 13: Sensitivity of the early life stages of a mayfly to fine sediment and orthophosphate levels. N.C Everall et al 2017

This adds weight to the conclusion from BFJ Environmental that “In-river restoration efforts alone have not been sufficient to fix the Lark’s water quality issues. To address the problems, management priorities should be on tackling the main issue at source, which are over abstraction and pollution from point [source] discharges (Hindes & Wellby, 2017).

1.4.3 Fish

Upper Lark

Fish populations in the upper Lark are currently dominated by chub, dace and gudgeon. This does not fit the WFD expected species composition, which expects brown trout to be present, but are unable to move upstream due to structures at Chimney Mill, Fornham Mill Lock and Eastgate weir (flows permitting). Quite strong coarse fish populations have been discovered within Abbey Gardens at Bury St Edmunds with roach, dace, perch, pike and even a small number of tench present; however repeated fishkill incidents (2005, 2011, 2012, 2015, 2019) and a fish relocation in 2018, all due to low summer flows, have reduced populations above Eastgate Weir. A lack of consistent flow, limited habitat and sporadic water quality issues means that the river is not suited to support the species at this location.

River Lark
Fish Problem

Due to the lack of oxygen in the water during the recent hot weather, some fish have died.

The Environment Agency have been aerating the water to avoid further problems and the council are working closely with them to decide the best approach for removing the dead fish without harming the surviving ones

Parks and Landscapes

Photo 6: Fishkill incident above Eastgate weir and Abbey gardens in 2015.

Perennial mid Lark

Brown trout are present between West Stow and Tuddenham Heath and although many of these are stocked fish some natural brown trout recruitment does occur in the Cavenham stream tributary (Environment Agency, 2014). Whilst stocked trout have been introduced to the Lark these have been triploid (infertile) fish since 2006 (in the Hengrave-West Stow section) to preserve the genetics of wild North Sea trout. Catch returns from anglers show that the trout had a declining presence in the this reach since 2014 and are thought to be no longer present since the 2018/19 drought. Populations remain in refugia downstream at Icklingham and in the lower reaches of the Cavenham and Tuddenham streams where water quality and habitat are more favourable.

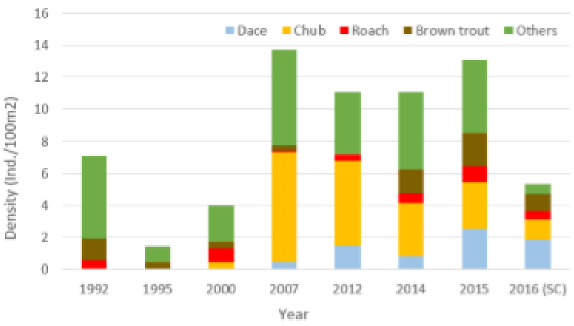


Figure 14: EA fish survey composition West Stow Country Park site 1992-2016. Photo 7: Brook lamprey in Tuddenham Mill Stream on 09/03/2021. Credit: Nicola Crockford.

Other species of high conservation value and protection include the European eel *(Anguilla anguilla)* and Brook lamprey (*Lampetra planeri)*, the latter of which is breeding successfully in the Lark, Tuddenham stream and cut-off channel. The once abundant eel has seen up to 95% decline in population over the last 25 years across the North Sea region and the Lark is no exception. The exact reasons for this remain unknown but structures that impeded migration of glass eels into and up rivers and pollution are cited as likely pressures.

2. Pressures

2.1 Physical Modifications

The Lark was once a true chalk stream with shallow water and firm gravel bed until it became tidal near Isleham where it flowed through the great fen to its confluence with the river Great Ouse. Today 9/12 Lark waterbodies are classed by the Environment Agency as 'Heavily modified', meaning they are so substantially altered that they cannot meet good ecological status in their current form.

2.1.1 Canalisation

Modifications to the Lark began with watermills but accelerated with the drainage of the fens necessitating the construction of the first staunches in 1600s to aid navigation. Subsequent canalisation (widening and straightening) and replacement of staunches with locks, to speed passage of barges, greatly altered the morphology and flow of the river below Bury St Edmunds. The perennial Lark and many of its tributaries are confined to their channels, lacking the natural shifting meanders that provide the varied riffle, pool, glide habitat.

2.1.2 Flood defence

Dredging as part of flood defence schemes in the 1970s and 1980s, in part in response to 1968 flooding, completely embanked the Lark and Linnet through and upstream of Bury St Edmunds, as well as large reaches of the Kennet, Cavenham stream, Culford stream and Linnet. The lowering of the river bed, removal of gravel, disconnection of floodplain and wetland habitat, increased siltation has left a legacy of poor submerged plant growth and impoverished invertebrate communities (Pawson, 2008).

Photo 8: Concrete Lark, St. Saviours Tesco Bury St Edmunds.

2.1.3 Barriers / Structures

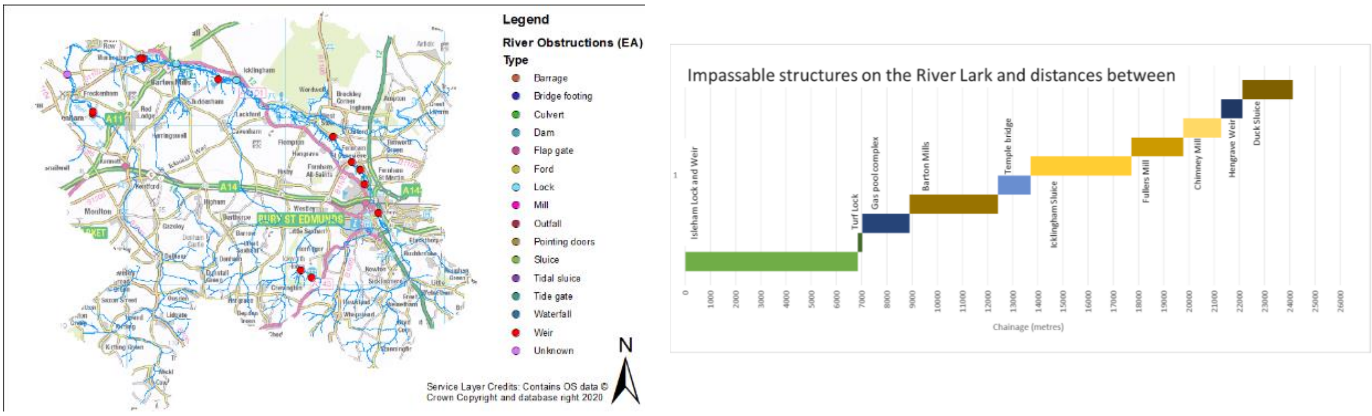


Figure 15: Left - structures on the Lark. Right- structures impassable to fish (Errey & Naura, 2017)

Man-made structures such as weirs, mills, locks, sluices and gauging stations inhibit the movement of fish species that migrate up and down river, such as trout and eels, but can also alter water levels and interrupt natural sediment movement. Many of the structures both redundant and active for flood defence purposes are the responsibility of the Environment Agency who undertaken a review of their impact. Some structures can be altered or managed differently, such as the lowering of sluice boards at Fullers mill and subsequent channel narrowing by RLCP, however other more heavily engineered assets are too expensive to be cost beneficial to be removed or replaced.

2.1.4 Morphology

Below is are three examples of poor morphology (left) as a result of physical modification in comparison to good or restored morphology (right) in different sized watercourses in the Lark catchment.

Arable ditch network – headwaters feeding the Culford stream

Before: Straight ditch turning 90 degrees around arable fields, receiving field underdrainage and overland run-off from low lying part of field.	**After:** Pond created to settle sediment and wetland planting to uptake excess nutrient. Additional tree planting will provide shade and in time add diversity through fallen wood.

Upper catchment streams – Lark upstream and downstream of The Wash at Hawstead

500m Downstream: Main river dredging has created a uniform embanked channel with steep eroding banks. Lack of riparian trees to provide shade results in burr reed dominated channel.	**500m Upstream:** Lark meandering in glacial gull (deep narrow gulley) with natural woody debris varying flow and maintaining a friable gravel bed.

Main river – Lark at West stow, Bury Trout Club restoration

Before: Overwide, uniform and ‘U’ shaped channel offered little diversity. Slow flowing and slumping banks increased silt deposition and low oxygen levels.	**After:** Dig and dump restoration and addition of gravels has created a diverse channel, with varied flow. Submerged and emergent plants add to oxygenation and provide habitat

2.1.5 Riparian / Floodplain habitat

Floodplain water meadows provide multiple benefits to terrestrial and aquatic ecology with fluctuating water levels creating and diverse array of ecological niches. They aid water quality and hydrology by storing floodwater, depositing suspended sediment and be a carbon sink, especially where continual wetting allows peat formation.

The Lark is disconnected from much of its floodplain which is fragmented, degraded and encroached by development and arable cropping. Removing embankments can allow natural process to create habitat, amenity value and reduce downstream flood risk. Bury St. Edmunds and Mildenhall both retain water meadows, which with restoration could create valuable community assets and protect properties from flooding.

Photo 9: (Left) Embankment at Holywater meadows, BSE preventing floodwater from draining back into river Linnet/

Photo 10:(Right) Lark reconnecting with its floodplain at Mildenhall in December 2020. Credit: Glenn Smithson.

Figure 16: Present state of connectivity of water meadows and fens of the upper Lark

2.1.6 Projects to improve river morphology / physical modifications

Attitudes and finances required to maintain the Lark's unnatural canalised channel, disused-structures, and have changed but scale of the restoration required has caused most projects to date to focus on improving the morphology within the existing embankments.

Active projects to improve morphology / physical modifications

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
Brecks Fen Edge Rivers (BFER) - Sea to Chalk: Restoring Sea Trout and Eels	Improve fish passage at Turf Lock, Gas pool sluice and trial/monitor lowering of Barton mills sluice.	Fish	Mildenhall lark	2020-2023	EA	NRT
BFER River Lark channel restoration	The River Lark chalk stream is a unique and important habitat of which there are very few worldwide. This project will undertake significant river restoration on the river Lark, between Fornham upstream and beyond Mildenhall whilst developing sustainable community-based river management.				RLCP	EA

Future projects required to improve morphology / physical modifications

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
River reset to Paleo channel at Icklingham	Remove river from canalised section and restore natural morphology in former paleo channel.	Fish	Lark	2022	EA	RLCP
Floodplain / water meadow reconnection	Remove embankments and allow natural reconnection to riparian meadow and wetlands around Bury St Edmunds.	Water quality	Lark, Linnet	2022	BWMG	NRT, NT, LA
Gravel cleaning and introduction	Restore friable gravel bed and introduce gravels to improve habitat.	Fish Inverts	Lark	2022	EA	RLCP, Angling groups

2.2 Low flows

Low river flows have the greatest impact during the summer-autumn when rainfall is lowest and water use by the public and agriculture is at its highest. Low summer flows on the Lark are the result of low rainfall in preceding winters that reduce the contribution of groundwater to support base river flow. Lack of water directly impacts the amount habitat available to the ecology with falling water levels but also by quality of habitat by concentrating pollutants.

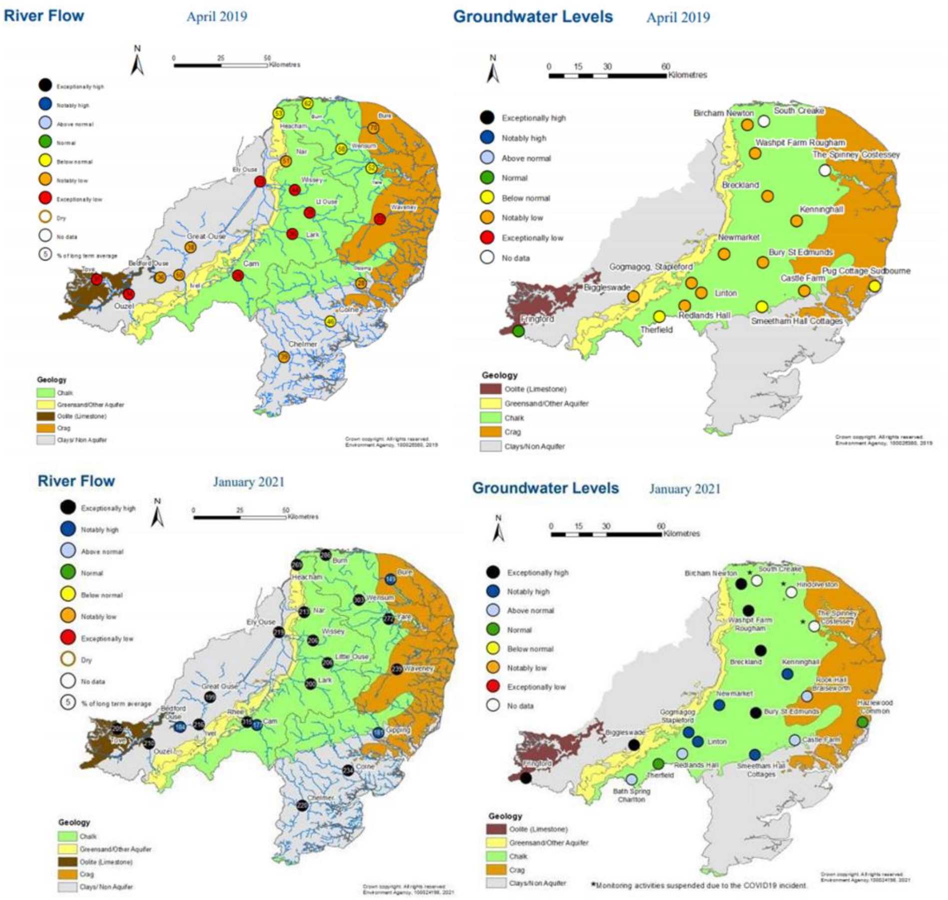


Figure 17: Impact of dry 2018/19 winter and wet 2020/21 winter on groundwater and river flow. Environment Agency water situation reports - East Anglia

2.2.1 Abstraction

Water is abstracted from both groundwater and from the surface river waterbodies for the purposes of crop irrigation, drinking water supply and industry. The majority of water abstracted in the catchment is from the chalk aquifer as it is accessible across away from surface waterbodies and requires minimal treatment prior to use. Assessments by the Environment Agency and Anglian Water have repeatedly shown that over abstraction of groundwater is negatively affecting the flow of the river Lark to the detriment of its ecology. Groundwater in the catchment has been acknowledged as over abstracted since 1992 and remains so despite licencing reforms (Barker, 1992).

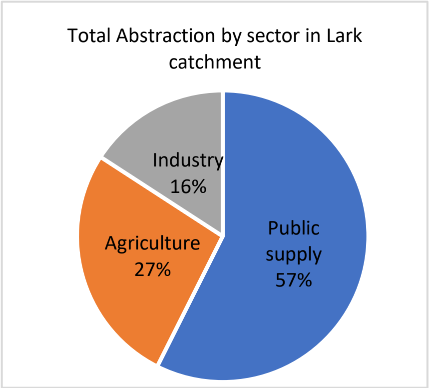


Figure 18: Source Environment Agency

2.2.2 Water company abstraction

The largest water abstractor is Anglian Water with 100% of the drinking water supply for the area is abstracted from boreholes in the chalk aquifer (Anglian Water, 2019). Population growth saw abstraction from the Lark groundwater unit increase 59% from 1966 to 1992 resulting in an additional 11 million m^3 water abstracted annually. Despite some reduction in domestic water use per person, since the 1990's, the population of Bury St. Edmunds alone has grown by a further 10,000 people leading to increased water use. Anglian Water project that there will be a supply/demand deficit of 249M/L per day by 2045 (>10% annual average use) without further action.

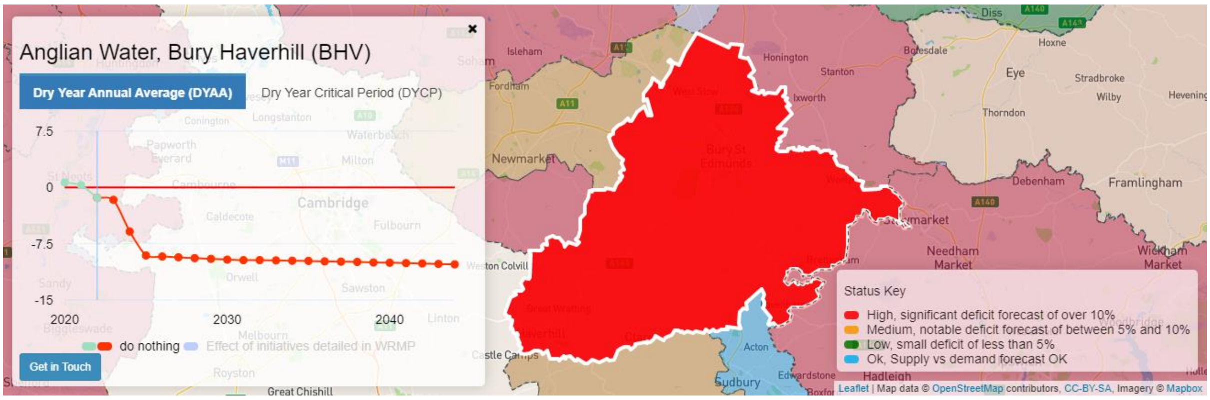


Figure 19:Wheatley Watersource viewer displaying water deficit in Anglian Water's Bury-Haverhill supply area.

2.2.3 Industrial Abstraction

Whilst smaller in annual volumes industrial abstraction can result in a higher percentage of water being exported from the catchment in food and drink products. Notable industrial abstractors include, British Sugar (962,500 m3/annum), Greene King (927,300 m3/annum), Mizkan (Branston pickle manufacturer) 143,200 m3/annum.

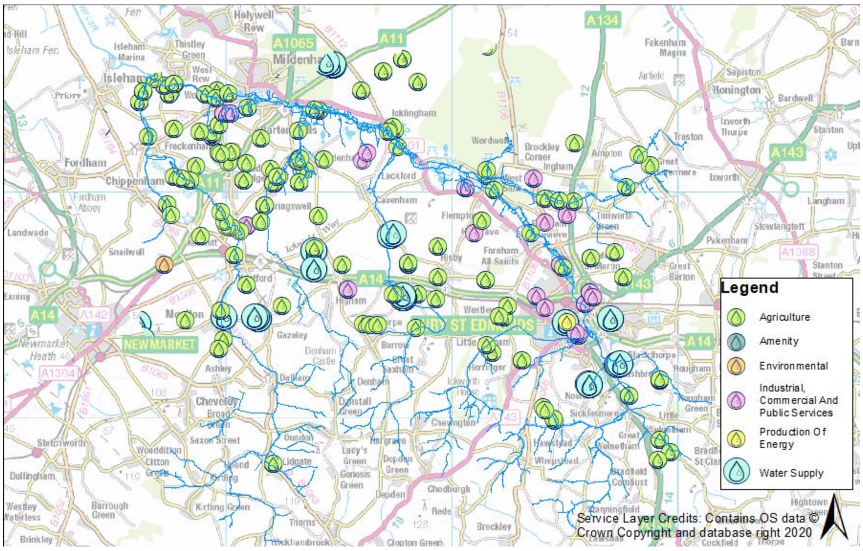


Figure 20: Abstraction licences by sector in the Lark catchment

2.3.4 Agricultural abstraction

Irrigation has allowed the sandy Breckland soils to go from being classed as agricultural 'waste' to one of the most product areas in the UK for the production of root vegetables. Despite being a highly visible use of both surface and groundwater during the summer season, many licences utilise winter flows to fill reservoirs. The Lark is priority catchment for the Environment Agency who have been working with the Lark [Agricultural] Abstractors Group and the River Lark Catchment Partnership to identify opportunities for water sharing and flexible licencing to drive efficiencies.

2.2.5 Projects to improve flow / water availability

Active projects

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
Lark water sharing pilot study	Investigate water sharing options for SW abstractors along the River Lark. The project included technical investigations and hydrological carried out by Cranfield University Water Science Institute	Flow – surface water abstraction	Lark (Abbey Gardens to Mildenhall)	2019-2021	RLCP	EA, NFU, Lark Abstractors Group
Water for tomorrow	CamEO one of 3 UK river catchments selected to investigate catchment based water resource magenta	Flow - Hydrology	Lark		WRE	RT, RLCP
Courtauld 2025 Water Ambition	Initiative to ensure fresh produce and other key foods produced in the CamEO catchment are sourced with sustainable water management.	Flow - Hydrology	Ground and surface water in CamEO catchment	2018-2025	NRT	WRAP, RT, WWF, Princes Responsible Business Network

Future projects required

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
Water saving campaign in West Suffolk	Educate and inform water users of the local environmental impact.	Flow	All		RLCP	AWS
Tributary flow assessment	Develop better understanding of flows in winterbournes using advances in remote monitoring technology.	Flow			EA	

2.3 Point Source Pollution

Point source pollution enters a waterbody from fixed locations, often regulated/permitted discharges, that can be monitored such as a WRC discharge.

2.3.1 Waste Water Point Source

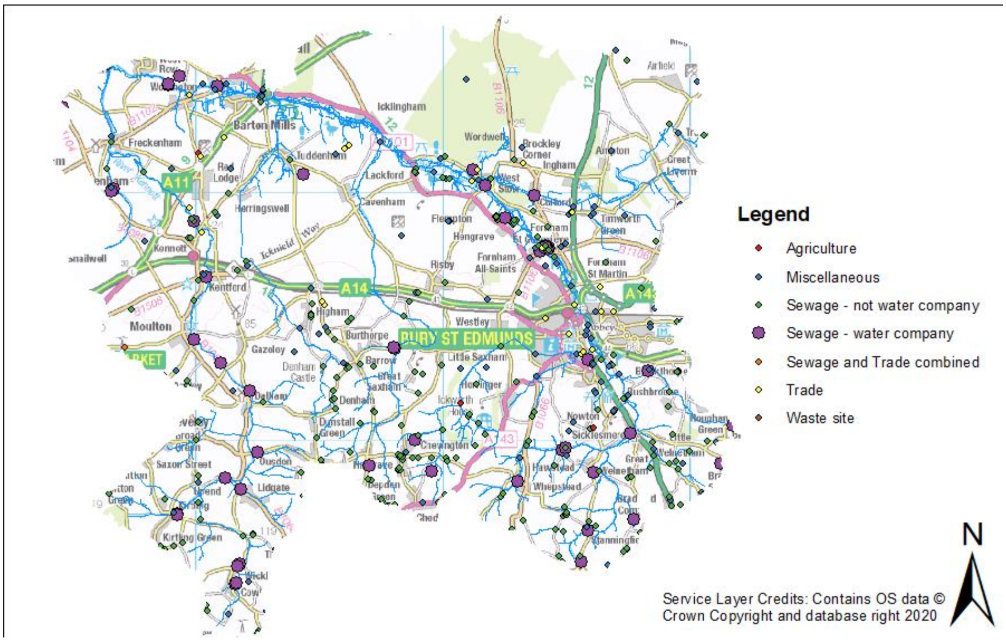


Figure 21: Map of waste water discharge permits. Source: Environment Agency dataset

A direct consequence of increased domestic and industrial water use is increased disposal of waste water effluent, discharged back into the river from sewage treatment works or Water Recycling Centres (WRCs) and other industrial outfalls. This abstraction of clean chalk groundwater water and subsequent discharge of treated final effluent has fundamentally altered the natural balance of both flow and water chemistry within the Lark and its tributaries. Survey boats from Thames21 and the EA in March 2019 showed that more than 70% of the flow in Lark at Fornham could be attributed to the WRC outfall.

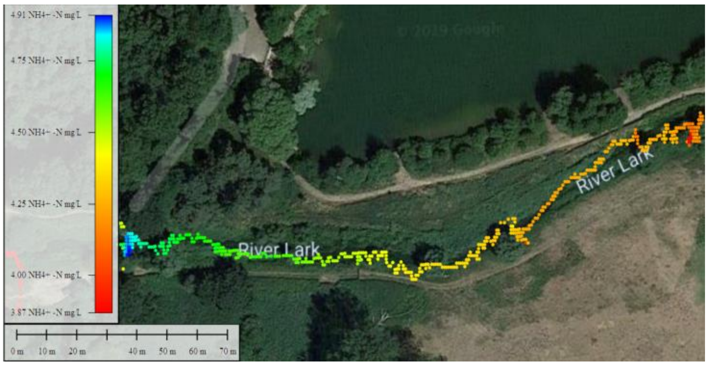


Figure 22 Outfall of Fornham WRC to the river Lark

Figure 23: Arc Boat in river monitoring showing real time ammonia monitoring at west stow March 2019.

Increased chemical complexity of waste water

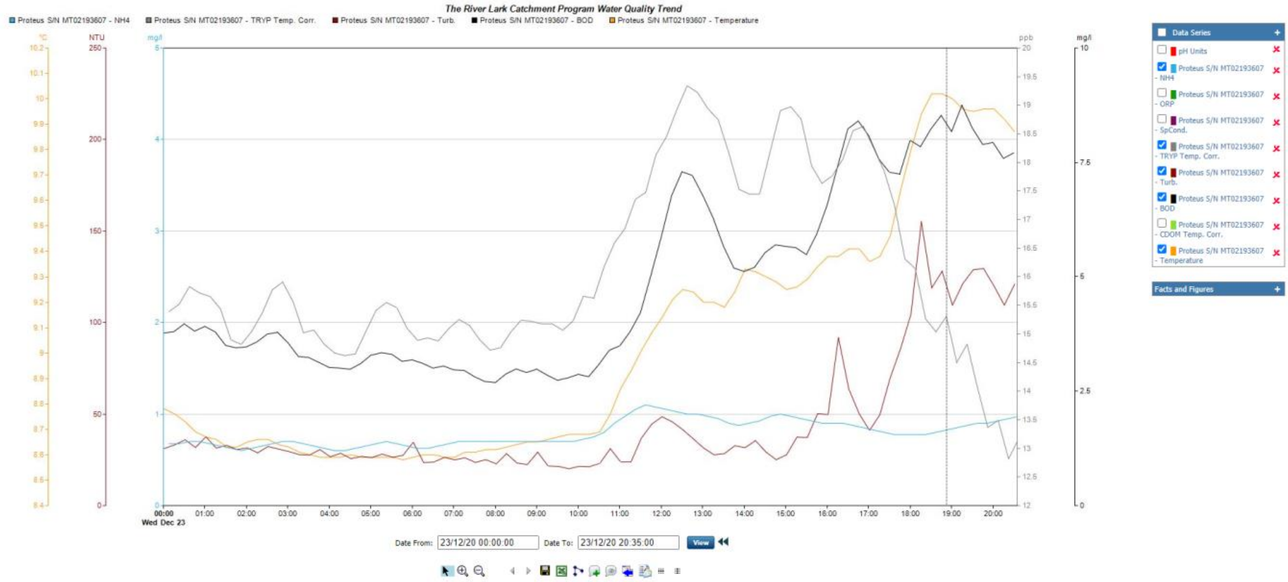
Despite some advances the technology of waste water treatment has changed little since the Fornham WRC was constructed in 1962 (Addy, 2016), relying on settlement and biological breakdown as primary treatment. Treated final effluent discharged contains levels of Nitrogen, Phosphate and bacteria many magnitudes higher than that found in groundwater and mediation of environmental impact is reliant on dilution from normal river flow. Pollutants such as hydrocarbons, pesticides, medicines, flame retardants, micro-plastics and other widely used chemical compounds are also not removed by the waste water treatment process and enter the aquatic environment with little or no control.

2.3.2 Storm sewage overflows

To avoid sewers backing up into properties during exceptional rainfall events WRC's and many sewage pumping stations have emergency storm overflows. These are consented by the EA to discharge dilute sewage, which has usually gone through some settlement and a 5mm screen, but can still contain high levels of solids, nutrients and biochemical oxygen demand (BOD). Sometimes mechanical failures, blockages from unflushables (wipes and sanitary products) can cause these overflows to occur without the dilution they would in high flow conditions, increasing their environmental impact.

Figure 24: Whepstead pumping station storm overflow occurring in December 2019

Monitoring equipment on the storm overflow at Fornham WRC showed that in 2020 the site discharged storm sewage on 16 occasion for a total of 199 hours. Analysis of an occasion when the storm overflow discharge was sampled, during a high rainfall event, had a BOD of 10.5mg/l on the 10th September 2020. Prior to this data being released by the Environment Agency Bury Water Meadows Group were monitoring water quality downstream of Fornham WRC with a portable Proteus sonde due a faulty sensor not providing accurate data in 2019. BWMG monitoring indicated 3 pollution/ storm overflow events based on calculated BOD levels immediately downstream of Fornham WRC in 3 month period from December 2020 - .



Date From: 23/12/20 00:00:00 Date To: 23/12/20 20:35:00

☐ pH Units
☑ Proteus S/N MT02193607 - NH4
☐ Proteus S/N MT02193607 - ORP
☐ Proteus S/N MT02193607 - SpCond.
☑ Proteus S/N MT02193607 - TRYP Temp. Corr.
☑ Proteus S/N MT02193607 - Turb.
☑ Proteus S/N MT02193607 - BOD
☐ Proteus S/N MT02193607 - CDOM Temp. Corr.
☑ Proteus S/N MT02193607 - Temperature

Figure 25: 23/12/2020 Lark at Hengrave - Proteus measurements of Ammonium, Tryptophan, Turbidity, BOD and Temperature

2.3.3 Point source urban pollution

Figure 26:Figure 25: Surface water drains and outfalls (taken in Bury St. Edmunds) Left: AWS Eastgate Bridge outfall, Top Right: Ram meadow outfall. Bottom right: Etna road (Travelodge) outfall.

Road run-off, misconnected or blocked drains, food waste and improper disposal of polluting substances to the surface water sewer system can all result in pollution to watercourses. There are multiple surface water sewer outfalls directly to the Lark and Linnet within Bury St. Edmunds that can introduce contaminated or misconnected drainage to the river. Three main surface water outfalls serving the centre of Bury St. Edmunds, one immediately downstream of Eastgate street bridge(semi-submerged) serving the town centre west of the Lark, one at the corner of Ram Meadow carpark serving east of the river and one at Etna Road discharging water from Tayfen road / North of the town centre. The historic nature of Bury St Edmunds surface water system and proximity to major roads contributes to the transfer of pollutants to the river.

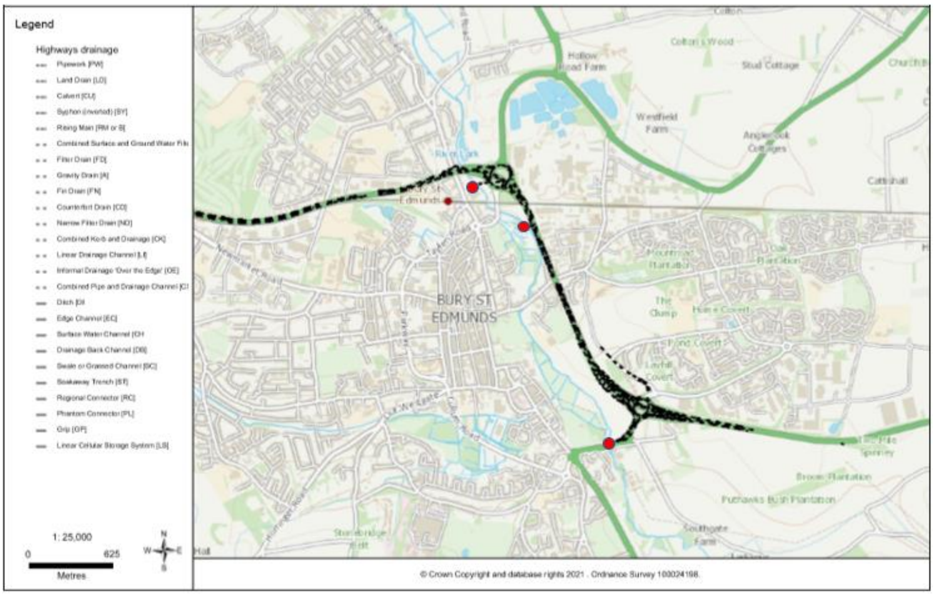


Figure 27: Highways England drainage network and outfalls to the river Lark marked in red.

The A14 cuts through Bury St Edmunds and runs parallel to the Lark for 2.3km with at three outfalls direct to the Lark at; Rougham road (A134) road bridge and opposite Ram Meadow and St Saviours Tesco (Figure 26). Outfalls have basic settlement ponds, but no designed filtration/treatment, with regard to reducing pollutants such as free phase hydrocarbons, polyaromatic hydrocarbons (PAHs) [combustion by-products], tyre particulates and metals. 37,155 people commute (inward and outward) every day in the St Edmundsbury area with 64.5% of journeys to work undertaken by car (Suffolk County Council, 2018) representing a significant pollution load to surface waterbodies. Aluminium, cadmium, chromium and lead all appear in higher concentrations at sample points above Fornham All Saints and at higher levels than the WRC effluent, indicating their source from the urban Bury St Edmunds area.

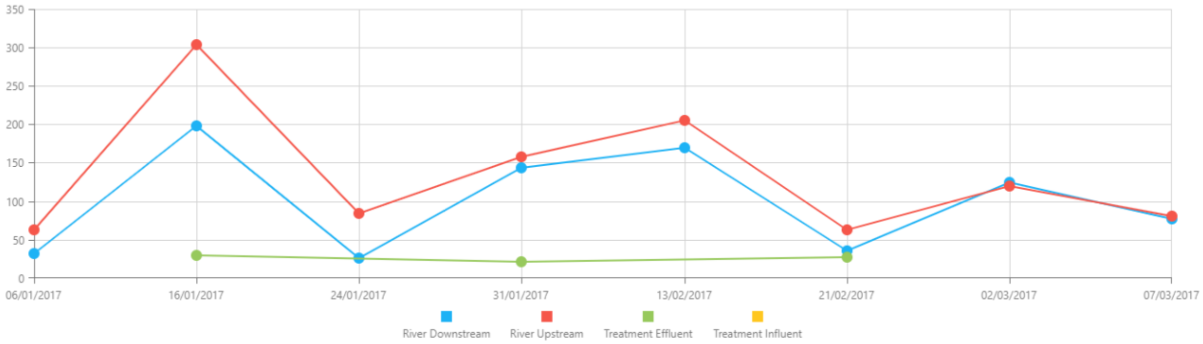


Figure 28: Aluminium (total) micrograms/Litre upstream of Fornham WRC (red), at Fornham WRC effluent (green) and downstream of Fornham WRC (blue). Source: UK Water Industry Research, chemical investigations programme portal.

2.3.4 Projects to address point source pollution

Active projects

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
RLCP pollution sub group	RLCP members undertaking citizen science to identify sources of pollution.	Water quality	Lark at Bury St Edmunds	Indefinite	RLCP	NRT, NE
Riverfly invertebrate monitoring	Invertebrate monitoring using trained volunteers.	Inverts Water quality	Lark	Indefinite	Ian Hawkins	Riverfly Partnership, CamEO

Future projects

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
Investigate A14 outlets with Highways England	Highways England have funds to tackle pollution from trunk road network	Water quality	Lark, Cavenham Stream & Kennet	2021	RLCP	HE, NRT
AWS live reporting of storm overflows	AWS to publish live data / warnings to river users when storm overflow are occurring.	Water quality	Fornham Lark		AWS	RLCP
Pesticide monitoring	As a watercourse without a surface drinking water abstraction little monitoring on pesticide products is currently undertaken.	Invertebrates	Lark			

2.4 Diffuse Pollution

2.4.1 Agricultural Diffuse Pollution

Photo 11: Arable field sloping down to Lark with no buffer, underdrainage and eroding bank.

Increased mechanisation and post war intensification of agriculture resulted in a near total loss livestock from the Lark catchment. As more land went under the plough for arable and cash crops (root vegetables), grass pasture was lost, hedgerows removed and land drained. This increased soil exposure and reduced interception and infiltration has in increased surface run-off and soil loss. Increased cultivation, short rotations and ever larger machinery have continued to degrade agricultural soils. As a result, there has been a growing movement of 'regenerative agriculture' focusing on soil health with practicing reduced tillage, cover crops and reintegration of livestock.

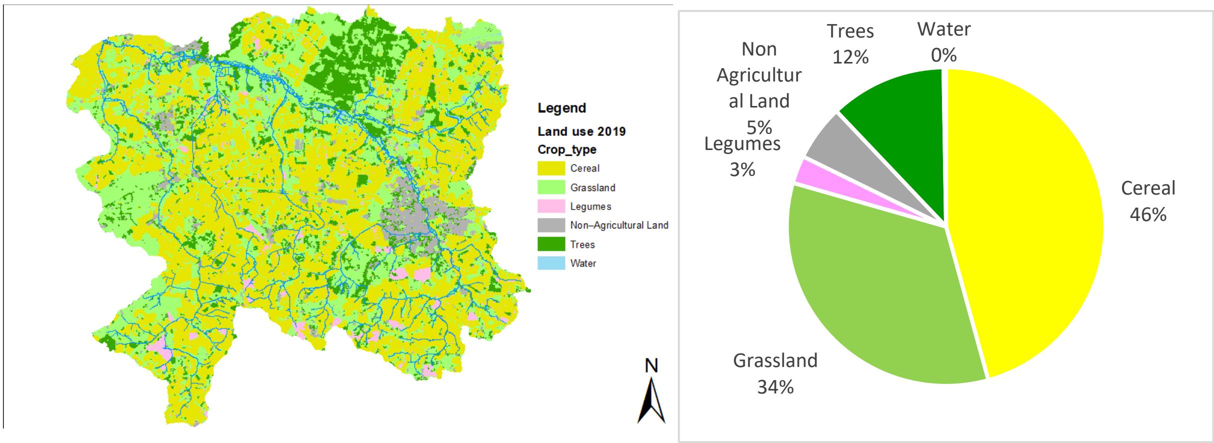


Figure 29: Land use in the Lark catchment 2019. Source: DEFRA data portal

The introduction of synthetic nitrogen fertiliser and extensive irrigation have allowed for continuous cropping of the nutrient deficient Brecks soils that previously required breaks[brecks] of several years, and were of "little agricultural value". Greater precision and cost of fertiliser has reduced recent nutrient losses, however legacy effects of excess application of nitrogen on groundwater and high phosphate indexes in some fields present a risk to water quality. Changing crop types and harvest techniques have also increased diffuse agricultural pollution.

2.4.1 Late harvested and root crops

Late and winter harvested crops such as sugar beet, potatoes, carrots, parsnips and maize present an increased risk of soil compaction and run-off from. Harvesters have to run on wetter ground squashing soil, create ruts and soil is left bare over winter as it is too late to establish a crop until the following spring. Root crops in particular are grown in beds or ridges which require the soil to be destoned and finely cultivated, removing structure, and creating channels for water to run between beds.

2.4.2 Energy crops

Maize is a recent addition to the landscape and is primarily grown to be a feedstock for Anaerobic Digestion (AD) plants which produce methane rich “biogas” is used to produce energy. Since the introduction of the Renewable Heat incentive in 2009 four AD plants have been constructed in the Lark catchment and the area of Maize grown in England has increased 262% since 2014. Maize’s wide row spacing, shallow rooting and autumn harvest date leave fields vulnerable to run-off. The by-product from AD is digestate, which is spread back to fields as a liquid and solid portion, and must be applied with care to avoid pollution.

2.4.3 Pig and poultry

Outdoor pigs are common a sight on light land in the catchment as the breeding units require free draining soils for welfare and all year machinery access. Breeding units are usually on the same fields for 2 years with pigs rooting nature quickly removing any grass cover, allowing rain, trotters and machinery to cap and compact the soil increasing soil run-off. Pig manure and slurry can also pose problems to drinking water source with high nutrient and bacterial counts. Most pigs are fattened (finished) indoors with liquid slurry or straw manure spread back to land. Slurry tanks and lagoons need to be empty before the autumn/winter closed period, which can result in heavy applications in September which can leach nitrogen to ground and surface waters.

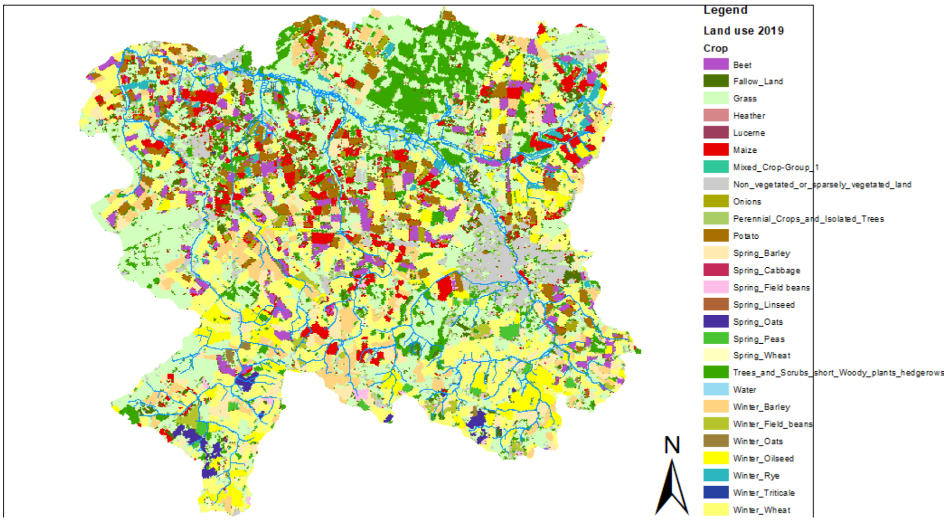


Figure 30: Crop types in Lark catchment in 2019

2.4.4 Pesticides

Pesticides and herbicides have been known to escape into the aquatic environment for some time, however testing has been limited in rivers without a surface water abstraction for drinking water (requiring water company monitoring). Research by Buglife in 2017 highlighted the presence of neonicotinoid insecticides at chronic and acute levels, i.e. likely to be impacting invertebrate communities, in East Anglian Rivers (Buglife, 2017). The Lark was not included in the Buglife study, the highest levels were found in catchments with a high proportion of intensive arable agriculture. The ban of noenicitinoid use in outdoor agriculture in 2018 has led to an increase in use of pyrethroid insecticides such as Cypermethrin, especially in oil seed rape crops. Wastewater chemical investigations programme sampling data (Figure 31) shows spikes in cypermethrin levels in the river Lark upstream of Fornham WRC in November 2015 & 16, at the time when the product is most commonly applied to crops. Cypermethrin is short lived in the environment so this demonstrates a rapid pathway for agrichemicals to the Lark, most likely through spray drift, uncontained filling/washout areas and soil run-off. The data shows an increased level of cypermethrin in waste water effluent in winter 2017, indicating a domestic / industrial source, as it is also the active ingredient in garden bug sprays and some wood treatments.

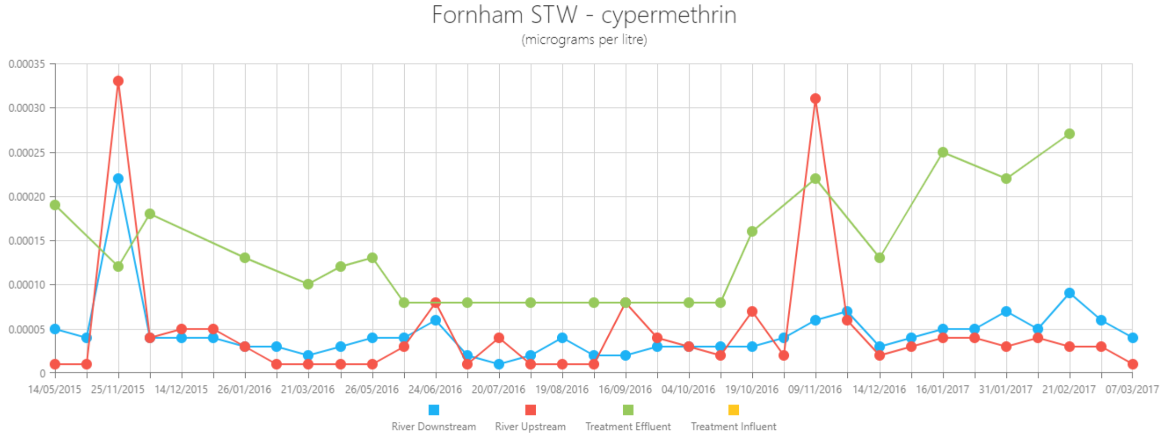


Figure 31: Spikes in Cypermethrin concentration upstream of Fornham WRC in November 2015/16 coincides with peak agricultural use. Source: UK Water Industry Research, chemical investigations programme portal.

2.4.5 Field risk mapping

Land is assessed by Natural England for its risk to the water environment to determine prioritisation of Catchment Sensitive Farming (CSF) visits and types of capital grants available to landowners. Further risk mapping models can be used to prevent soil, nutrients and pesticides entering watercourses via mapping for connectivity, bare winter soil maps, slope angle, erosion risk and surface flow pathways.

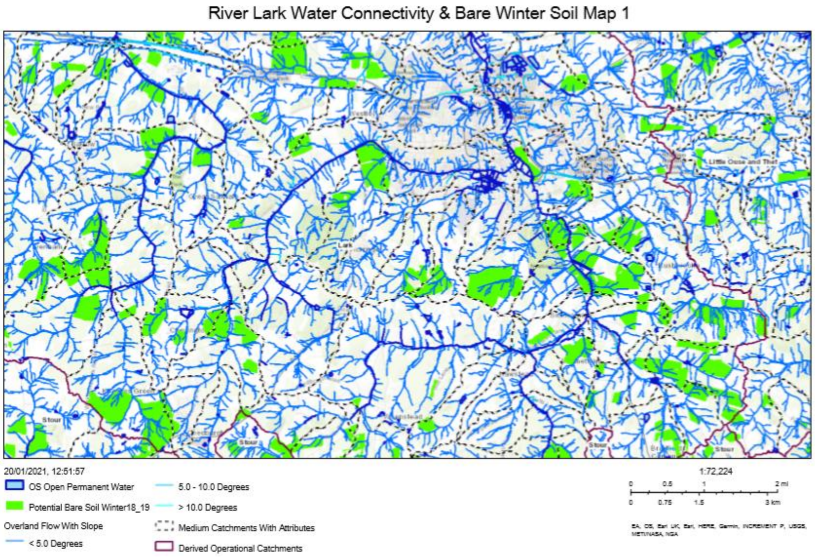


Figure 32: Natural England Water connectivity and bare winter soil mapping

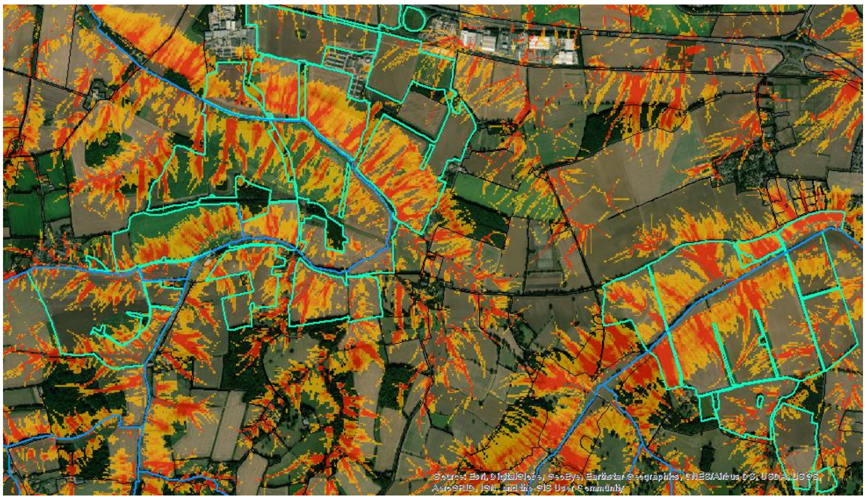

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 33: Scimap surface erosion risk areas

2.4.6 Agri-Environment Stewardship Schemes

59.6% of agricultural land within the Lark catchment is in some form of environmental stewardship agreement where landowners or land managers claim payments for managing parcels of land for environmental benefit. This is on top of the Common Agricultural Policy derived Basic Payment Scheme (BPS) which can be claimed for complying with minimum environmental standards.

Land in environmental schemes may still be a source of diffuse agricultural pollution but is more likely to have measures such as buffer strips or overwintered stubbles which can mitigate spray drift and run-off. The design of an environmental land management schemes, and the placement of options within the scheme specifically, is key in order maximise the benefit to the water environment.

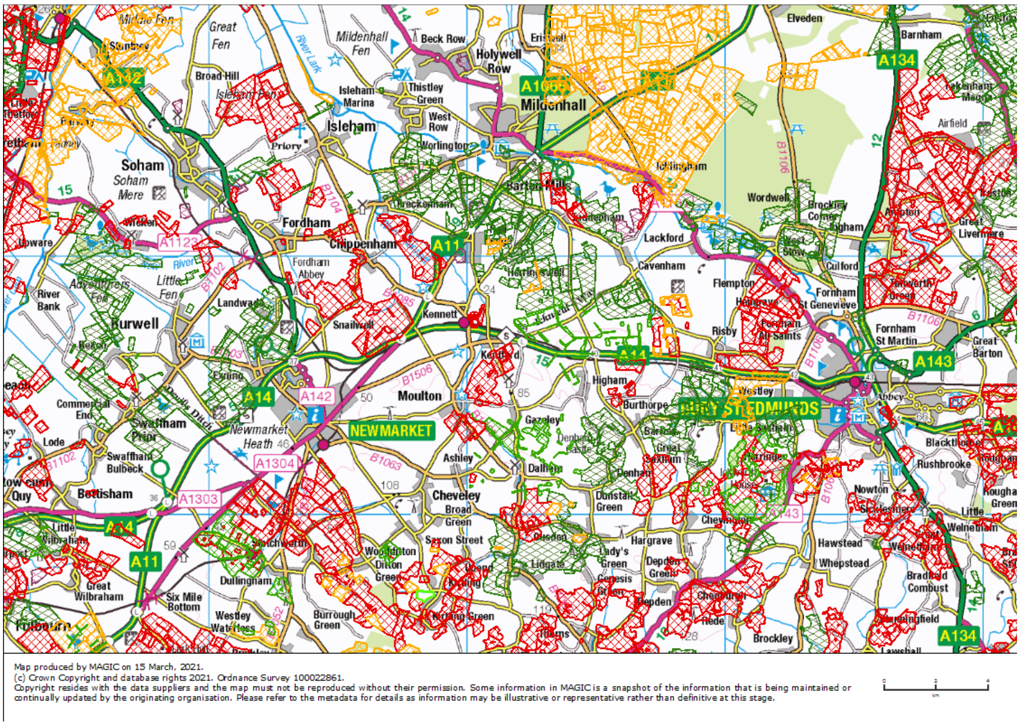


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*Figure 34: Live Entry Level Scheme & High Level Scheme = 8,026.15ha** Live Countryside Stewardship Agreements = 18,252.31ha.*This figure does not account for any extended agreements – just those ending in 2021 onwards.

2.4.7 New Environmental Land Management Scheme (ELMS)

Following the UK's departure from the European Union, BPS payments are being phased out from 2021- 2027 and current Countryside stewardship agreements will be replaced with new ELMS. ELMS is based on the principle of using "public money for public good" with 3 new schemes; Sustainable farming, Local nature recovery and Landscape recovery aimed at delivering:

- clean air and plentiful water
- thriving plants and wildlife
- protection from environmental hazards
- reduction of and adaptation to climate change
- beauty, heritage and engagement with the environment

ELMS will begin piloting around 10 projects in 2022, and launch in 2024.

2.4.8 Projects to address diffuse pollution

Active projects

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
Lark & Little Ouse diffuse pollution	Walkovers identified 79 intervention opportunities to reduce diffuse pollution from upper Lark catchment. Extensive improvements made to land in Culford stream in 2020/21.	Water quality (sediment & phosphate)	Lark catchment	2019-2022	NRT	EA
Catchment Sensitive Farming	CSF gives free training and advice to farmers and land managers in high priority areas. It provides practical and cost-effective solutions that improve water and air quality.	Water quality Air quality	High priority areas within Lark catchment	-2024	NE	EA
Norfolk Rivers Trust Water Sensitive Farming	Free farm advice, visits and intervention grants in the CamEO catchment	Water quality	Lark catchment	2015-2021 (June)	NRT	
Interreg Topsoil	EA –AWS– Farmer working in partnership to get a profitable business and sustainable groundwater supply for drinking water	Groundwater quality	CamEO catchment	-2022	NRT & AWS	EA
BFER Riparian Landowner Advice	Free advice, events and capital grants to improve water quality, efficiency and habitat along Breckland rivers.	Water quality, flow, ecology	Lark, Little Ouse, Thet, Wissey	2021-2024	NRT	BFER, RLCP

Future projects required

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
ELMS	Sustainable farming, Local nature recovery and Landscape recovery	Water quality, River & riparian habitats	Catchment	2024 -		Farmers, NFU, CSF, NRT
Nitrogen / Phosphate Trading	Water companies finance use of cover crops and slow-release fertilisers to protect groundwater sources. Could be adapted for phosphate as part of catchment nutrient.	Water quality, phosphate	Lark			AWS, Farmers
Buffering of watercourses	Buffer watercourses depending on size increasing from 6m minimum to 50m depending on size of waterbody. Would require funding through ELMS or significant legislative change.	Water quality, Habitat	All			

2.5 Invasive Species

2.5.1 Signal Crayfish

Signal crayfish were introduced from North America in the 1970s and their subsequent escape has pushed the native white clawed crayfish near to extinction through competition and introduction of disease fatal to native populations. Signals are thought to have entered the Lark in the early 1990's and by the year 2000 were thought to have replaced white clawed crayfish in the through competition, direct predation and disease. Signal crayfish have a significant impact on other species, predating fish eggs, benthic invertebrates and small fry. Their increase in numbers correlates to a significant decline in eel numbers in the lower reaches of the lark. Signal crayfish burrows also increase bank erosion and bank retreat by up to 253% and can input 25 tonnes of sediment per kilometre (Sanders, 2021).

Extensive trapping at Mildenhall from 2001 -2017 reduced signal crayfish numbers in the Lark at Barton Mills but showed total eradication was not possible (West, 2017). Otter spraints consistently show that a high proportion of their diet consist of signal crayfish and it is hoped that their return will limit the growth of the crayfish population.

Figure 35: (Left) Extensive signal crayfish burrows on the Lark near Mildenhall Road BSE. (Right) Signal crayfish

2.5.2 Demon and Killer freshwater shrimp

Demon shrimp (*Dikerogammarus haemobaphes*) has been recorded on the Lark but is not thought to be endemic, although populations are known present in the region. Other invasive shrimp species that have made their way to the UK in recent years include Killer shrimp (*Dikerogammarus villosus*), present in Graham water and the Broads, and *Gammarus fossarum.*

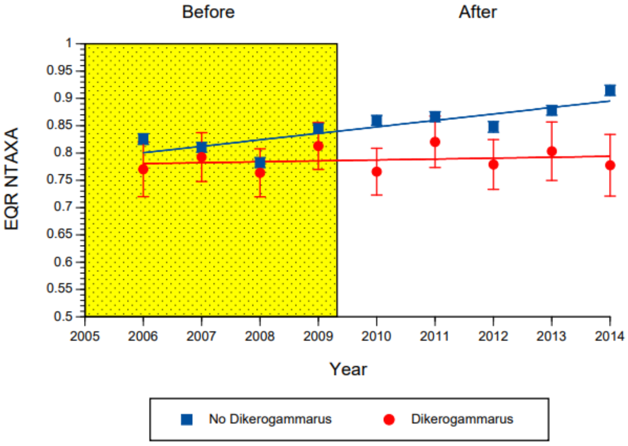


Figure 36: Graph showing impact of Demon shrimp on freshwater macroinvertebrate populations

2.5.3 Himalayan Balsam

Himalayan balsam, a non-native invasive species was widespread along the banks of Lark and Linnet, dying back annually to leave exposed banks in the winter that are vulnerable to erosion. RLCP have undertaken extensive surveying for Himalayan balsam in 2020 with locations recorded for removal in 2021.

2.5.4 Floating pennywort (*Hydrocotyle ranunculoides*)

Invasive non-native plant that forms dense mats on the water surface shading out submerged plants, deoxygenating water, smothering habitat and increasing flood risk. Has been present on the River Cam since 2012 and has spread down the Great Ouse, as small fragments can float downstream to colonise downstream areas.

Figure 37: (Left) Himalayan balsam dominating planted areas next to the Travelodge, Compiegne way in BSE. (Right) Floating pennywort Photo credit Environment Agency.

2.5.5 Projects to address invasive species

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
Himalayan Balsam	Recording and removing Himalayan balsam.	Invasives Sediment	Lark (U/S Fornham & Linnet	2017-2022	BWMG	RLCP, EA

Future projects required

Project	Description	Target Element	Waterbodies / Location	Timescale	Lead	Stakeholder(s)
Study of impact of otter predation on Signal Crayfish	Knowledge gap for further research	Invasives Inverts Sediment	Lark		RLCP	
Study impact of river restoration on signal crayfish	Knowledge gap for further research	Invasives Inverts Sediment	Lark		RLCP	

2. 6 Future Risks

2.6.1 Growth

In 2008 the government forecast that the population of St Edmundsbury would grow from an estimated 103,500 in 2009 to 121,700 in 2031. This represented a 17% growth in population over the 22 year period. 11,480 homes required from 2012 numbers to 2031 (BSE Vision 2031 local plan).

Urban growth, increase footprint impermeable footprint of Bury St. Edmunds, leads to reduced infiltration (SUDs not withstanding) and increased surface water run-off. Potential for more urban pollutants and water use.

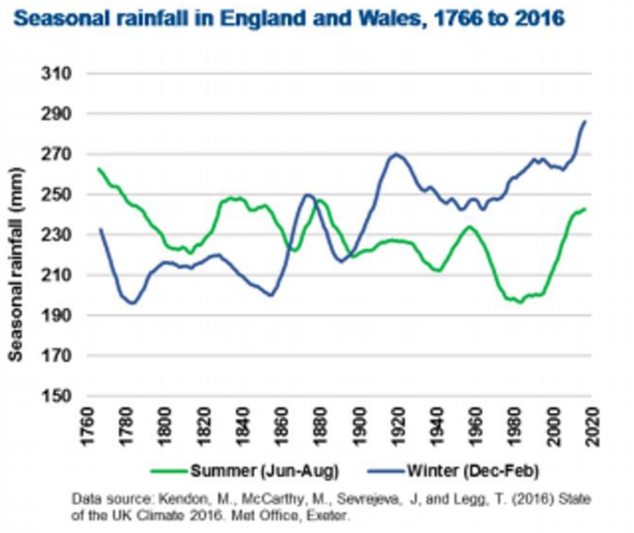
2.6.2. Climate Change

Work carried out as part of the UK Climate Impacts Programme (UKCIP)9 predicts that the earth's climate will undergo a number of changes into the future. Using this research as a basis, the Suffolk Climate Action Plan10 was created. In general, by the 2080s, the East of England is likely to experience:

- An average temperature rise of 3.6°C
- 20% increase in winter rainfall leading to increased flooding
- Sea level rise

The strategy highlights that:

- Increased flood events will lead to increased damage to property and disruption to economic activity;
- Higher incidence of damage to transportation, utilities and communications caused by an increase in extreme weather events;



Seasonal rainfall in England and Wales, 1766 to 2016

Data source: Kendon, M., McCarthy, M., Sevrejeva, J, and Legg, T. (2016) State of the UK Climate 2016. Met Office, Exeter.

3. Evidence gaps

- Flow monitoring above Bury St. Edmunds and on winterbourne tributaries
- Pesticide monitoring – Noenicitinoid seed treatments to return to sugar beet in 2021
- Fish surveys post 2018-19 drought period. 2020 survey not conducted due to covid.
- Impact on AWS abstraction above BSE at Nowton and Rushbrook on river ephemeral flow

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