River Wye Management Catchment Integrated Data Analysis Report

Data Cut-Off: 31st March 2022

Report Date: May 2022

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

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About this Report

The River Wye SAC (Special Area of Conservation) is failing to meet phosphate targets in some reaches and is very close to the threshold in others. There have been reports of algal blooms in the river and recognition of ecological decline over a number of years.

The scale of data being captured in the Wye Management Catchment is increasing exponentially as more continuous monitoring sondes, autosamplers, remote sensing, and citizen scientists are deployed.

All this data contributes to the overall picture of what is happening in the catchment. We will combine new evidence with existing datasets four times a year to contribute to a common understanding among all stakeholders of the issues and actions required.

The report covers:

1. What are the main variables contributing to algal blooms in the Wye?
2. What other ecological and water quality issues does the data show?
    a. When did these occur?
    b. Where did these occur?
3. Which locations, sectors and activities were responsible for the ecological and water quality issues identified in the data?
4. What recommendations can be made for regulatory, partnership and industry sector actions to prevent the reoccurrence of ecological and water quality issues identified in the data?

If the available data does not allow us to answer a question, we describe what data is needed to be able to answer it.

If you have any feedback on this report or additional information to contribute to future reports, please contact Enquiries_WestMids@environment-agency.gov.uk

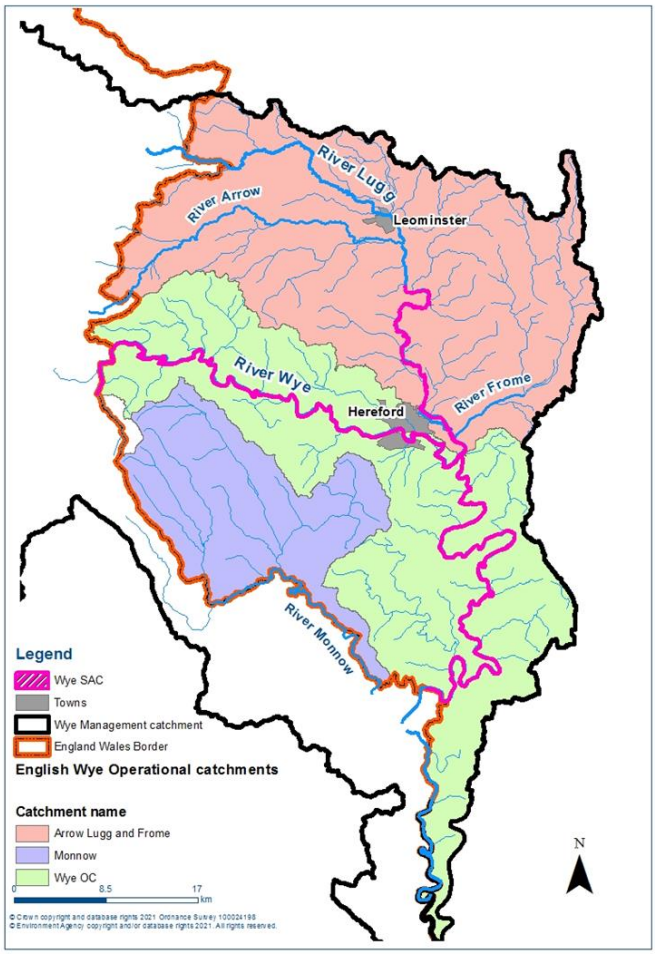

Figure 1: River Wye Management Catchment within England and associated Operational Catchments and major tributaries.

Summary of Conclusions

This includes and builds on conclusions drawn from previous reports.

We can currently conclude, based on the latest available data, that:

1. What are the main variables contributing to algal blooms in the Wye?

Significant algal growth occurs on the main River Wye during the summer. A large amount is filamentous algae and diatoms covering the riverbed. The relative proportion of riverbed to free floating algal growth is currently unknown.

Excessively high summer water temperatures on the main River Wye are a major contributing factor to this algal growth.

Water column phosphate concentrations appear to increase temporarily prior to this algal growth, following summer rainfall events, while river flows are relatively low. These temporary increases are likely to contribute to the algal growth. More frequent and

widespread orthophosphate, total phosphorus, and sediment nutrient data is required in partnership, to continue to build an understanding of contributing factors to these algal blooms.

Water column nitrogen concentrations are excessive throughout the catchment, but nitrogen is not the most important nutrient causing algal blooms. If phosphate availability to aquatic plants were low enough, it would limit algal growth.

2. What other ecological and water quality issues does the data show?

Salmonid fish populations have declined over the last 10 years, and there has been a shift to the headwaters of the Lugg for the main Atlantic Salmon population in the English sections of the Wye.

Invertebrate populations currently appear to be generally healthy, although some smaller tributaries are affected by sedimentation and water quality issues.

Macrophyte communities sampled in 2021 show evidence of eutrophication across the whole catchment.

Nutrients within the water column are a bigger problem in tributaries than the main Wye. Sediment analysis is needed to build a more complete understanding. Since 2010, there has been an increasing trend in orthophosphate on tributaries of the Wye and an increasing trend in nitrogen across most of the catchment.

There have been short-term water quality improvements in some parts of the catchment. However, these are minor compared to the long-term decline and fall short of the SAC and SSSI targets in the Lugg Catchment.

Rainfall events correlate with increases in phosphate and turbidity across the whole Wye Management Catchment, confirming that diffuse pollution is a component of water quality issues in the catchment.

3. Which locations, sectors and activities were responsible for the ecological and water quality issues identified in the data?

Analysis of Citizen Science data collected since the start of 2021, and new incidents reported since October 2021, supports and enhances the analysis of Environment Agency data.

Arable agriculture, particularly maize and autumn sown crops like winter wheat on permeable soils or those prone to surface-run-off contribute significantly to orthophosphate concentrations.

There has been a significant increase in the proportion of land managed as arable since 2016, particularly maize and potato crops, which are more susceptible to soil loss.

Sewage treatment works (STW) discharge rates are significant contributing factors to orthophosphate concentrations. STW phosphorus limits are effective in reducing the contribution to orthophosphate concentrations, however, combined sewer overflows (CSOs) and agricultural run-off are suspected to contribute towards target exceedance where phosphorus limits are in place.

The number of poultry units in a catchment shows a positive but very weak correlation (R^2=0.04) with orthophosphate levels and appears to show a stronger link with nitrogen levels and total phosphorus. Total phosphorus data is currently too sparse to demonstrate a causal relationship and this analysis does not account for pathways of impact outside the unit such as spreading of manure or digestate on fields outside the catchment where the poultry units themselves are located. Further investigation is needed to demonstrate that this is a cause and confirm the pathways.

Sewage discharge and agriculture account for the largest share of environmental incidents reported to the Environment Agency in the Wye Management Catchment between 01/11/2020 and 31/03/2022.

4. What recommendations can be made for regulatory, partnership and industry sector actions to prevent the reoccurrence of ecological and water quality issues identified in the data?

Taking a catchment-based approach all contributing partners in the Wye Management Catchment could target investigations, analysis and remedial actions in key five focus areas:

- River Arrow near Kington
- River Arrow near Pembridge and Curl Brook
- River Lugg and tributaries near Presteigne
- Little Lugg and Withington Marsh Brook
- River Frome

These five areas have been identified as upstream parts of the catchment with high phosphate concentrations relative to the wider catchment, taking the size of watercourse into account. They also experience a high proportion of the pressures identified in this report.

Significant reduction in nutrient input from all sources is required across the whole catchment to contribute to the recovery of river quality including macrophytes. Reducing run-off and leaching of nutrients from land during summer rainfall events when dilution is low, and temperatures are high is an important element of this remedial activity.

Further investigations in partnership should include understanding the pathways and impacts of manures and wastes that are spread to land and a comprehensive appraisal of options to mitigate the impacts of poor water quality, including whether we could manage water resources differently to create more dilution.

Where Citizen Scientists can support the efforts of land managers and discharge operators to reduce the impact of their operations by targeted monitoring and evaluation in response to identified high nutrient events, we would encourage them to do so and have suggested areas to undertake further monitoring.

Efforts to increase shade by tree planting and better management of riparian trees could help mitigate high temperatures. We are developing a high temperature and algal bloom early warning system to enable us to respond to excessive temperatures with advice and extra monitoring.

Data Sources

Citizen Science Monitoring

We are working with a variety of partners in the development and delivery of a Citizen Science monitoring programme. This additional resource is used to collect water quality data throughout the Wye Management Catchment and will help to identify and prioritise where measures can be targeted to reduce inputs of pollution.

We politely request Citizen Scientists to follow our data collection and reporting guidance to ensure the data can be used effectively.

We are extremely grateful for the commitment of Citizen Scientists in the catchment, who have contributed to a higher resolution of data, which bolsters shared efforts to understand the issues affecting the Wye Management Catchment. This data is also contributing to ongoing calibration of improved water quality models for the catchment.

Details of the Citizen Science Groups are available here: Citizen Science Groups | The Wye Catchment Partnership

We have used data from the following groups in this report and thank them for their efforts.

- Campaign for the Protection of Rural England, Herefordshire
- Friends of the Lugg
- Friends of the Upper Wye
- Wye Salmon Association

Open data and details of methodologies can be found here Wye Catchment Collaborative Monitoring Network | The Wye Catchment Partnership

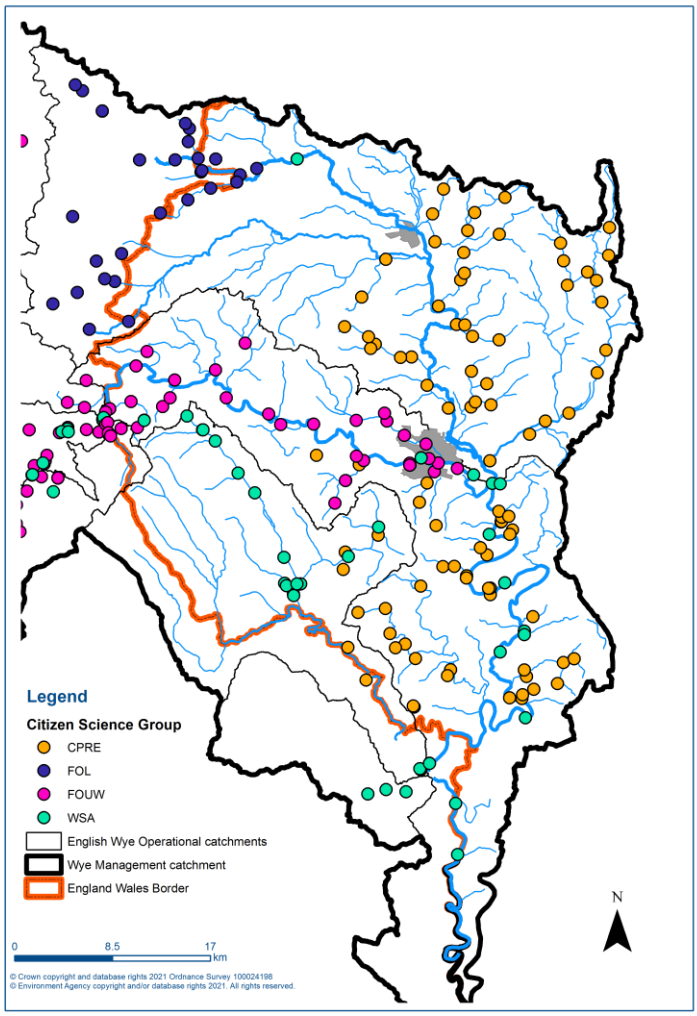

Figure 2: Citizen Science sampling points within the Wye Management Catchment in England.

Continuous Data Loggers (sondes)

Sondes are remote water quality measuring units, which are comprised of a probe placed in a waterbody and a unit that collects and transmits data in real time. Data is cleaned prior to analysis by omitting erroneous measurements caused by probe fouling or sensor malfunctions.

One sonde was deployed between October 2021 and April 2022 on the River Lugg at Mortimer's Cross. The sondes present on the Wye in 2021 were removed over the winter to prevent flood conditions from damaging them (Figure 3). They have been returned in spring 2022 and will be supplemented with additional units during the summer and autumn. Several water quality parameters were recorded at 30-minute intervals at each site. Dissolved Oxygen, Temperature and Turbidity and Ammonium have been examined in detail.

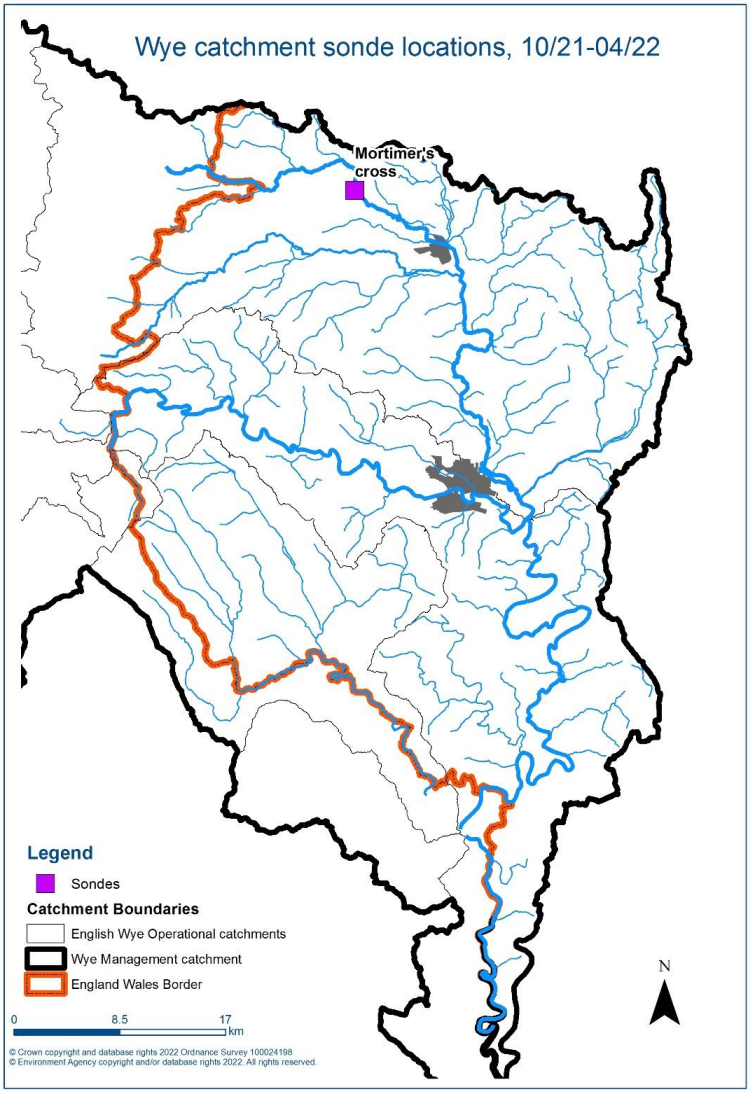

Figure 3: Locations of sondes deployed over winter 2021 that were used in this analysis.

Algal samples

No new algal samples were collected since the last report as there is limited algal growth over winter.

A comprehensive algal sampling programme has been developed for spring and summer 2022, which will inform future reports.

Routine Water Quality Sampling

The Environment Agency's water quality data is available as open data on the Water Quality Data Archive.

The water quality parameters analysed for this the report were orthophosphate (also known as soluble reactive phosphate), ammonia, dissolved oxygen and total oxidised nitrogen (TON).

Invertebrates

The Environment Agency's macroinvertebrate data is available as open data on gov.uk

EA Ecology & Fish Data Explorer

Crop Map of England

Since 2016 the Rural Payments Agency has been using satellite imagery collected by the European Space Agency's Sentinel network to annually classify agricultural land use in England. The project is known as CROME (Crop Map of England) and assigns crop types using a machine learning approach called Random Forest Classification. Large validation efforts were undertaken to ensure reasonable accurate classification of crop types, with approximately 18300 field visits conducted to validate the crop assignments generated by the classification system.

To generate crop cover area England has been divided into approximately 32 million equally sized hexagonal tiles, each 4156 square meters (0.42 hectares) in area. The English portion of the Wye Management Catchment contains approximately 452,000 tiles; each individually assigned a cover type.

Although CROME classifies arable land by individual crop, with the exceptions of maize and potato, crops have been aggregated into mixed arable for this report to account for crop rotation cycles and to simplify analysing changes in land use. The cover of permanent grassland, woody plants (trees, shrubs and hedgerows), non-agricultural/sparsely vegetated land, and open water were also classified. This had made it possible to compare changes in rural land cover between 2016 and 2020. There are some caveats around overall accuracy of the classification, with it predicted to be 84% accurate

in 2016 and 70% accurate in 2020. However, due to the large number of classification tiles, this still makes it possible to observe overall changes in land use with reasonable confidence.

UKCEH (UK Centre for Ecology & Hydrology) Land Cover Map 2019

The UKCEH Land Cover Maps show land cover across Great Britain using UKCEH Land Cover Classes. These are based on UK Biodiversity Action Plan broad habitats.

The 2018, 2019 and 2020 datasets used in this report (Morton, et al., 2020; Morton, et al., 2020; Morton, et al., 2021) were developed by the UK Centre for Ecology & Hydrology by classifying satellite images from 2018, 2019 and 2020 respectively. The 2020 data has a higher 10m resolution.

National Soil Map

The National Soil Map is produced by Cranfield University (National Soil Resources Institute, 2001) and was last updated in 2013. It details soil associations across England and Wales and includes typical characteristics of soil series in each association.

Environment Agency remote sensing analysis of poultry units

During 2021 the Environment Agency analysed current and historic LIDAR data alongside available permit data to identify possible poultry units and assess change. This analysis is exploratory and subject to change so is not currently available as open data.

Environment Agency permitted discharge outlets

These data provide details of all permit details as required under the Environmental Permit Regulation. Information is held for all permit holders and covers all substances that are controlled.

The dataset is available as open data on the Defra Data Services Platform.

Natural Resources Wales permitted discharge outlets

These data provide details of all permit details as required under the Environmental Permit Regulation. Information is held for all permit holders and covers all substances that are controlled.

The dataset is available as open data on the Lle Geo-Portal for Wales.

Welsh Water combined sewer overflows

Welsh Water/ Dwr Cymru monitor their combined sewer overflows and report spills as Event Duration Monitoring. These reports include the site, number of spill incidents per year, number of hours spilled and percentage outage in the monitoring.

Analysis Methods

We have used the following exploratory, statistical, and spatial methods in this analysis.

Time series analysis

Parameters associated with algal blooms and other water quality problems were combined on single time series plots, where each parameter was available; particularly, temperature, dissolved oxygen, turbidity, ammonium, chlorophyll, orthophosphate as P, total oxidised nitrogen as N and daily mean flow. The flow gauging station, monthly sampling point and sonde location were matched based on proximity and how representative the sites were.

Indicative Water Framework Directive (WFD) Classifications

Where sufficient data has been collected over the last 12 months for quality elements that are assessed under WFD, indicative WFD classifications have been produced using this recent data. These are not formal classifications but allow comparisons with the 2019 formal classification and previously reported indicative classifications. An update to the formal classifications is scheduled for 2022 and the next full classification is scheduled for 2025.

Spatial Mapping

Plotting each data source on a map of the River Wye Management Catchment allows a comparison of the results for each Operational Catchment or Waterbody. This helps locate the sources and pathways of ecological and water quality problems identified.

Watershed analysis

The potential sources of nutrients for each sampling point have been analysed. A watershed analysis was carried out to determine the area that drains to each sampling point, which was overlaid with the following datasets to obtain summary statistics:

- RPA Crop Map of England 2018-2020
- UKCEH Land Cover Map 2018-2020
- Environment Agency remote sensing analysis of poultry units in 2021
- Environment Agency permitted discharge outlets
- Natural Resources Wales permitted discharge outlets
- Welsh Water combined sewer overflows
- National Soil Map

These summary statistics were plotted against Environment Agency measurements of reactive orthophosphate as P, total phosphorus as P and total oxidised nitrogen as N and Citizen Science measurements of phosphate.

Invertebrate analysis

The macroinvertebrate indices we review include the WHPT Average Score Per Taxon (ASPT), Biological Monitoring Working Party (BMWP), Proportion of Sediment sensitive Invertebrates (PSI), Empirically weighted Proportion of Sediment sensitive Invertebrates (EPSI), and Number of Taxon (NTaxa). These indices are compared to predicted scores for each site to produce a WFD classification using the River Invertebrate Classification Tool (RICT).

Hydroecological Validation

Hydroecological validation (HEV) uses ecological and hydrological data to help us assess the ecological response of a site to river flow. It compares the ecological community we would expect to find at a site with physical and chemical characteristics under un-impacted conditions with the ecological community we observe in our collected sample data. By incorporating hydrological data, we can then look at whether there any observable patterns in measured flow and the condition of the ecological community. HEV is also used to infer the effect of other pressures, such as water quality, sediment, and morphology.

The results from HEV could provide us with evidence where water resources activities, such as abstraction, might be contributing to an ecological problem. In turn this helps us decide where we need further investigation and possible action to protect river ecology.

Data Used

Historical macroinvertebrate survey data (from 2000 to end of 2021) from survey sites within the Wye Management Catchment have been analysed. Not all sites have recent data (within the last three years) but do have useful historic data.

A screening process was undertaken as not all sites were suitable for HEV assessment. Data pre 2000 was excluded as AQC and audit systems were not in place for macroinvertebrate analysis until 2000 and data could be deemed to be more reliable. Only HEV assessments are included where we have sufficient ecology data to understand the link with flow. As a general guide, sites with less than 9 samples are not suitable for this purpose

Poor water quality can mask any impacts due to low flows. This would be seen on the HEV plots where the NTaxa (number of scoring taxa) and ASPT (Average Score Per Taxon) values would be below the Good/Moderate boundary line, suggesting that water quality issues were affecting the suitability of the site as an indicator of flow issues. Sites where this was the case are shown in Figure 12

Sedimentation (PSI) Index

The proportion of sediment sensitive invertebrates (PSI) is an invertebrate metric developed to act as a proxy to describe temporal and spatial impacts of sedimentation and is used in HEV analysis.

SPEAR Analysis

SPEAR (SPEcies At Risk) is a trait-based approach, linking a specific environmental stress and invertebrate community composition.

$SPEAR_{pesticide}$ estimates the contamination by pesticides in a watercourse and is based on invertebrate monitoring data. It is calculated as the relative abundance of vulnerable taxa at risk to being affected by pesticides.

In the analysis for this report, we used this metric to test whether sites may be affected by pesticides. However, this methodology has not yet been adopted in the UK and we await the results of further work, currently being undertaken, on this analysis tool to determine whether we can confidently apply it and present the results in this context.

Total Reactive Phosphorus Index (TRPI) Analysis

The Total Reactive Phosphorus Index is an index that has been produced to use macroinvertebrate data to assess the impact of elevated phosphorus levels in rivers. We have trialled the use of this on a small subset of river surveillance sites within the Wye Management Catchment. There was an issue with the method for defining the site types as the Wye appears to be a borderline case. The AI tool used in the original study is no longer available and for the index to be applied and tested nationally and objectively, we would need the tool. The multi-pressure Walley Hawkes Paisley Trigg index (WHPT) was developed and responds to oxygen, organic, fine sediment, flow and nutrients. This is now the standard index used in WFD classification.

Results

The results section of this report is divided into three sections to answer the questions posed at the start of this analysis.

1. What are the main variables contributing to algal blooms in the Wye?
2. What other ecological and water quality issues does the data show?
3. Which locations, sectors and activities were responsible for the ecological and water quality issues identified in the data?

1. What are the main variables contributing to algal blooms in the Wye?

The report covering data up to 31/10/2021 highlighted increases in chlorophyll and dissolved oxygen (DO) levels detected by sondes at Holme Lacy (Figure 4) and Ross on Wye (Figure 5) that indicated two periods of increased photosynthesis on the River Wye during the summer. These signalled periods of increased algal growth.

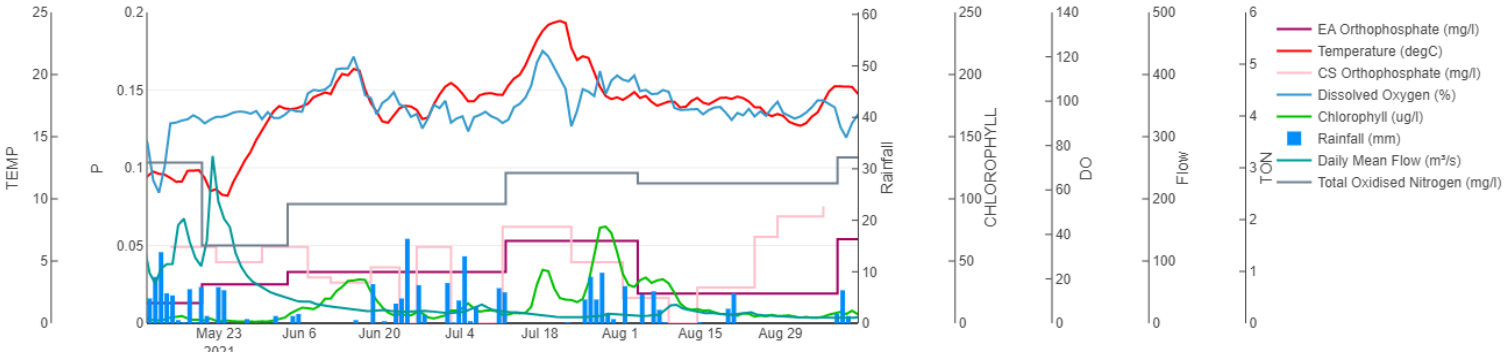

Figure 4: Holme Lacy daily mean sonde data, Ballingham Citizen Science orthophosphate data, Holme Lacy Bridge monthly orthophosphate and total oxidised nitrogen measurements, Redbrook daily mean flow data, and Broomy Hill daily total rainfall data. Between 11/05/2021 – 11/09/2021.

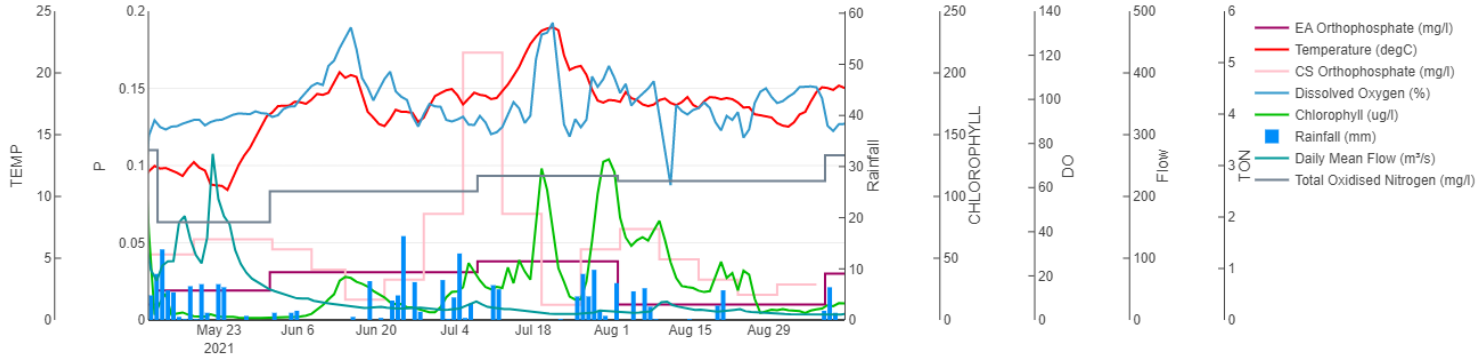

Figure 5: Ross on Wye daily mean sonde data and Citizen Science orthophosphate, Wilton Bridge monthly orthophosphate and total oxidised nitrogen measurements, Redbrook daily mean flow data, and Broomy Hill daily total rainfall data. Between 11/05/2021 – 11/09/2021.

The report covering data up to 31/10/2021 suggested that high summer water temperatures on the Rive Wye are one of the key drivers of prolific algal growth.

Both phosphorus and nitrogen play a role in river eutrophication, although the main limiting nutrient, and therefore most important factor, in freshwater river systems is usually phosphorus. This is still most likely the case for the River Wye, as all sampling points continue to fall within the zones where phosphate is typically the limiting nutrient (Mainstone & Parr, 2002) (Figure 6).

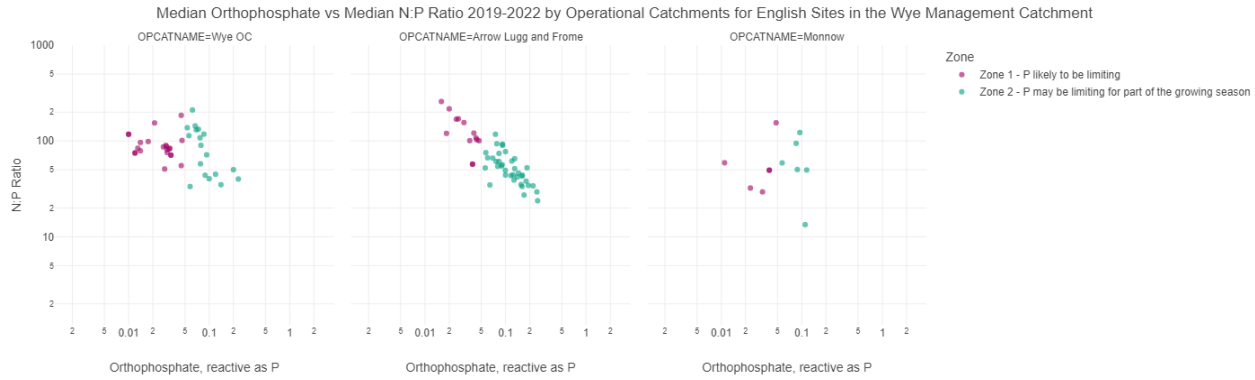

Figure 6: Median orthophosphate as P plotted against median N:P ratio (Total Inorganic Nitrogen as N:Orthophosphate as P) by Operational Catchment for Environment Agency sampling points in the Wye Management Catchment. Colours by zone of typical nutrient limitation (Mainstone & Parr, 2002). Note log scales.

Available monthly phosphate and nitrogen data for 2021 for Ross on Wye and Holme Lacy generally fall into the zone where phosphate would usually limit plant growth (orthophosphate <0.05mg/l and N:P ratio >8 (Mainstone & Parr, 2002)). None of the sampling points fall into zones where nitrogen would typically limit plant growth.

The previous report indicated that higher time resolution phosphate monitoring could contribute to an improved understanding of the role of nutrients in this algal growth.

Some Citizen Science data collected more frequently than the monthly Environment Agency sampling, suggests there may have been increases in phosphate concentrations immediately prior to the periods of higher algal activity (Figure 4 & Figure 5).

There is some discrepancy between high measurements at Ross on Wye and Fawley and zeros recorded upstream at Ballingham, which is downstream of Holme Lacy. However, this extra data suggests the contribution of excess nutrients in the water column to the algal growth may be greater than can be seen with standard monthly sampling. The increases in phosphate appear to correspond to summer rainfall events captured by the rain gauge at Broomy Hill (Hereford), suggesting that diffuse pollution via run-off plays a role in contributing to these blooms.

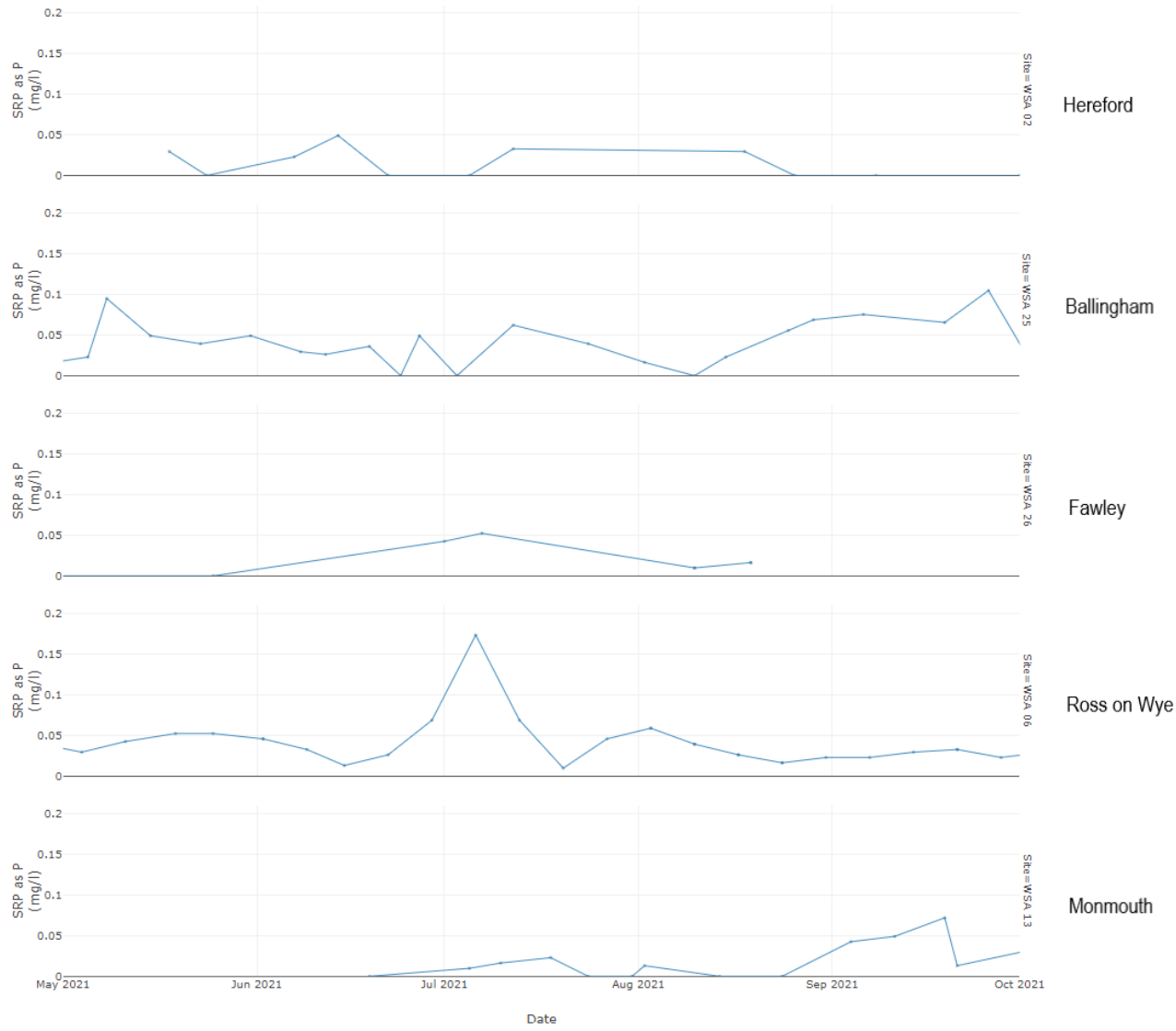

Figure 7: Data from handheld phosphate meters collected by Wye Salmon Association Citizen Science Group. The results have been converted from ppm orthophosphate to mg/l orthophosphate as P for comparison with other figures in this report.

Citizen Science data collection was not widespread enough at that time to identify where run-off in the catchment contributed most during these rainfall events as many groups began or increased the coverage of their sampling in autumn 2021.

We do not have sufficient data to explore whether the blooms would still occur at these excessively high-water temperatures with lower water column concentrations of phosphate.

Additional forms of nutrient monitoring such as sediment analysis are also still needed to explore the role that other sources of nutrient uptake play.

2. What other ecological and water quality issues does the data show?

Water quality

There were no apparent issues with dissolved oxygen or temperature recorded by the sonde deployed on the River Lugg at Mortimer's Cross between October 2021 and April 2022. This is likely due to cooler conditions and associated reductions in photosynthesis. Dissolved Oxygen levels were consistent during this time, and never fell below 90% saturation. The dissolved oxygen concentrations recorded are indicative of good water quality and able to support pollution sensitive fish and invertebrate communities. (Figure 8)

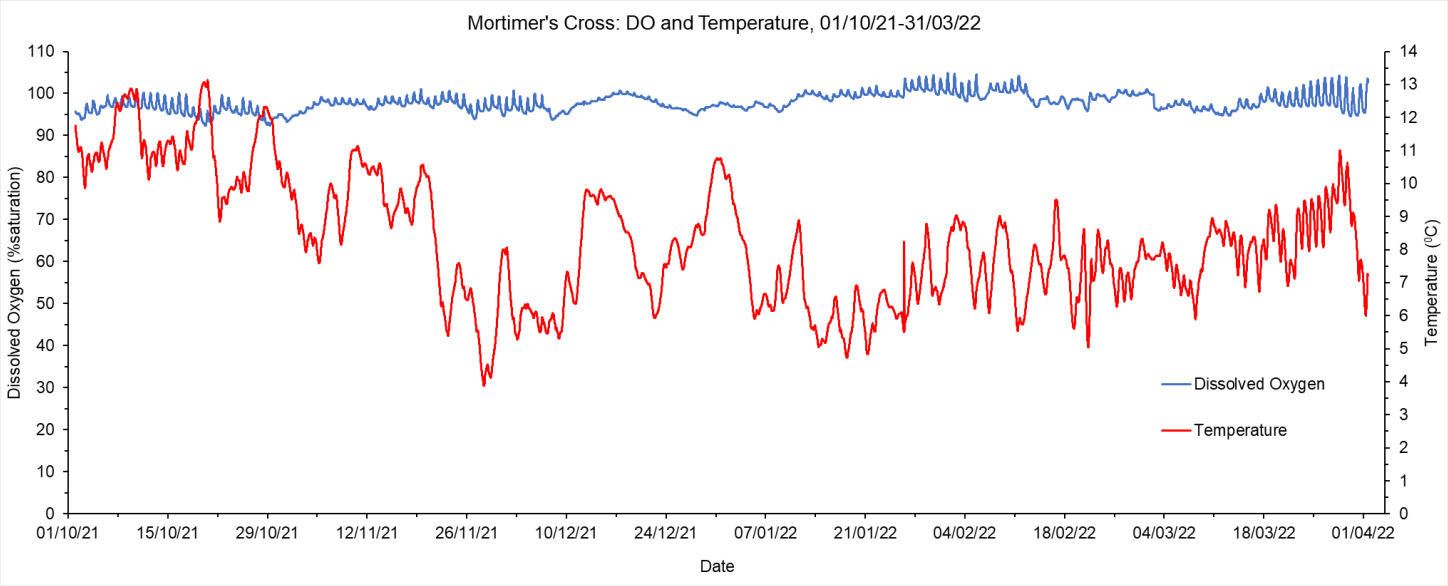

Figure 8: Time series plot of temperature and DO readings collected from the Mortimer's Cross sonde (Lugg), 01/10/21-31/03/22

Several periods of increased turbidity and ammonium were detected by the sonde during the same period (Figure 9) and there is a positive, albeit weak, correlation (R value: 0.3) between the two parameters. However, there were no periods where ammonium concentrations were great enough to adversely impact the ecology of the watercourse between October and April.

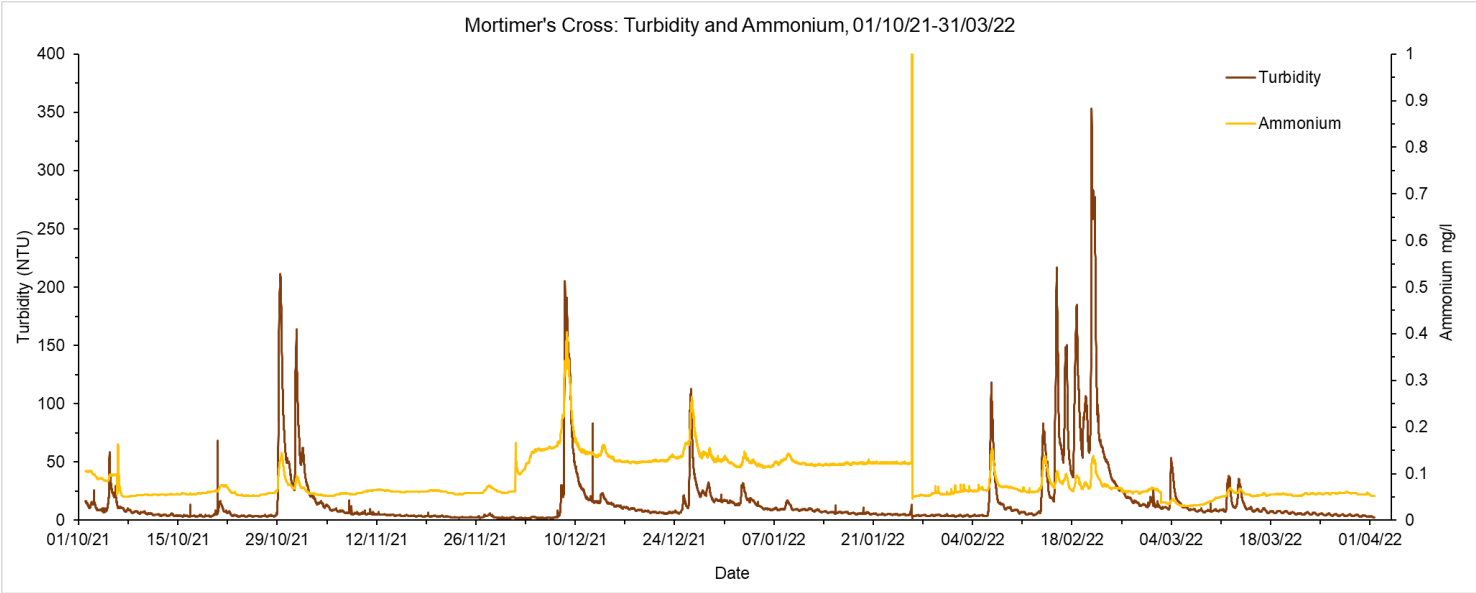

Figure 9: Time series plot of turbidity and ammonium readings collected from the Mortimer's Cross sonde (Lugg), 01/10/21-31/03/22.

All periods of increased turbidity either occurred during or shortly after periods of rainfall (Figure 10), suggesting that periods of increased turbidity are caused by runoff of soil caused by rainfall and increased mobilisation of in channel sediments due to increased river flow.

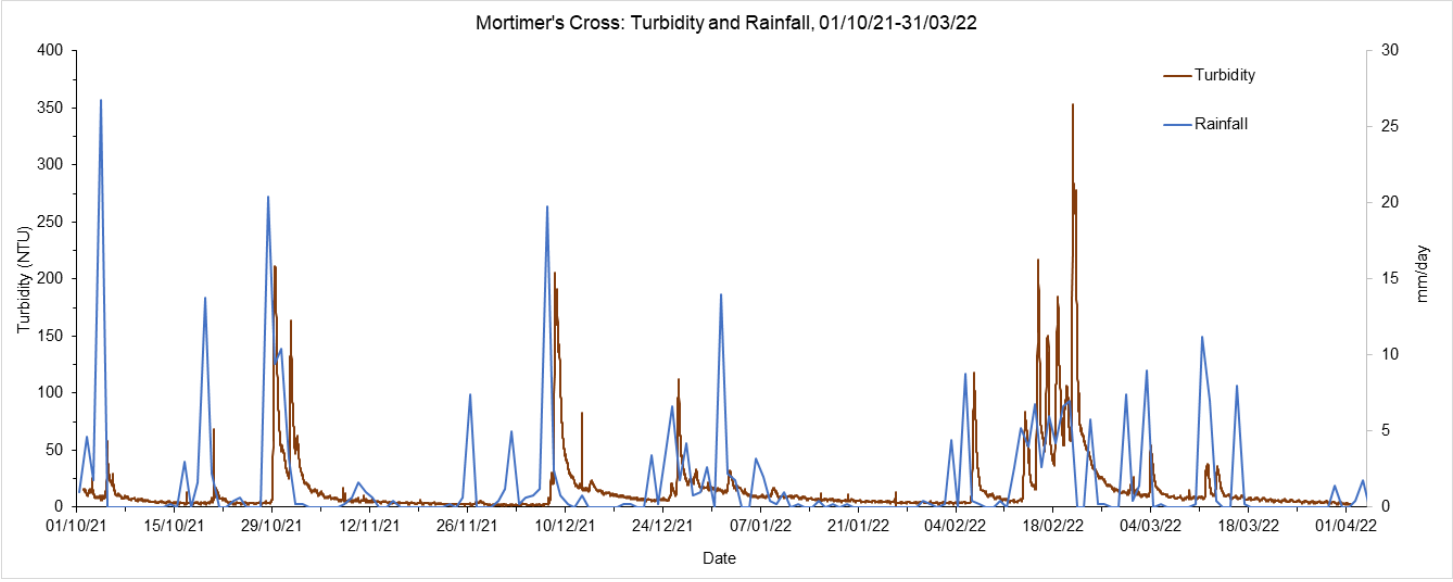

Figure 10: Time series plot of turbidity and daily rainfall (Leominster rain gauge) readings collected from the Mortimer's Cross sonde (Lugg), 01/10/21-31/03/22.

Analysis of Citizen Science phosphate data reveals a similar picture, with orthophosphate levels tracking rainfall and high flow events.

This analysis is complicated by variation in which sites are sampled in any given week and the varying range of sizes of watercourse that those varying samples can span.

We will be able to analyse the geographical spread of data better when more sites have had at least one year's worth of data.

Measurements of orthophosphate in smaller watercourses are likely to be disproportionately higher than larger watercourses due to the dilution effect. During this analysis, we attempted to control for that data bias by using the mean catchment area that drains to all sites sampled within a week to normalise the corresponding weekly mean orthophosphate readings. The result tracks rainfall and flow readings reasonably well (Figure 11).

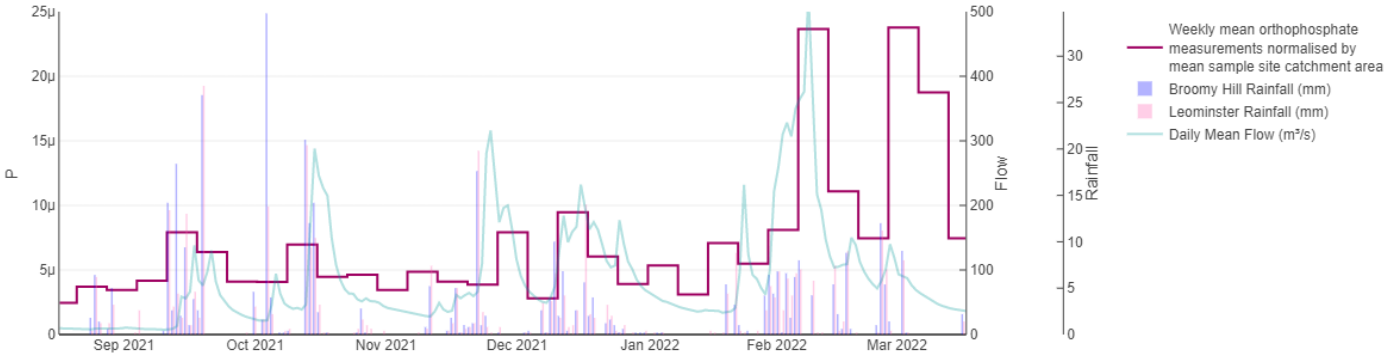

Figure 11: Rainfall data from Broomy Hill and Leominster Rain Gauges and flow data from Redbrook Flow Gauge plotted against weekly mean orthophosphate measurements derived from all Citizen Science samples taken within a given week normalised by the mean catchment area draining to the sampled locations. Results are presented from September 2021, when most sites have been active. Normalised orthophosphate (P) values are unitless.

Hydroecological Validation

Initially data from 76 sites were analysed. Table 1 summarises the data analysis, highlighting those sites that show a flow impact, limited dataset or where water quality is masking potential impacts of low flow on the invertebrate community.

Table 1: Summary of Hydroecological Validation (HEV) data analysis

	Number of sites
Ecology not impacted by flow	38

Possible impact from flow	2
Uncertain/borderline	2
WQ issues overriding flow	18
Limited data set	16

Two sites were shown to have the potential to be impacted by low flow and further investigation is now required to fully understand the issues at these sites.

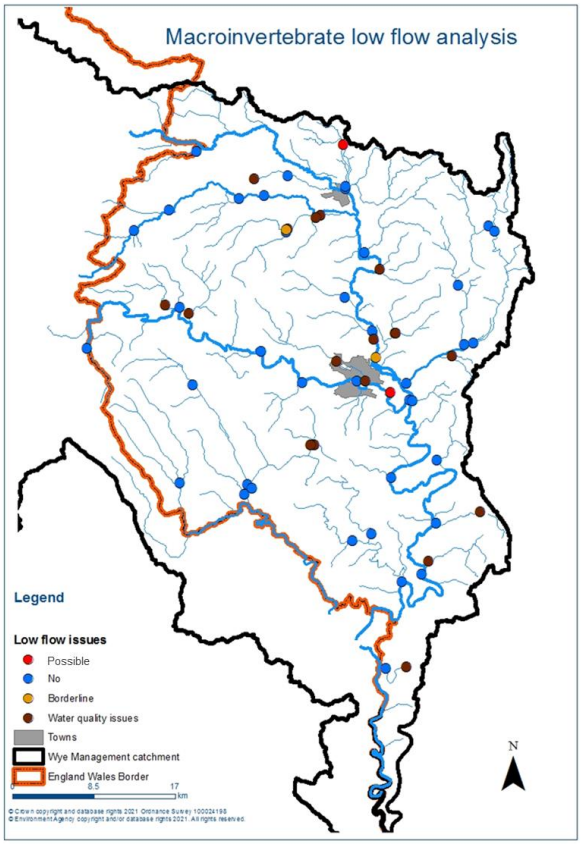

Figure 12 Map of outputs from HEV analysis showing any macroinvertebrate response to low flows

In the current study, it was found that 15 sites were impacted by sediment. However, all sites that showed sedimentation concerns, were also affected by water quality. More work will be needed to try and establish if any of those sites that are potentially impacted by sediment are independent from water quality.

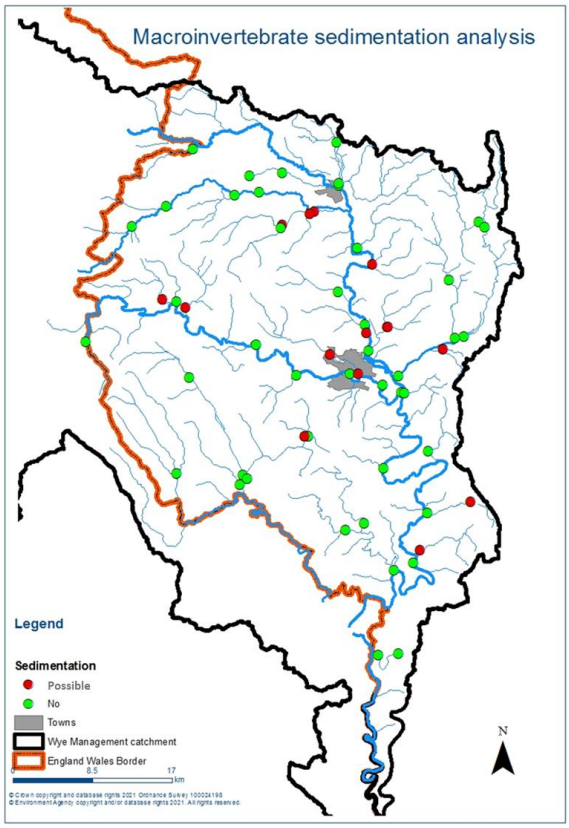

Figure 13 Map of outputs from HEV analysis showing any macroinvertebrate response to sedimentation

Short term trends in water quality

Figure 14, Figure 15 and Figure 16 show the individual sampling point status for phosphate, dissolved oxygen, and ammonia. These figures show the classifications from the last report showing an indicative classification for 2021 (01/01/2019 to 31/10/2021) and a new indicative status using the latest data (01/04/2019-31/03/2022). We will continue to produce new 'rolling' indicative WFD classifications for each site in the quarterly reports where new data is available.

Not all sites within the Wye Management Catchment have any new data within the latest rolling three-year period. Monitoring data for a small number of sites within the Lugg catchment is not available for this quarter, as access for EA staff was restricted.

Most of the sites remained the same status; however, four sites improved from Moderate to Good status for phosphate (these sites were all on the Good/Moderate boundary in the last indicative classification, so any improvements were minor). The four sites improving to Good status were:

- Yazor Brook as discharge to R Wye (50175)
- R Lugg at Eaton Bridge, Leominster (50042)
- R Lugg at Ford Bridge (50043)
- Pentaloe Brk D/S STW (at rd bg) (50135)

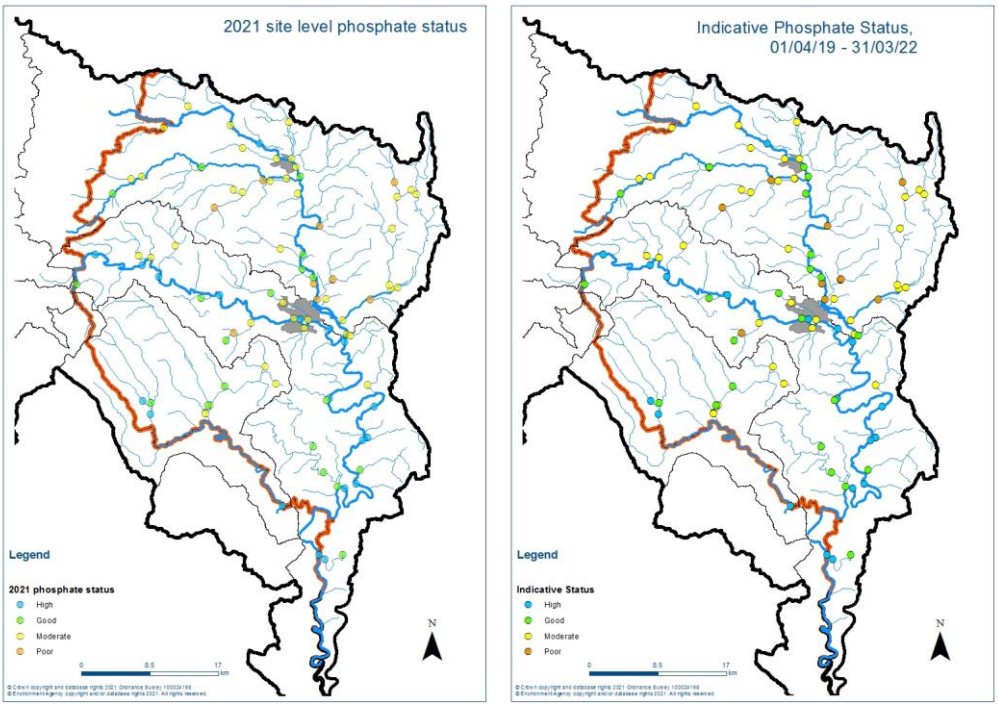

Figure 14: Change in indicative status for phosphate calculated for sites within the Wye Management Catchment between 01/01/2019-31/10/2021 and 01/04/19-31/03/22. Showing slight improvement.

One site improved from Moderate to Good status for dissolved oxygen (R Lugg at Ford Bridge, 50043) and all sites remained the same status for ammonia. One site did appear to change from Good to High status for ammonia, however this was due to an error in the classification conducted in the last report and should have been reported as High so no change took place between the indicative classifications.

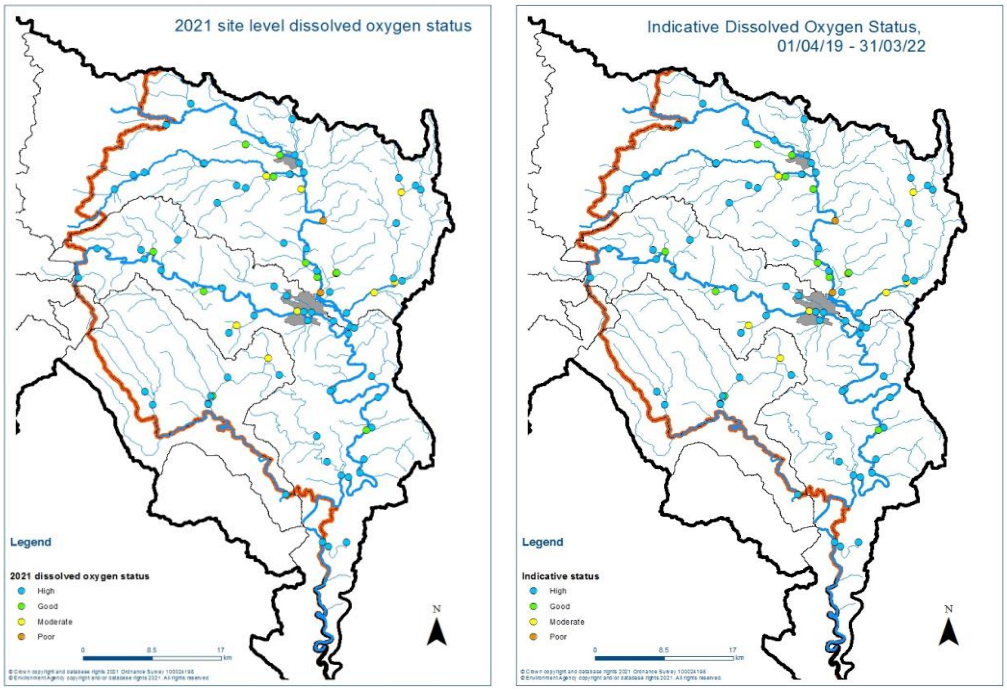

Figure 15: Change in indicative status for dissolved oxygen calculated for sites within the Wye Management Catchment between 01/01/2019-31/10/2021 and 01/04/19-31/03/22. Showing an improvement on the River Lugg at Ford Bridge.

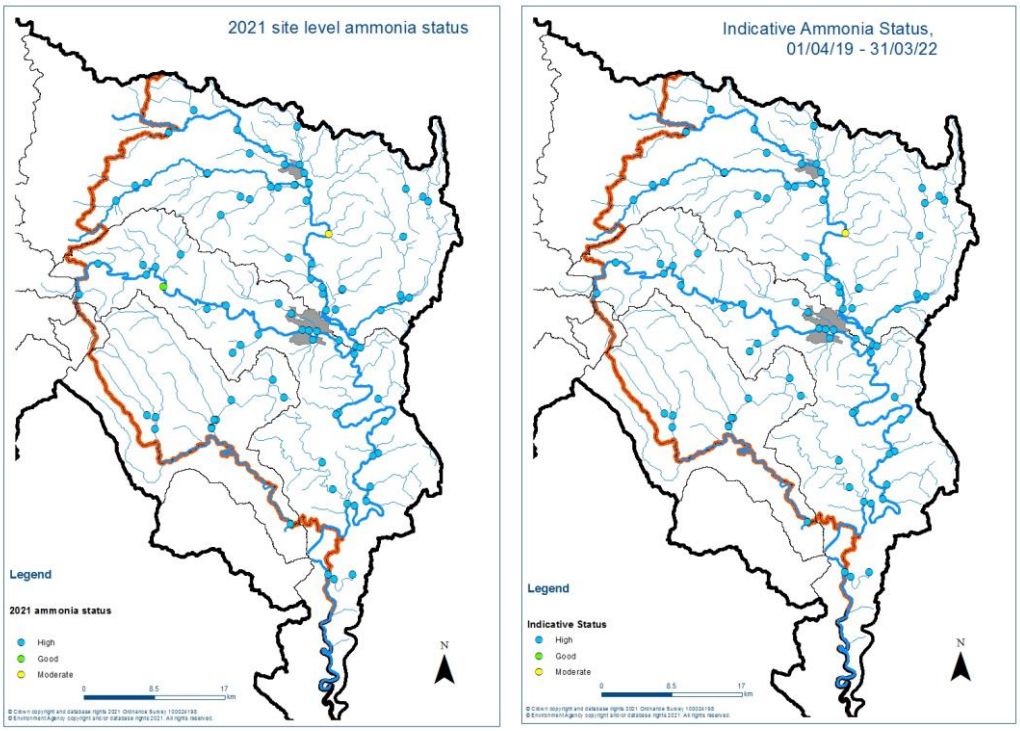

Figure 16: Change in indicative status for ammonia calculated for sites within the Wye Management Catchment between 01/01/2019-31/10/2021 and 01/04/19-31/03/22. Showing minimal change.

Figure 17 shows the mean total oxidised nitrogen (TON) values for 2019-21 and from 01/04/19-31/03/22. There is no WFD classification for TON. Norton Brook U/S Wye (51310) saw the largest increase in mean TON between the two sampling periods rising from a mean TON of 4.016 mg/l to 10.253 mg/l. Gamber Brook At Kilbreece Bridge (50128) continues to have the highest mean TON (11.448 mg/l)

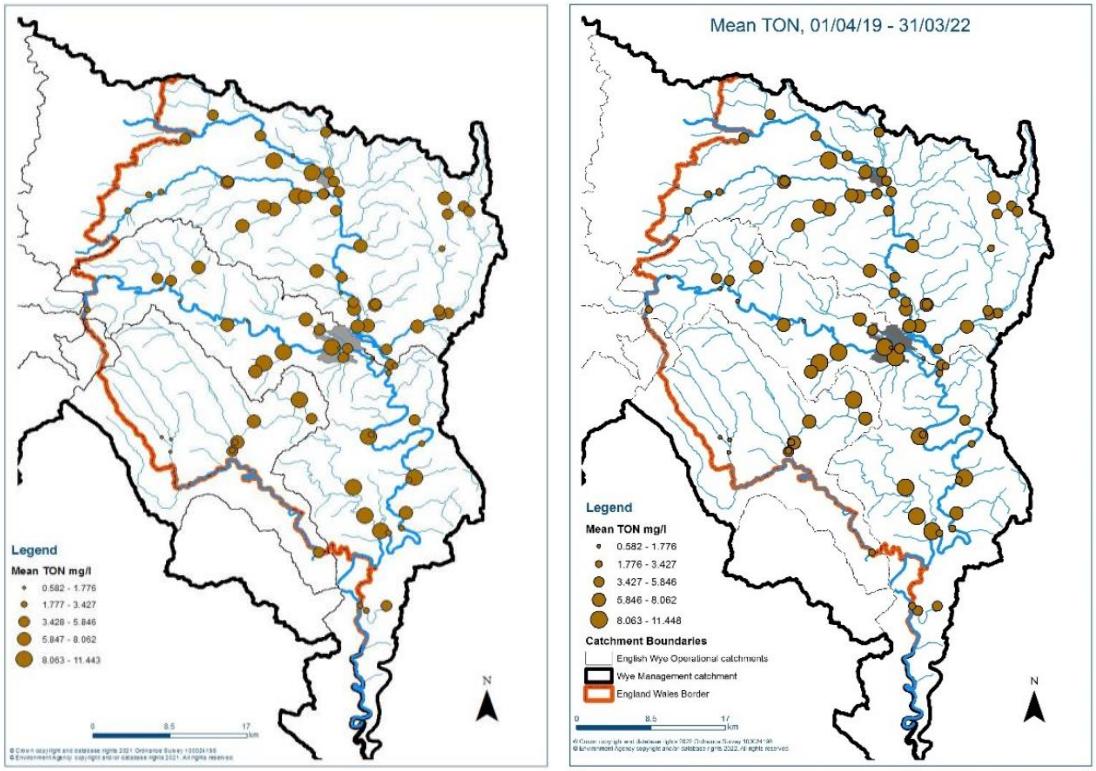

Figure 17: Change in mean total oxidised nitrogen in the Wye Management Catchment between 01/01/2019-31/10/2021 and 01/04/19-31/03/22. Showing a slight decrease in some sites on the Lugg and Arrow and a slight increase in the Norton Brook.

3. Which locations, sectors and activities were responsible for the ecological and water quality issues identified in the data?

Temperature

Data presented in the previous report suggests that elevated water temperature is a key factor triggering algal blooms in the River Wye. Climate change, lower flows and lack of shade are likely to contribute to increased temperatures.

Nutrients

Previous watershed analysis of sampling points supported the results of modelling work, suggesting that arable agriculture and sewage treatment works without phosphorus limits are both significant contributors to the nutrient loading of the wider catchment.

The previous report highlighted that there has been a decline in coverage of pasture and hedgerows in the Wye Management Catchment in England, with permanent grassland being replaced by arable crops.

The CROME data for the English Wye shows considerable change in rural land use between 2016 and 2020 (Figure 18), with the agricultural land use shifting from over 50% permanent grassland in 2016 to 70% arable in 2020.

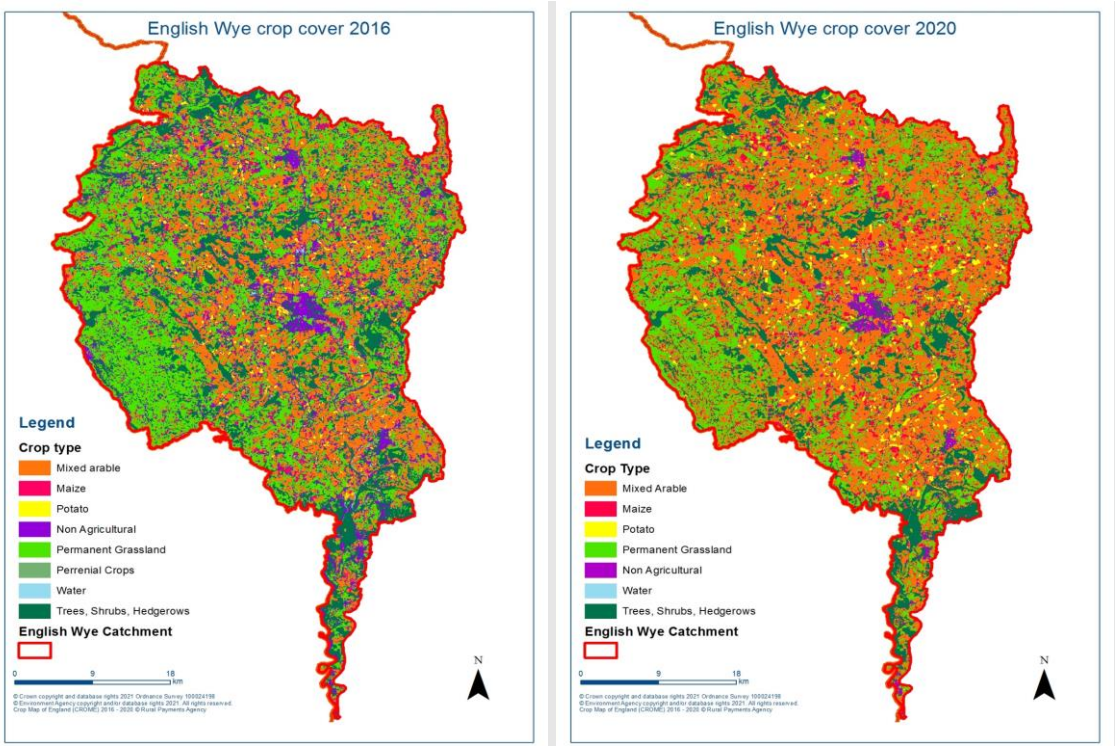

Figure 18: 2016 and 2020 CROME derived land cover maps for the English Wye Management Catchment.

For this report, we re-ran the watershed analysis using the most recent water quality measurements from the Environment Agency and Citizen Science Groups, updated land cover mapping and an improved digital elevation model underpinning the delineation of catchments.

The analysis confirmed the previous results, with agreement between the Environment Agency measurements and those taken by Citizen Scientists. There is a general skew towards higher phosphate concentrations in the Citizen Science data as there are more Citizen Science sites within smaller tributaries where there is less dilution.

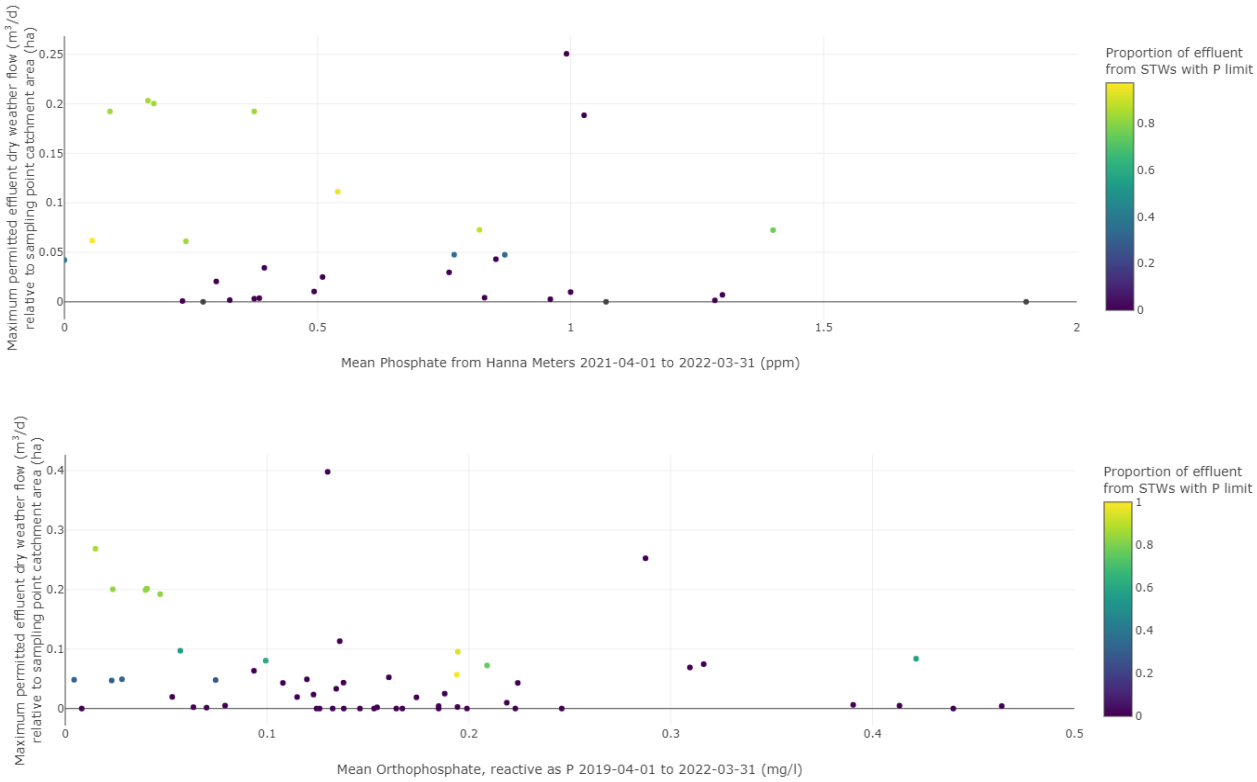

Figure 19: Comparison between Environment Agency sampling point orthophosphate measurement correlations with sewage discharges and Citizen Science site phosphate meter measurement correlations. Note the different x-axis scale for Citizen Science data.

There is most notably a positive correlation between the proportion of land draining to a sampling point that is managed as arable and the mean orthophosphate at that sampling point.

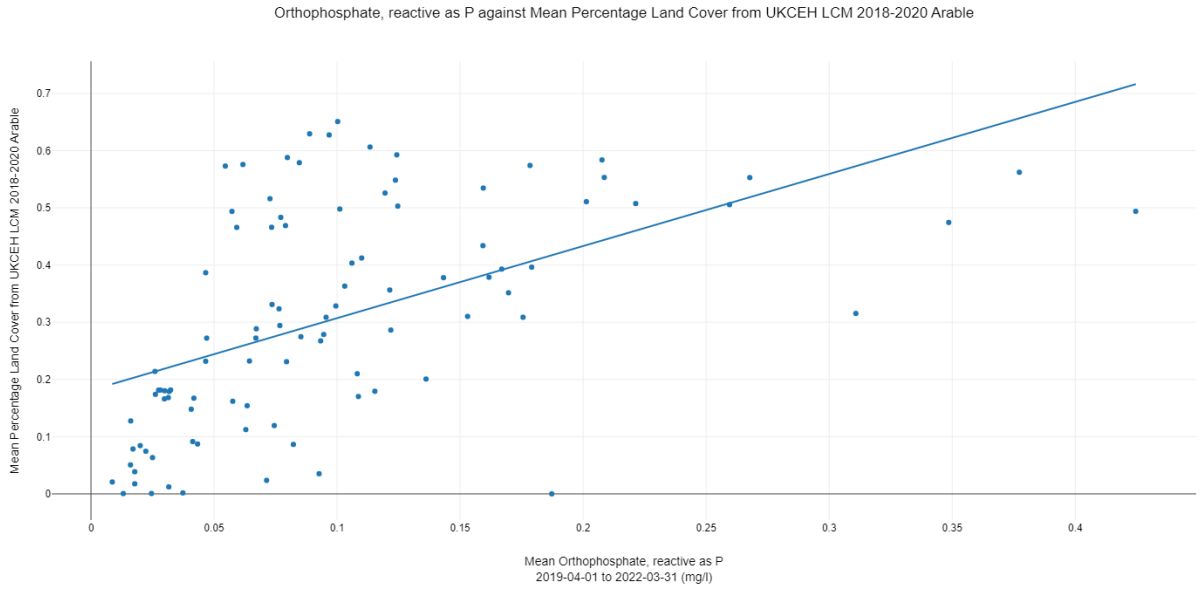

Figure 20: Correlation between mean percentage land cover arable between 2018-2020 and mean orthophosphate between 2019-2022.

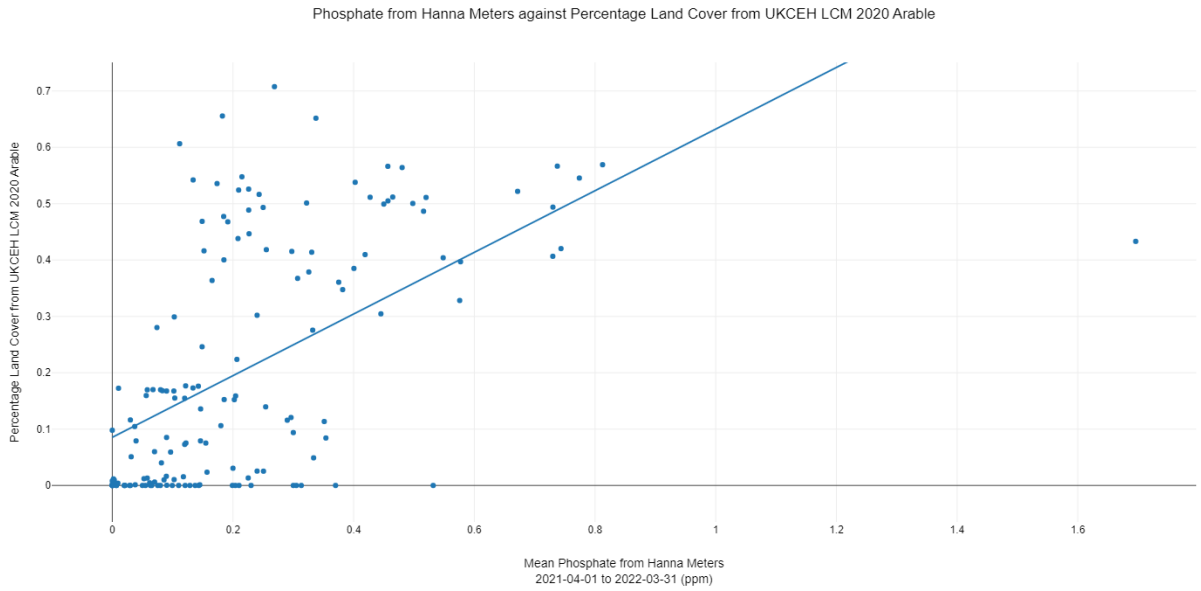

Figure 21: Correlation between percentage land cover arable in 2020 and mean orthophosphate measured at Citizen Science sites using handheld phosphate meters during 2021/22.

The proportion of arable land upstream of each sampling point showed a strong correlation with total oxidised nitrogen. This was complemented by a strong negative

correlation between the area of grassland, particularly acid grassland, and total oxidised nitrogen.

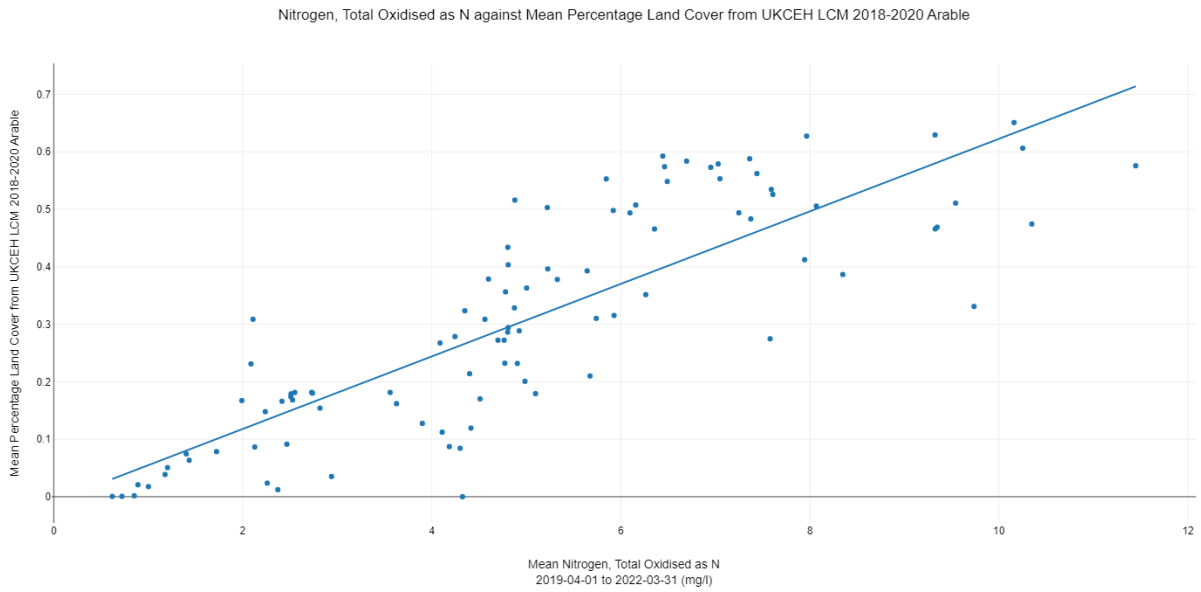

Figure 22: Correlation between mean percentage land cover arable between 2018-2020 and mean total oxidised nitrogen between 2019-2022.

There also appears to be a positive correlation between the number of chicken sheds in a catchment and total oxidised nitrogen.

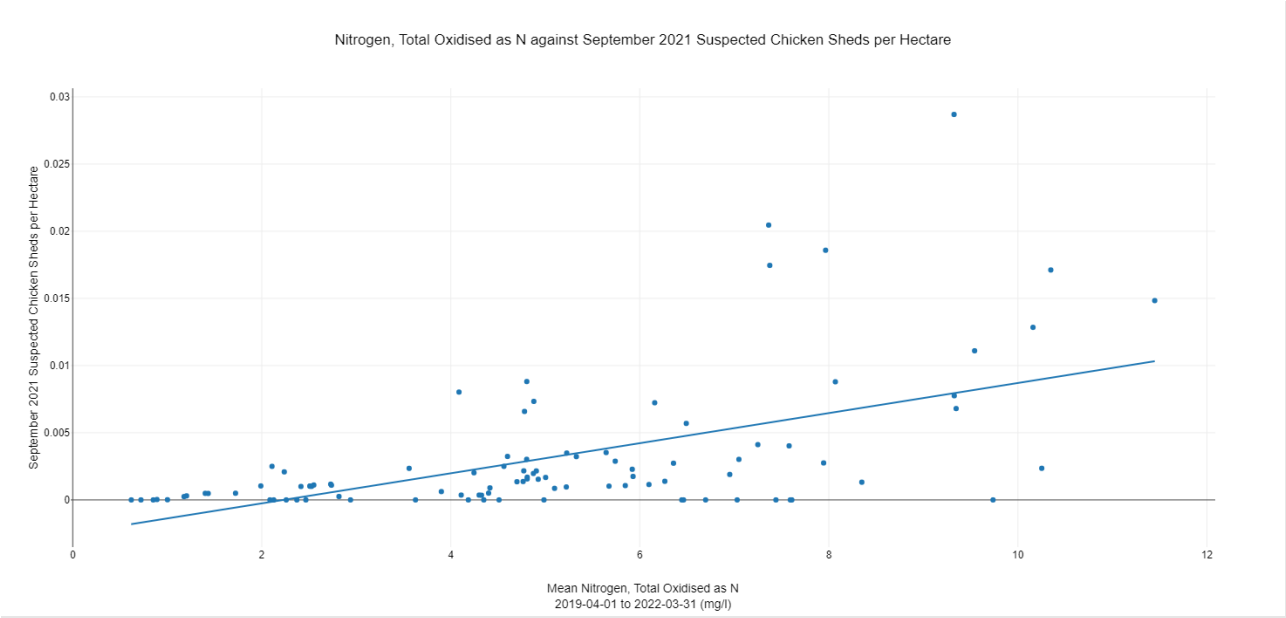

Figure 23: Correlation between number of chicken sheds in a catchment and total oxidised nitrogen, estimated using analysis of satellite imagery.

There is positive but very weak correlation between the number of chicken sheds in a catchment and recent orthophosphate measurements taken by both the Environment Agency and Citizen Science groups. There are quite a few outliers so a greater understanding of where manure from these sites is spread is still required.

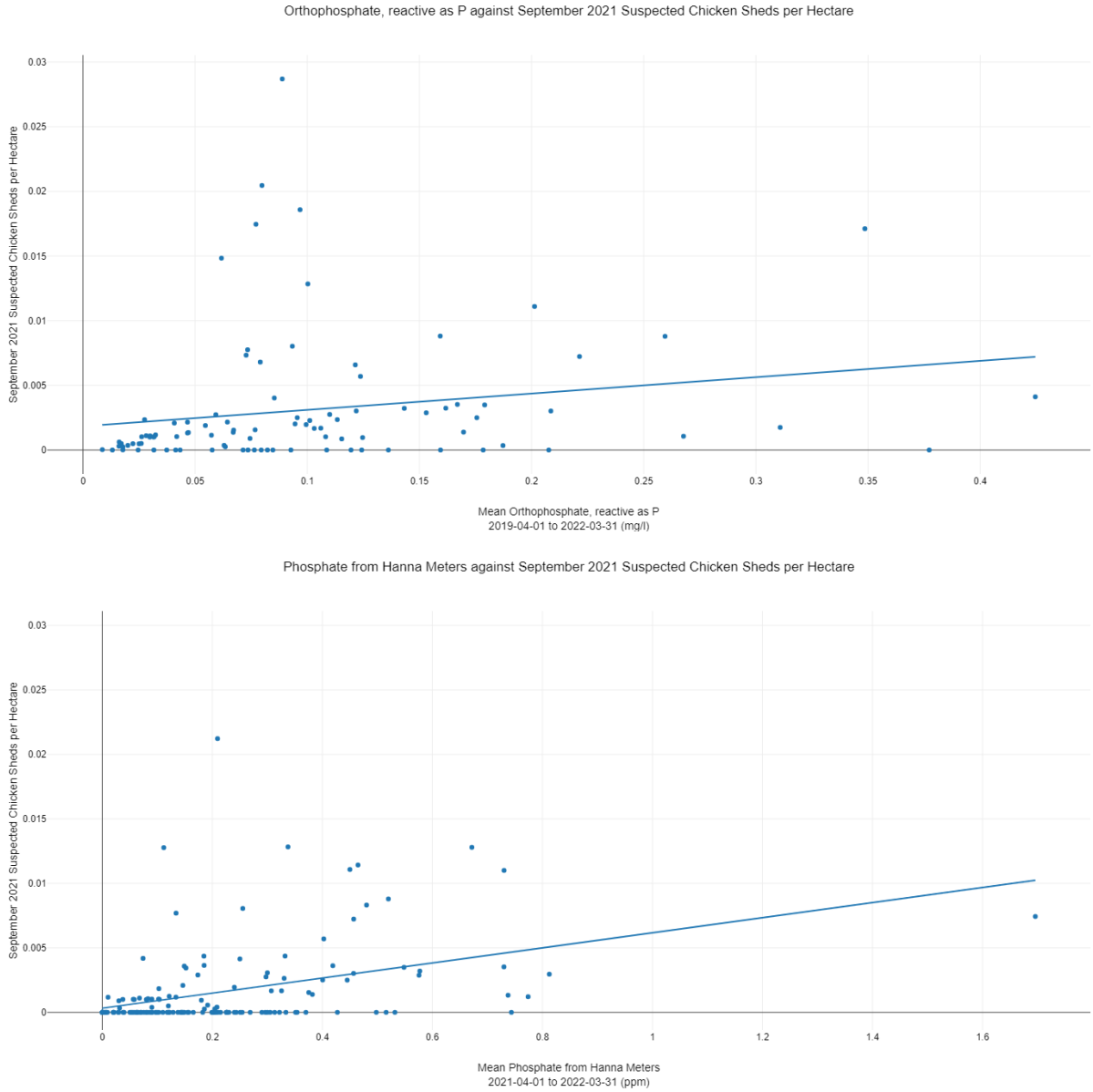

Figure 24: Correlation between number of chicken sheds in a catchment and Orthophosphate measured by the Environment Agency (top, R^2=0.04) and Citizen Science groups (bottom, R^2=0.03), estimated using analysis of satellite imagery.

Total Phosphorus

To date, Phosphorus, Total as P (total phosphorus) has been analysed at relatively few sites across the catchment and more widespread data is required for more robust analysis of correlations between land use, total phosphorus, and ecological impacts as we have done for orthophosphate and nitrogen.

Total phosphorus appears to correlate more strongly than orthophosphate with poultry units, arable and improved grassland. However, there are not enough sampling points to understand the statistical significance of these correlations. Further investigation is required to demonstrate that these are causes and confirm the pathways.

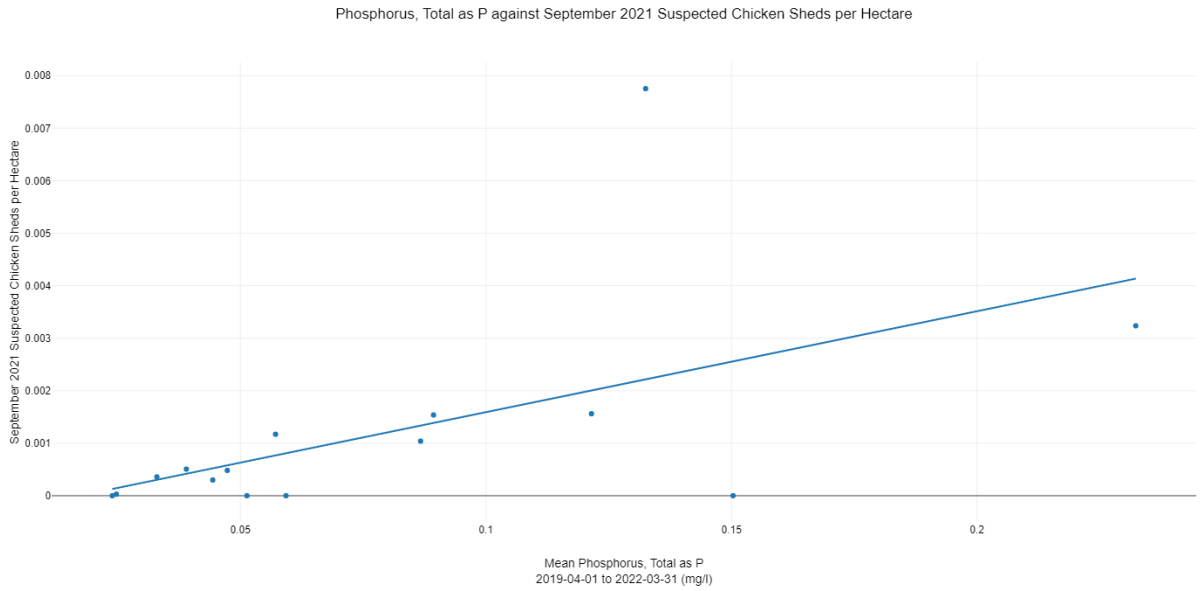

Figure 25: Total-P plotted against the suspected count of intensive poultry units per hectare in the catchment upstream of each sampling point.

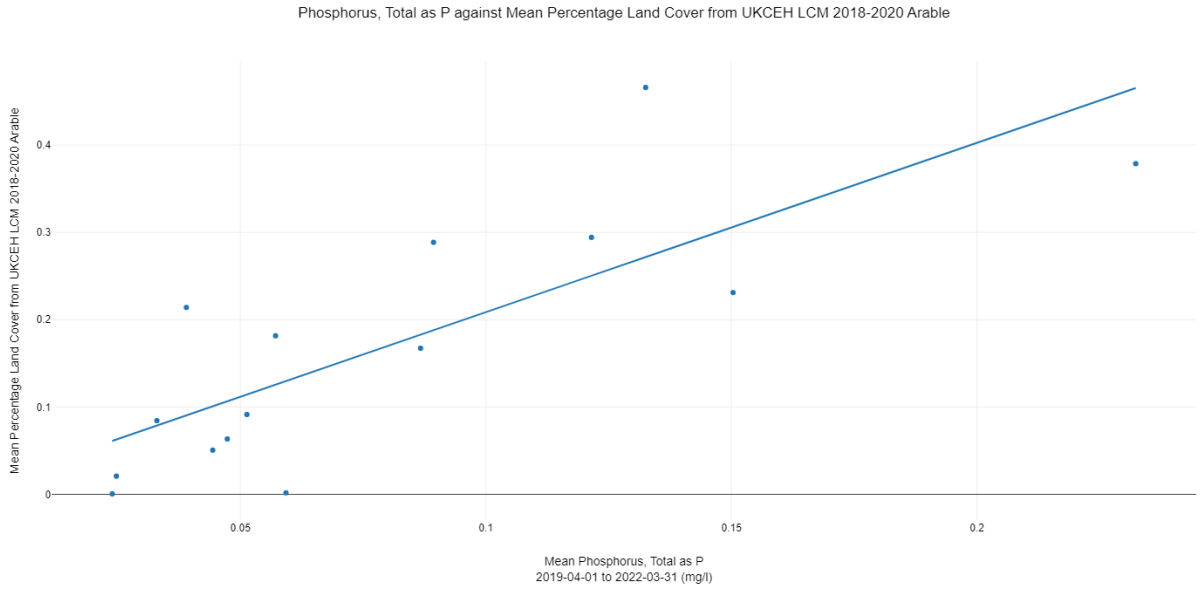

Figure 26: Total-P plotted against the proportion of arable land use in the catchment upstream of each sampling point.

The Citizen Science monitoring provides a useful extra spatial and temporal resolution to trace the source of peaks of phosphate. Citizen Science groups can continue to improve the usefulness of this data by improving the consistency of sampling intervals and where

possible sampling upstream and downstream of suspected sources of nutrient input, allowing sufficient space for full mixing in the water column. As time goes on, and each site develops data across a representative spread of flow conditions, weather conditions and seasons, this data will become more and more useful.

Particular care must be taken currently in inferring information from mean data across different sites where there is wide variability in the number and timing of samples. It is also important to recognise the influence of the size of the watercourse over phosphate concentrations due to the dilution effect.

The extra resolution provided at some Citizen Science monitoring sites helps identify potential sources of phosphate but also highlights the extreme difficulty in being able to come to definitive conclusions without continuous data in every part of a catchment alongside complete understanding of land management operations, discharge activities and localised flow and rainfall data.

For example, the data presented in Figure 27 shows a short-lived peak in phosphate at the top of the Lugg near the Welsh/ English border. The data appears to show that the peak originated from a small drain where there is a high proportion of arable land, which was bare in October.

A reasonable face-value conclusion could be that this was a surface run-off diffuse pollution event linked to land management activities in those fields. However, the peak occurred in September, before the bare fields analysis, during a dry spell of weather, possibly at the same time as a minor localised rainfall event, but this cannot be confirmed. We also cannot rule out contributions from other sources because the locations of other monitoring sites in the area do not allow us to rule out nearby point sources.

This illustrates the inherent difficulty in identifying sources of diffuse pollution and the large data requirements to do so confidently. Where Citizen Science groups identify such events, they could work in more detail with landowners or discharge operators to identify the root cause of the problem and help check whether efforts to resolve the situation are effective.

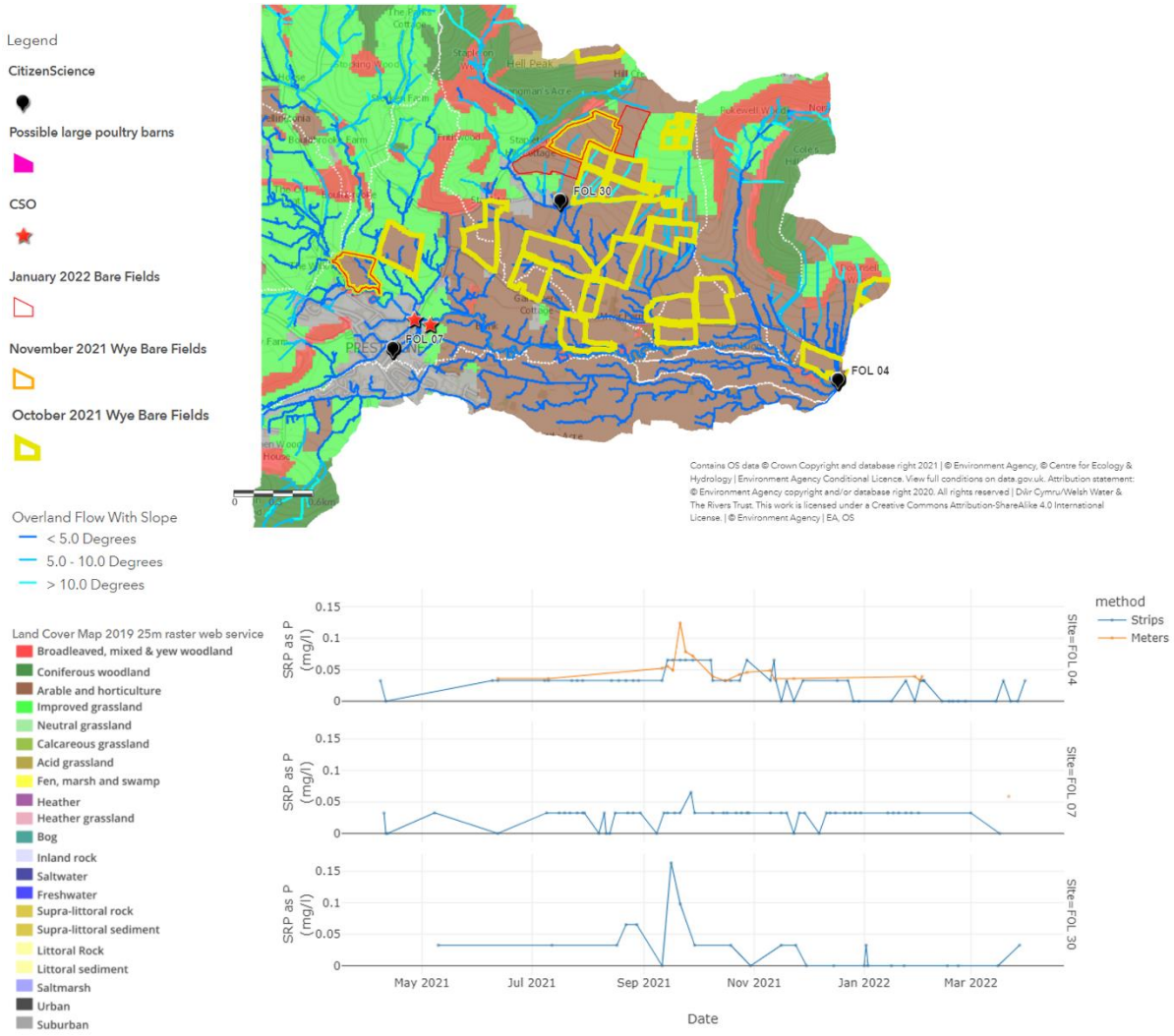

Figure 27: Map of land use analysis and results from Friends of the Lugg Citizen Science Group phosphate monitoring over a high P event in September 2021 near Presteigne. Citizen Science phosphate measurements have been converted to mg/l orthophosphate as P for consistency.

Incident Reports

Reports of environmental incidents from members of the public to the Environment Agency give an indication of the sectors and activities that are contributing to ecological and water quality problems in the English parts of the Wye Management Catchment (Figure 28).

The location and number of incident reports is heavily biased towards areas of higher population, recreational activity and Citizen Science monitoring points, where there are greater numbers of observers, however this data does generally support the findings from spatial, water quality and ecological monitoring, that both agricultural land management and sewage discharges are significant contributing factors to problems within the River Wye and its tributaries.

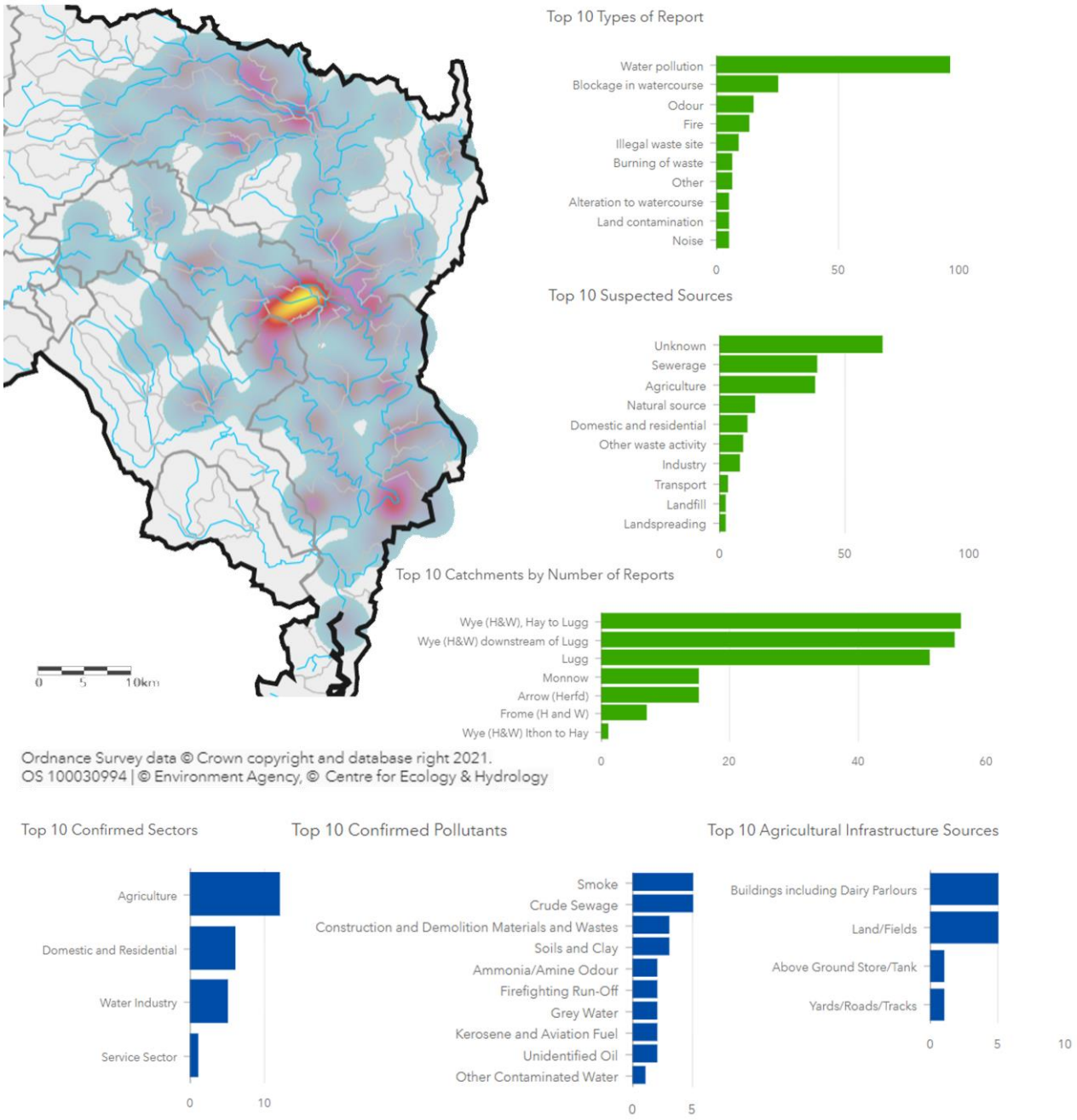

Figure 28: Heatmap of number of incident reports by location between 01/11/2021 and 31/03/2022. Multiple reports can be received for the same incident. Green bar charts show the breakdown of types of report, sources suspected by the reporter and locations. Blue bar charts show confirmed incident details where the Environment Agency attended and/or investigated the incident (source sector, pollutant and source agricultural infrastructure where applicable).

Recommendations

Additional data and analysis required

There is a large amount of Citizen Science monitoring that has taken place within the Wye Management Catchment by third parties in the past year. We will continue to analyse Citizen Science data in future reports and expect that the usefulness of this data will grow even more when all sites have at least a full year's worth of data. We aim to integrate this data more with incident report intelligence.

Further investigations into the species of algae involved in blooms on the Wye are required to determine more conclusively whether free floating or benthic algae is more of a problem and whether this interaction changes over the course of a bloom event. We have developed an algal monitoring programme to do this during 2022. We will be sampling key locations every month through late spring and summer, with capacity to increase the frequency of sampling if bloom events occur.

Further work is also required to assess the sources of nutrient uptake to macrophytes and algae which are not detectable by water column monitoring. Sediment sampling especially, should be explored to fill this gap in understanding. We will pursue all available funding and delivery routes for this, including asking for support from partners where our resources do not allow us to undertake the desired sampling.

Describing the habitat through Habscore and River Habitat Surveys would help in understanding the interplay between the physical conditions and biological communities and contribute to understanding the impacts of climate change on habitat availability. We will pursue all available funding and delivery routes for this, including asking for support from partners where our resources do not allow us to undertake the desired sampling.

More detailed time series data on volumes spilled by CSOs is required to rigorously assess the relative contribution that such sources play. We will ask for support from partners, particularly Dwr Cymru Welsh Water to contribute this information to the shared understanding in the catchment.

Detailed information on the movements of manure and wastes spread to land is needed to be able to understand the impacts of activities that generate these materials.

We will use Citizen Science monitoring data alongside our own data to inform the calibration of water quality modelling updates.

Targeting Regulatory and Partnership Action

While more information is still required to provide more detailed recommendations to support targeted action, we can recommend the following:

Significant reduction in nutrient input from all sources is required across the whole catchment to contribute to the recovery of river macrophytes. Reducing run-off and leaching of nutrients from land during summer rainfall events when dilution is low and temperatures are high is an important element of this remedial activity.

Efforts to increase shade by tree planting and better management of riparian trees could help mitigate high temperatures. We have developed a high temperature and algal bloom early warning system to enable us to respond to excessive temperatures with advice for anglers and river users and extra monitoring.

Taking a catchment-based approach, all contributing partners in the Wye Management Catchment could target investigations, analysis and remedial actions in key focus catchments that meet the following criteria:

- As far upstream as possible
- High phosphate concentrations relative to the wider catchment, taking the size of watercourse into account.
- A high proportion of the following factors and drivers are present:
    - Arable land use
    - Maize
    - Poultry sheds
    - Anaerobic digesters
    - Sewage treatment works
    - Combined sewer overflows
    - Macrophytes status less than good and indicative of eutrophication
    - Declining Atlantic salmon populations
    - Land allocated for development to which Nutrient Neutrality guidance applies
    - Active Citizen Science groups
    - Active partnership projects

Based on these criteria the following functional groups of waterbodies seem most suitable initially:

1. River Arrow near Kington
2. River Arrow near Pembridge and Curl Brook
3. River Lugg and tributaries near Presteigne
4. Little Lugg and Withington Marsh Brook
5. River Frome

Further investigations in partnership should include understanding the pathways and impacts of manures and wastes that are spread to land and a comprehensive appraisal of options to mitigate the impacts of poor water quality, including whether we could manage water resources differently to create more dilution.

Where Citizen Scientists can support the efforts of land managers and discharge operators to reduce the impact of their operations by undertaking targeted monitoring and evaluation in response to identified high nutrient events, we would encourage them to do so.

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