

# ECP Monitoring Report

## Water quality status and sources of pollution in the Littlestock Brook



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## List of Acronyms

EA	Environment Agency
AOD	Above Ordnance Datum
BOD	Biochemical Oxygen Demand
CDOM	Colorised Dissolved Organic Matter
CS	Citizen Scientist
DO	Dissolved Oxygen
ECP	Evenlode Catchment Partnership
EDM	Event Duration Monitor
FWW	Fresh Water Watch
mg/l	Milligrams per litre
MuW	Milton under Wychwood
O <sub>2</sub>	Oxygen
Ppb	Parts per billion
STW	Sewage Treatment Works
TW	Thames Water
WFD	Water Framework Directive
WIMS	Water Information Management System

## Summary

The Littlestock Brook is classified by the Environment Agency (EA) as having ‘poor water quality’. This report brings together the available data sources that help us build a comprehensive picture of the water quality status of the Littlestock Brook at Milton under Wychwood (MuW). The bulk of this report summarises the findings from the multi-parameter probe dataset, but also draws on other sources such as the Citizen scientist data, the EA data and data from Thames Water to fill any gaps and illustrate the current situation more clearly. The data provide a substantial body of evidence of the impacts of water pollution on the brook and has wider implications further downstream for the River Evenlode and eventually the River Thames.

The main conclusions are;

- Despite the MuW Sewage Treatment Works (STW) being able, to the most part, to comply with the sanitary standards in the environmental permit issued by the EA (see Chapter 7), this analysis shows that the STW has a significant negative impact on the water quality of the Littlestock Brook and is the main contributor to the brook being classified as being of ‘poor water quality’.
- The EA environmental discharge permit conditions for the treated sewage effluent discharge from the STW are too lax to protect the water quality of Littlestock Brook.
- The environmental discharge permit conditions for the treated sewage effluent discharge from the STW do not contain any limits for phosphate, and this is a significant omission, as phosphate is one of the main determinants that causes the brook to be classified as having ‘poor water quality’.
- There is insufficient dilution available in the brook to absorb the flow and concentration of pollutants that are discharged from the STW. Even when all of the flow to the works is processed and treated to the permit standards the dilution is insufficient for the brook to reach Good Ecological Status due to the sewage works discharge. This situation is exacerbated in the summer months when the flow in the brook is low but the STW discharge remains steady.
- As well as the treated sewage effluent discharge, the works also has permit to release untreated sewage when the works is overwhelmed from ‘storm sewage effluent resulting from rainfall or snowmelt’. These untreated sewage discharges exceed 2,200 hours discharging per year, far in excess of what would be expected from ‘rainfall or snowmelt’ in MuW. It is obvious that there is insufficient capacity in the sewerage system and sewage works to treat the full flow and this leads to frequent use of the untreated storm overflow discharge to avoid overwhelming the STW.
- The operation of the storm overflow under an historic ‘Deemed Temporary Permit’ makes it determination of the level of illegality of the untreated sewage discharges problematic. It is therefore incumbent on the Environment Agency to promptly review and re-issue a revised permit with environmental conditions that protect the Littlestock Brook.

## 1 Recommendations

On the basis of the findings of this report, the Evenlode Catchment Partnership recommends that;

- 1) Given the poor performance of the present works, there should be no further development in the area served by MuW STW, until the STW is upgraded to treat all of**

**the flow, and the treatment process is enhanced to ensure that the quality of the effluent discharged does not harm the brook.**

- 2) The EA reviews the permit and sets tighter limits that protect the water quality and ecology of the brook. This will require enhancements to MuW STW and its associated sewerage network, to include both the enhanced quality and increased quantity of treatment.**
- 3) The EA sets a phosphate limit in the STW discharge permit at a level that protects the water quality of the brook. This will require enhancements to MuW STW, to include phosphate stripping.**
- 4) The EA to enforce the conditions of the Storm Overflow Permit in order to encourage Thames Water to make improvements to the sewage system and the STW to reduce the frequency of untreated sewage discharges.**

## **2 Background and approach**

The Evenlode Catchment Partnership's (ECP) mission is to 'Restore the Evenlode Catchment for the benefit of all'. The vision is for an Evenlode with improved water quality, enhanced flood management, enriched biodiversity, with greater community engagement with rivers, at local and landscape scales.

The Littlestock Brook is a tributary that joins the Evenlode River just above Shipton under Wychwood road bridge and has been known to be of 'poor water quality' for some years. In response to this the ECP supports and encourages Citizen scientist to carry out both 'Freshwater Watch water quality sampling' to monitor nutrient levels, and 'Riverfly sampling' to monitor invertebrates in the brook. Additionally, in 2022, the ECP installed two 'Proteus Instruments' multi-parameter water quality sondes upstream and downstream of Milton-under-Wychwood Sewage Treatment Works (MuW STW) with the expectation that Thames Water would install phosphate stripping at the works; they have since reneged on this commitment.

The bulk of this report summaries the findings from the multi-parameter probe dataset but draws on the other sources such as the Citizen scientist data, the EA data and data from Thames Water to fill any gaps and illustrate the current situation more clearly. The focus is on the sources and impacts of pollution, to better understand the causes of poor water quality and to start to address them for the benefit of the people and ecosystems that rely on the Littlestock Brook, the wider Evenlode Catchment and eventually the River Thames.

## **3 Littlestock Brook description**

The Littlestock Brook catchment is located within the predominantly rural River Evenlode catchment, a tributary of the River Thames (southern England). The brook flows through both Milton-under-Wychwood and Shipton-under-Wychwood and drains an area of 16.262 km<sup>2</sup> (EA data). The brook rises from various smaller tributaries at Bruern, Idbury and Fifield and is joined at the outlet of the local STW by the Simmonds Brook from Upper Milton. The land, which is predominantly agricultural, consists of a mixture of permanent improved grassland used for grazing cattle and sheep and arable fields. The catchment also includes some of Ascott-under-Wychwood.

The area has a minimum and maximum elevation of 103 and 202 m respectively, and an average slope of 6.3%. The western part of the catchment is underlain by a limestone geology with shallow lime-rich soils. Further down the catchment, the soils are largely seasonally wet, slowly

permeable clay and loamy soils with some impeded drainage. The area receives an average annual rainfall of 765 mm and experiences an average annual minimum and maximum temperature of 5.7 and 13.1, respectively (MetOffice, 2021) (Robotham, 2023).

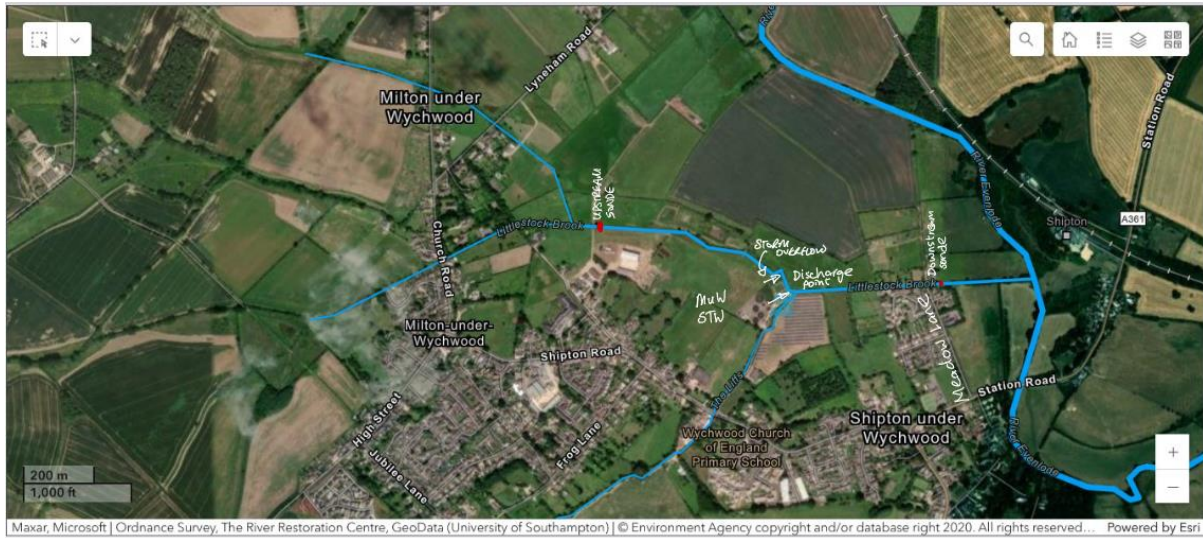


Figure 4-1: Watercourses, STW, and villages in the study area

#### 4 Why we are interested in the Littlestock Brook and pollution sources

The Littlestock Brook has been classified as having ‘Poor Chemical Status’ and ‘Poor Biological Status’ by the EA since their assessments began in 2009. Although there are a range of criteria included in the assessment, we focus on the water chemistry and the organic pollutants measured, as well as the impact this has on riverfly abundance (higher abundance generally equates to healthier water quality). The chemistry of the brook gives an indication of the health of the environment and will largely determine the suitability of the brook as a habitat for plants and animals and the biodiversity that it can support.

The Brook still holds fish including bullhead, minnow and stone loach. Across the whole Evenlode catchment, there are regular sightings of North American signal crayfish, which is an invasive species that carries a virus that is fatal to native, white-clawed crayfish; they also tend to be more aggressive than native crayfish and eat fish and amphibian eggs, tadpoles, and aquatic invertebrates. The Brook generally runs clear, unless there has been heavy rain, in which case it can be discoloured from soil runoff.

The main sources of pollution in the catchment are

- **Treated sewage discharges.** The biggest environmental discharge permit in the catchment is for the MuW STW, which treats sewage from Milton, Shipton, Ascott and the surrounding villages. Treated sewage effluent is discharged to the Littlestock Brook after being processed in the STW and should comply with an environmental permit issued by the EA.
- **Untreated sewage discharges.** As well as the treated sewage effluent, the STW has an associated Storm Sewage Overflow, which is also permitted by the EA to release untreated sewage during storm conditions when the STW cannot cope with the incoming flow. The temporary nature of this permit makes it very hard to assess compliance of releases of untreated sewage.

- **Agricultural surface water runoff.** During heavy rain, surface water tends to rapidly mobilise the fine clay soils in the area. Some work has already been done to address this (Robotham, 2023), but this continues to be a problem.
- **Eutrophication from agricultural nutrient sources.** Historical agricultural practices, such as the addition of fertilizers, contribute to eutrophication of the watercourse and result in elevated levels of nitrates and phosphates being measured in the water. These nutrients are released from seepage through the soil and land-drain discharges. They are also released from the clay carried by the surface water run-off mentioned above.
- **Septic tanks.** Although the soils in the catchment are on the whole unsuitable for septic tanks, there are known to be some installed in the catchment.

## 5 Water quality sources of information and how they have been integrated into this report

### 5.1 Sonde data

Earthwatch installed two 'Proteus Instruments' multi-parameter water quality probes in the brook during February 2022. These probes were installed ~600m upstream of the STW and ~400m downstream of the STW respectively to assess the impact of MuW STW on the brook. The probes take a reading every 15 minutes of a wide range of water quality parameters, and so to date there are over 20,000 individual readings for each of these water quality determinants. This frequency of readings helps to understand the hourly, daily and seasonal patterns of variation of the measured pollutants in great detail.



**Figure 5-1 Proteus Instruments multi-parameter probe with the protective cage removed**

### 5.2 Environment Agency data

The EA data is taken from the EA's Water Information Management System (WIMS) database, and consist of the following datasets;-

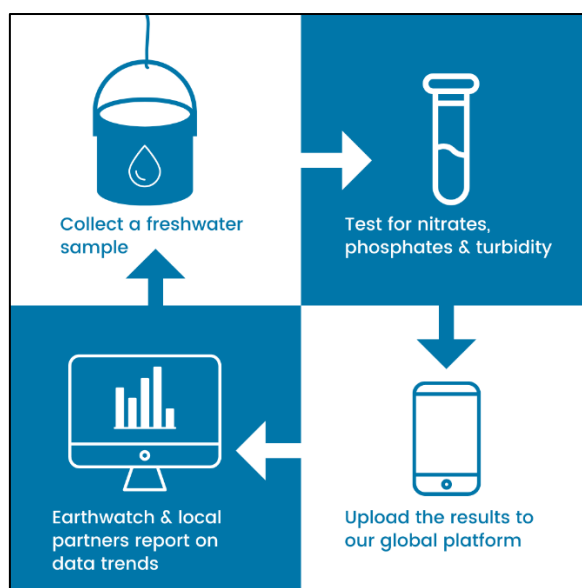
- Water quality - historically the EA have taken water quality samples at the Meadow Lane bridge, which is the most easily accessible point ~ 300m above the confluence with the

River Evenlode. These are the water quality samples that the EA used in determining the water quality classification mentioned previously. This location is downstream of the STW and approximately 10m upstream of the downstream sonde. These EA readings have been used to validate the readings from the sonde.

- ‘Operator Self-Monitoring Compliance Data’ - Thames Water are obliged to provide the EA with this data for MuW STW.
- Rainfall – The EA maintains rainfall gauges at Worsham Mill, near Minster Lovell and at Chipping Norton (though the latter has been out of commission for a considerable time during the study period). The rainfall figures give useful insight into pollutant trends and exceedances observed in the stream.
- River level – The EA has a river-level gauge at Shipton under Wychwood road bridge over the River Evenlode.

### 5.3 Citizen science ‘Fresh Water Watch’ data

- **FreshWater Watch water quality data.** The state of the river is obviously a concern for local residents, and a number have volunteered to act as Citizen Scientists (CS) and have made the effort to undergo training so that they can test water samples and make observations on the state of the river. These measurements and observations are a useful check on the other sources of water quality information we have on the Brook. The testing kits, training, and website hosting are provided by Earthwatch Europe as part of their activities within the ECP.



- The water quality testing includes nitrates, phosphates, and turbidity measurements and observations of algae and other indicators of river health. For the nitrate and phosphate tests, a small sample of river water is taken, and added to a pre-measured quantity of reagent in a sample tube. After 3 and 5 minutes respectively, the colour of the sample is then compared with the standard colours shown below. This gives an immediate indication of the concentrations of nitrates and phosphates present. The test results and observations are then compiled into a water quality category and hosted as a map on the Fresh Water Watch website<sup>1</sup>. Freshwater Watch sampling is typically done on a monthly basis.

<sup>1</sup> [www.freshwaterwatch.org](http://www.freshwaterwatch.org)

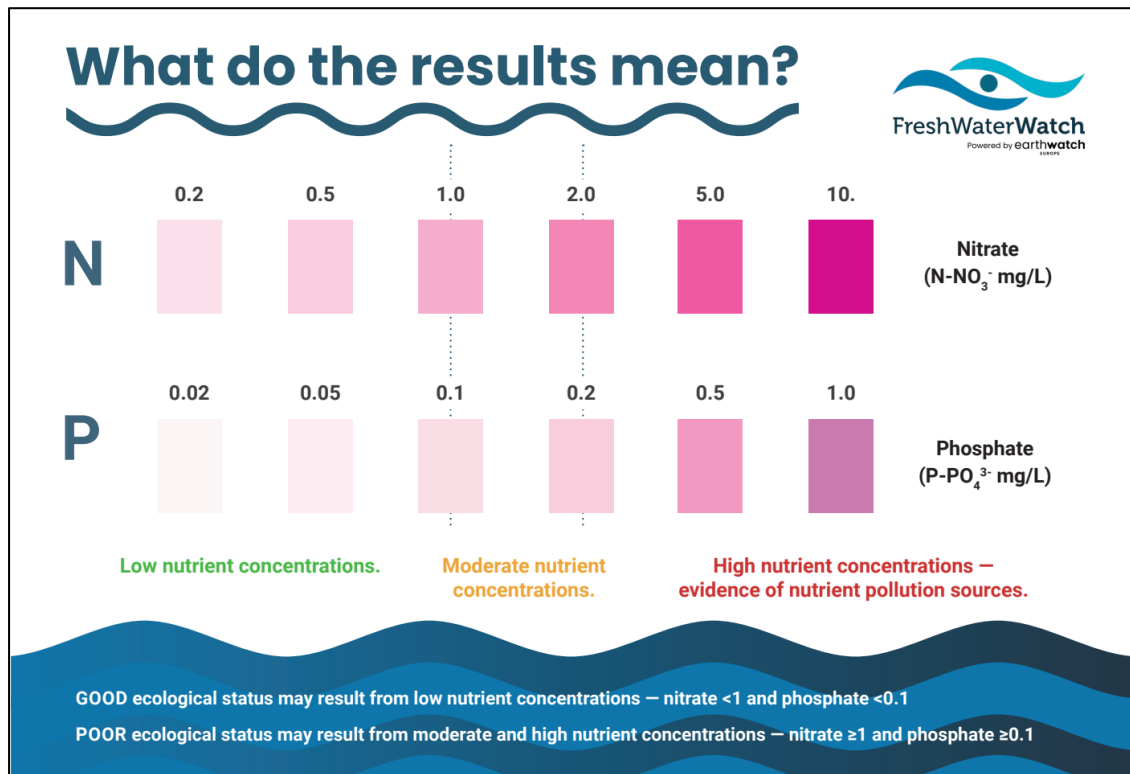


Figure 5-2 Fresh Water Watch sample colour card

#### 5.4 Citizen scientist Riverfly data.

Riverfly Sampling involves surveying the invertebrates that live in the watercourse. These are a useful indicator of river condition, as they live permanently in the river. They are a vital link in the aquatic food chain and are sensitive to changes in environmental conditions. They give an additional indication above spot chemical samples, as they experience all states of the river and any pollution events. The numbers of more sensitive species are quickly reduced if there is any pollution in the watercourse, but more resilient species will persist, providing an indicator of the long-term health of a river.

Training of Citizen Scientists (CS) typically takes a full day and then requires a significant commitment from the CS to survey their local watercourse on a regular (typically quarterly) basis. Riverfly surveys provide information about the health of a river by calculating a score based on the abundance of pollution-sensitive invertebrates in the water. Numerical values are derived to indicate how much a site has been affected by environmental stressors like organic pollution or silt content. A higher score indicates a healthy river with large populations of invertebrates. A lower score suggests fewer invertebrates, which could be a sign of pollution. If the total score falls below a specific trigger level (a score of less than 4), the EA is notified.

The table in Appendix 2 shows the results of Riverfly surveys conducted upstream and downstream of MuW STW. The data shows that Riverfly scores downstream of the sewage works were lower than upstream in every year, thereby highlighting the negative impact of the sewage outfalls from the STW (treated and untreated) on the Littlestock Brook. Importantly, the Riverfly scores have occasionally fallen below the trigger level, prompting an EA investigation.

## 5.5 Thames Water data

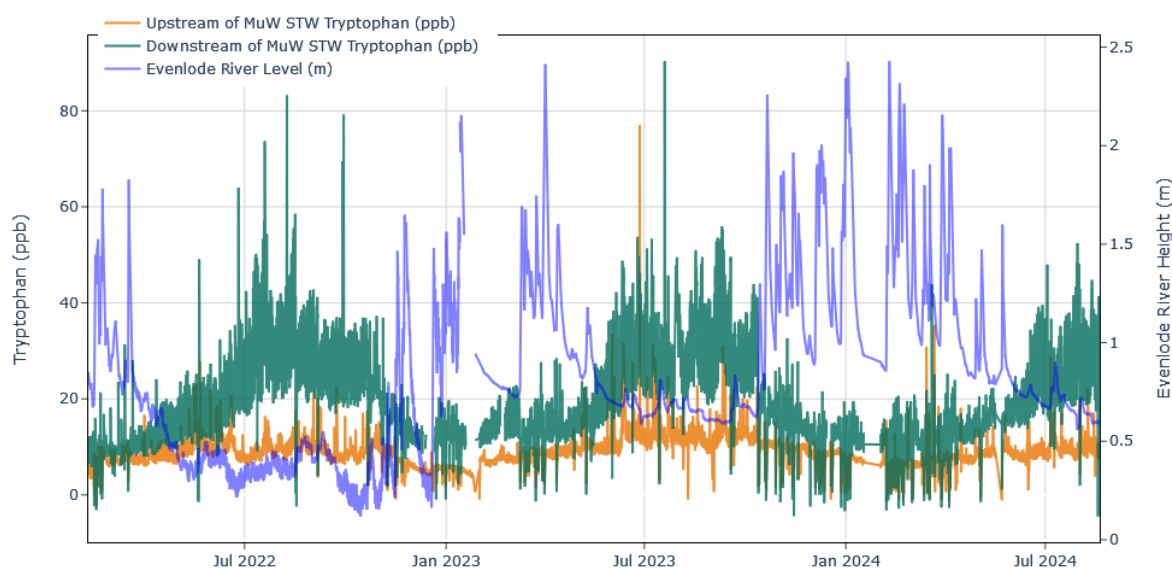
- Operator monitoring samples are submitted to the EA as mentioned above.
- Water companies were required to install Storm Overflow ‘Event Duration Monitors’ (EDM) by the end of 2023. These EDMs record when a storm overflow is discharging (but unfortunately do not measure flow). The EA is then notified of the time and duration of any untreated sewage discharges from these storm overflows.

## 6 Monitoring results and interpretation

### 6.1 Interpreting the sonde data using Tryptophan as an example

The frequency of sampling and the number of readings taken by the multi-parameter sondes provides a good understanding of the mechanisms at play in Littlestock Brook. As an illustration of the level of detail available, consider the three charts below for Tryptophan (Figure 6-1, Figure 6-2, and Figure 6-3) as we zoom-in to different time periods. Tryptophan is an amino acid and is indicative of microbial activity / microbial contamination. It is used as a proxy to indicate the presence of organic matter in the watercourse. All streams carry some organic matter, but high levels of tryptophan (e.g. above 10 ppb) indicate that there is an organic load, probably either from sewage or farm waste, present in the water.

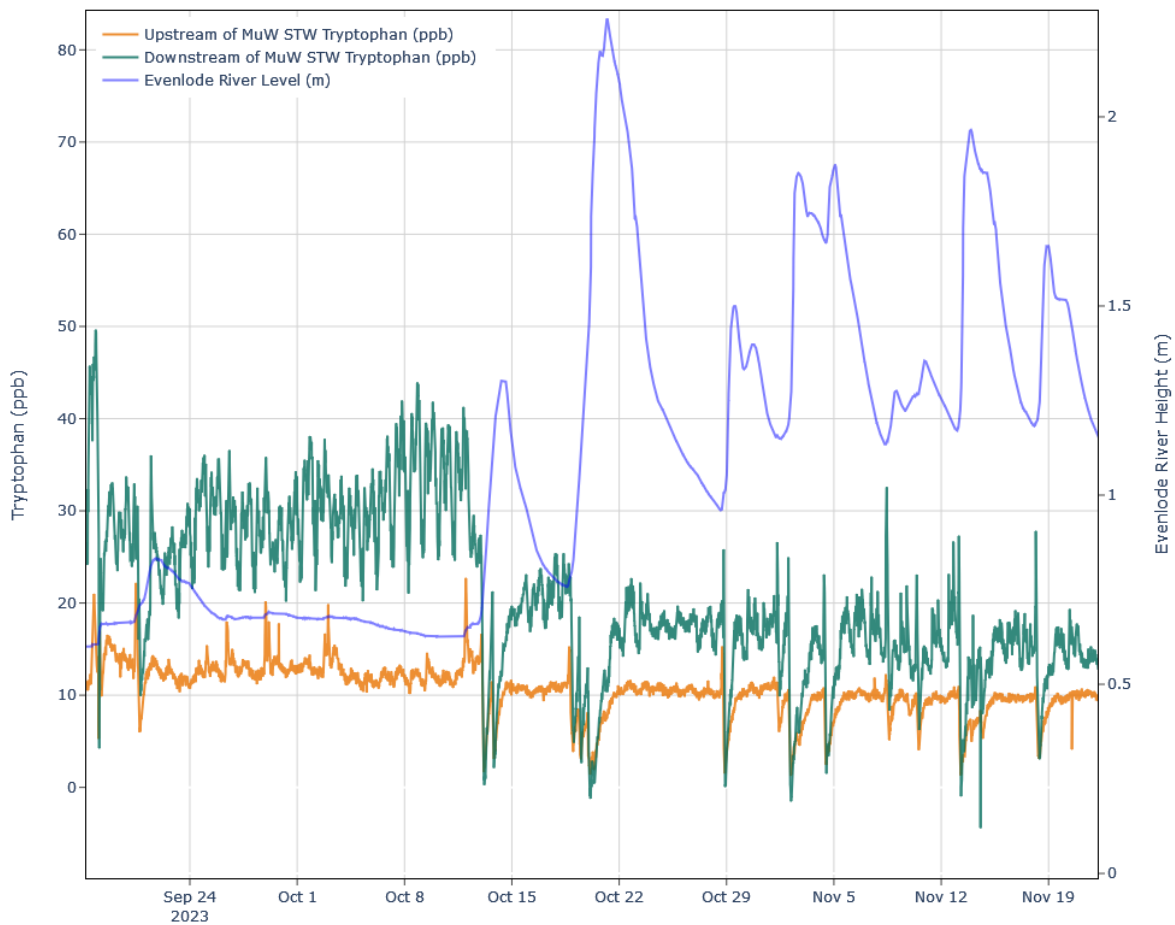
Tryptophan (ppb) Littlestock Upstream and Downstream of MuW STW



**Figure 6-1 Tryptophan concentrations.**

The first plot (Figure 6-1) covers the period since installation of the probes in February 2022 to the present day and shows much higher tryptophan levels measured by the downstream probe (green trace) compared to the upstream probe (orange trace). River levels on the Evenlode at Shipton road bridge (blue trace) are also included, as this is the nearest river level gauge available. There is a seasonal trend, where we observe higher concentrations of tryptophan in the dryer summer months when Littlestock Brook has lower flow (using the Evenlode level gauge as a surrogate). In other words, there is less water available to dilute the discharge from the STW.

## Tryptophan (ppb) Littlestock Upstream and Downstream of MuW STW

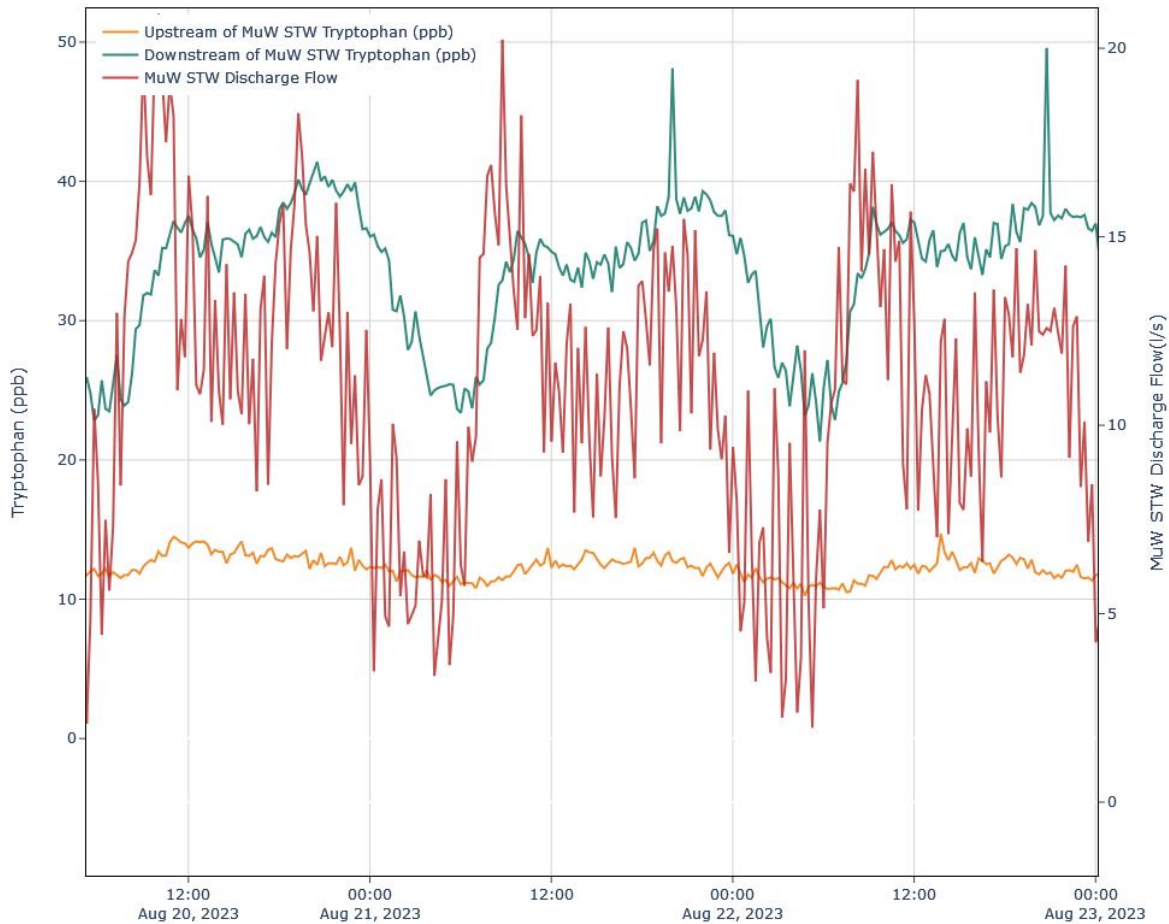


**Figure 6-2 Tryptophan concentrations**

In the second plot (Figure 6-2) we focus on September-November 2023 and show the daily rhythm of tryptophan concentration in both the upstream and downstream trace. The elevated concentrations downstream caused by the discharge from the STW are also evident. Although the observed effect is the variation in tryptophan ‘concentration’, it closely follows the flow of the discharge from the STW (see Figure 6-3). This suggests that the brook is saturated and there is insufficient dilution in the brook to absorb the volume and concentration of effluent discharged by the STW. This effect is particularly obvious (up until ~10<sup>th</sup> Oct), before the rain starts and increases the flow and dilution available in the brook.

This phenomenon is especially obvious during end of summer ‘low-flow’ conditions. A change occurs on ~10<sup>th</sup> October, when tryptophan concentrations suddenly fell at the same time that water level (blue trace) suddenly rose following rainfall. Because upstream and downstream concentrations both fell, we can deduce that this is *not* because the STW outflow suddenly decreased, but instead because the flow in the Littlestock Brook **increased** due to rainfall, diluting the constant outflow of sewage from the STW.

STW Flow vs Tryptophan (ppb) Littlestock Upstream and Downstream of MuW STW



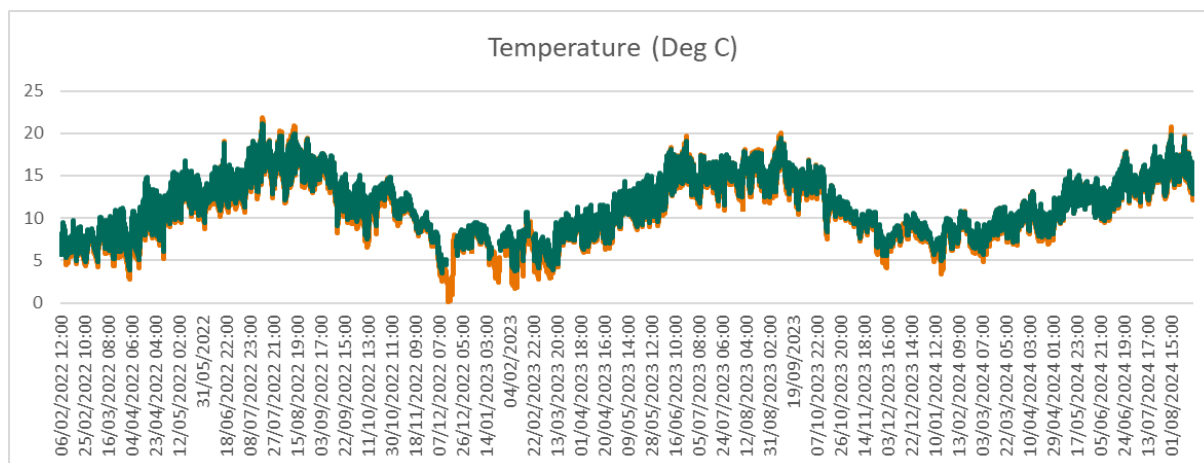
**Figure 6-3 Tryptophan concentrations.** As we focus in further to a period of less than a week (Figure 6-3) and add the trace for discharge flow from MuW STW (red), you can see the close correlation between STW flow and the downstream Tryptophan trace (green) illustrating the link between the STW discharge and water quality in the brook. The STW discharge flow and the downstream tryptophan concentrations show the expected domestic sewage flow pattern from the daily cycle of toilet flushing/ showering/ clothes washing/ dishwashing, reflecting the activities of the residents of Shipton/ Milton/ Ascott and surrounding villages as their waste passes through MuW STW, is discharged to Littlestock Brook and impacts the water course downstream.

The concentration of tryptophan / MuW STW discharge flow drop overnight as people go to bed in the evening; there are a couple of sharp upticks in the early hours, which we believe are increased flow through the STW as various pumping stations in the network reach a level to turn the pumps on, sharply increasing the flow to the works. Then at 7am~8am as people wake up and start flushing, showering and washing, the flow starts to increase to a peak at around 11am, before a plateau/dip in the early afternoon. There is another uptick at around 5pm as people come home from work/school, rising until late evening, when it starts to drop again as people go to bed and the cycle repeats.

We have used tryptophan to illustrate the phenomenon, but these patterns are visible for all of the sanitary determinants measured by the sondes (e.g. CDOM, phosphate, BOD, tryptophan).

## 6.2 Temperature

The chart below shows the results from upstream of the STW in orange and the downstream readings in green for the whole study period. There is a very obvious seasonal trend between summer and winter, but only a very marginal increase in the downstream temperature. These data show good agreement with the EA samples that are taken approximately 10m from the downstream sonde at Meadow Lane bridge.



**Figure 6-4 Temperature readings from the sondes.**

## 6.3 Phosphates

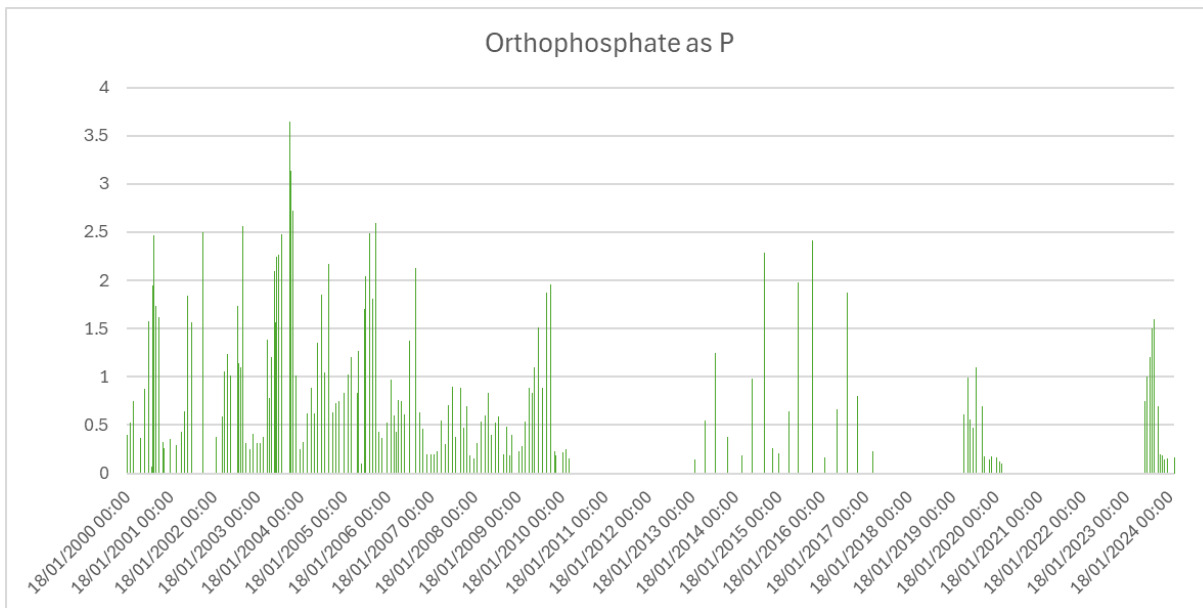
Phosphates as phosphorus are one of the criteria that leads to the ‘Poor Water Quality’ classification for the Littlestock Brook. Phosphates are a nutrient, which is normally the limiting factor for plant and algal growth in a watercourse. When phosphates are introduced to a stream that already has nitrates present, it can lead to eutrophication, quickly accelerating algal growth and causing excessive oxygen fluctuations.

The terms ‘reactive phosphorus’ and ‘orthophosphate’ are used interchangeably and describe the form that can be directly measured. There are limits specified in the Water Framework Directive for phosphorus, as listed in the table below.

Classification	Annual mean of reactive phosphorus (mg/l)
High	<0.024
Good	0.048
Moderate	0.132
Poor	0.898

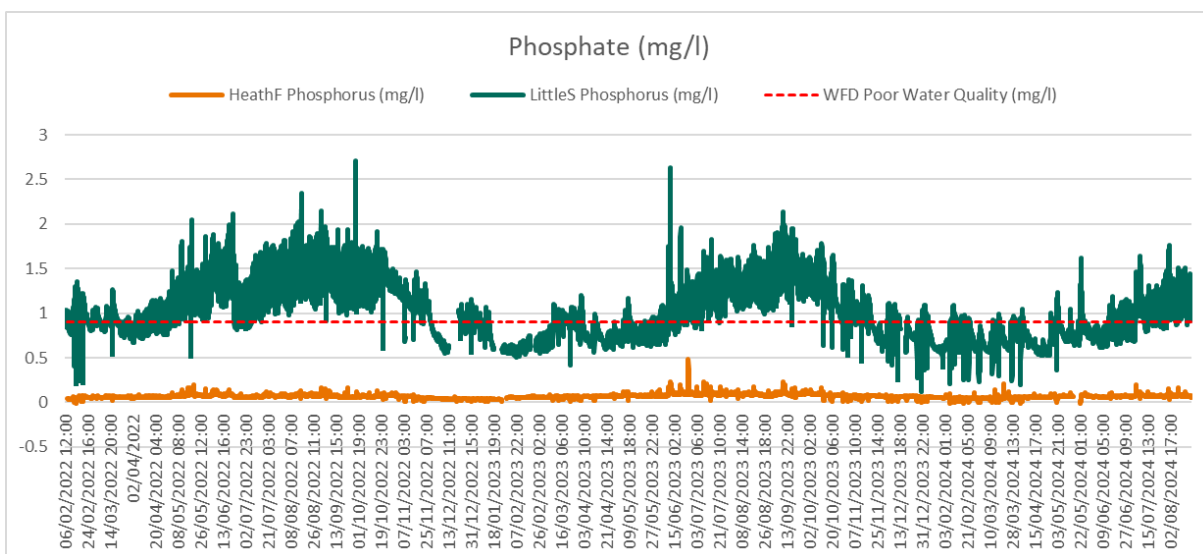
**Table 1 WFD class thresholds for phosphorus for rivers (Alkalinity 204 mg/l, 100mAOD)**

The concentration of Orthophosphate as P measured by the EA at Meadow Lane bridge directly contributes to the ‘poor water quality’ status of the Littlestock Brook.



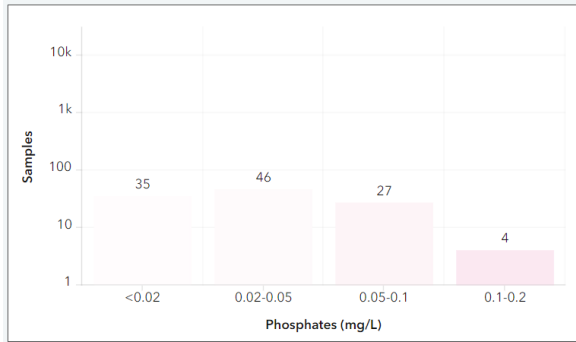
**Figure 6-5 Phosphates (in the form of Orthophosphate as P) as measured by the EA at Meadow Lane bridge.**

Over the period 2023/2024 the EA have taken 14 samples. The average of these 14 samples is 0.64 mg/l (moderate), but what these results do not show is the seasonal trend that we can see from the sonde (see the chart below). If the 14 EA samples are split summer/winter, then the averages become 1.05mg/l (poor) in summer and 0.23mg/l (moderate) in winter when additional dilution is available.

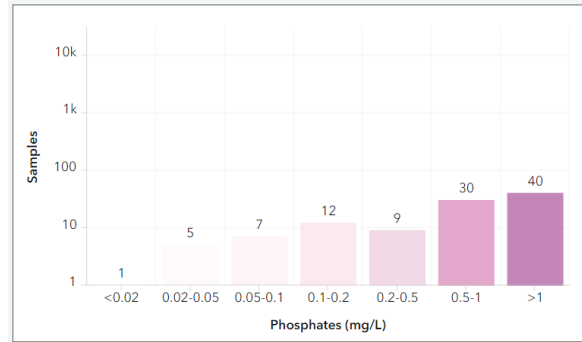


**Figure 6-6 Phosphate readings from the sondes** Although the sonde measures phosphates by a different methodology to the EA, there is reasonable correlation between the sonde readings for phosphate and the EA sample results. ( $R^2$  value of 0.58 although, this comparison is only possible for a limited number of samples (14 EA samples taken in 2023/2024).

Both data sets (EA and sonde) are also in the same range as reported by CS at Meadow Lane bridge (though most of these sample are above the range that the CS test kits can measure (>1mg/l)). Out of the 103 samples taken by CS at Meadow Lane, below MuW STW, 70 showed high levels of phosphates (30 (0.5-1 mg/l) + 40 (>1 mg/l)).



Citizen scientist FWW samples taken upstream of MuW STW



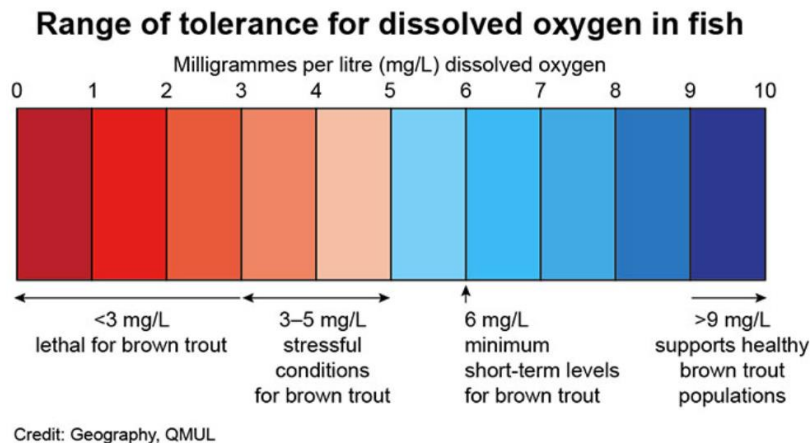
Citizen scientist FWW samples taken at Meadow Lane bridge downstream of MuW STW

**Table 2 Citizen scientist phosphate samples taken upstream and downstream of MuW STW**

The data show that there are high levels of phosphate in the brook and that the main source of these phosphates is MuW STW. Phosphates are one of the key criteria used to determine that the Littlestock Brook is of ‘poor water quality’. The EA environmental permit for the STW needs to be revised to reduce the quantity of phosphates being discharged and the STW needs to install additional treatment to remove the phosphate content.

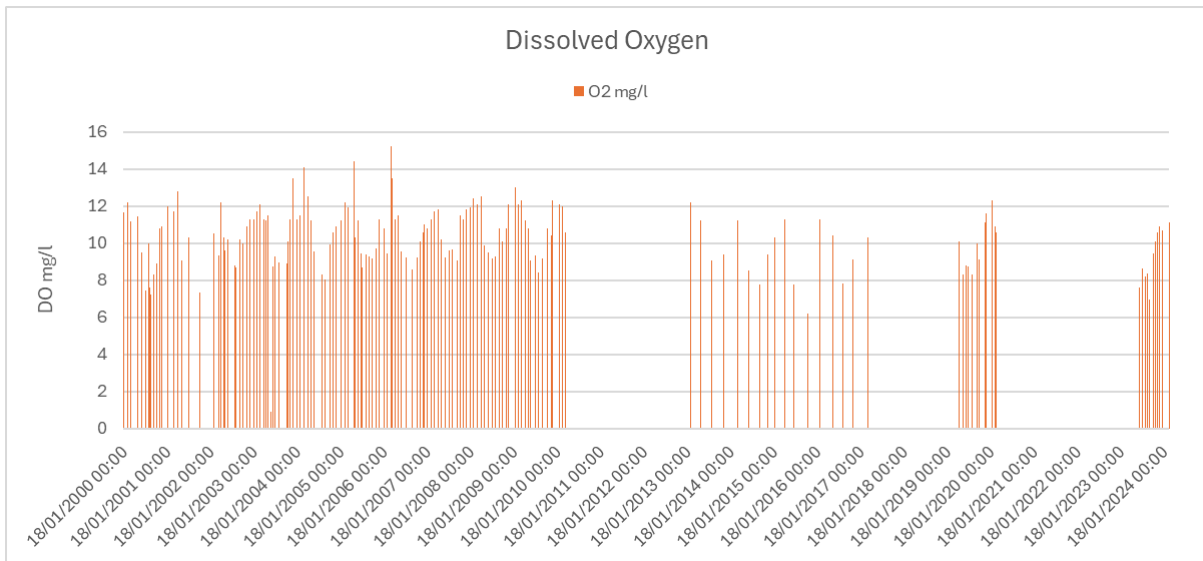
#### 6.4 Dissolved Oxygen

The dissolved oxygen in a watercourse is critical for supporting aquatic life. Excess nutrients cause excess plant and algal growth. When organic matter in a watercourse breaks down it uses up some of the available dissolved oxygen. Additional organic matter from STWs, together with excess rotting plant and algal matter, can significantly reduce the available dissolved oxygen in a watercourse. Organic matter and nutrients will also encourage algal growth which further depletes the available oxygen. If oxygen levels are depressed it stresses invertebrates, amphibians, fish, and other organisms and limits the diversity of species that can survive in the watercourse. Ideally, in a healthy river, dissolved oxygen levels would be maintained above 5mg/l in order to support brown trout (see chart below that illustrates the Range of Tolerance for Dissolved Oxygen in Fish).



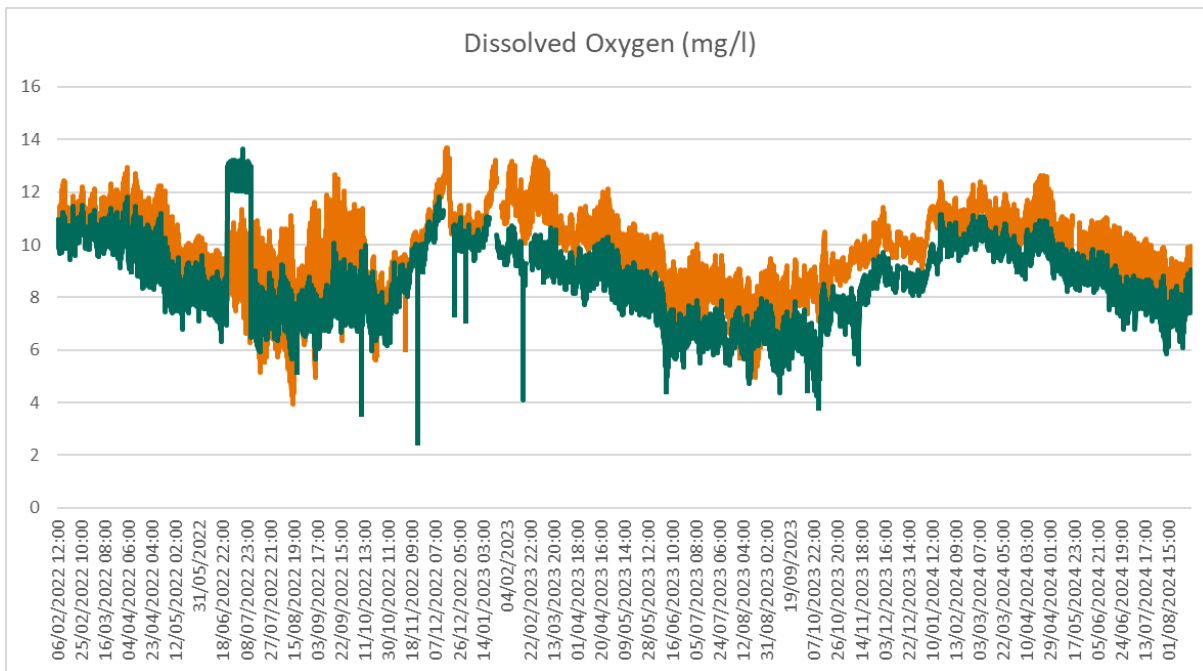
Comparing these limits with the results reported by the EA from Meadow Lane bridge, we see that they record levels between 7mg/l and 11mg/l in their results. The sonde results presented in Figure 6-8 show that the intermittent sampling carried out by the EA fails to illustrate the full

picture. The EA take samples during office hours and miss critical peaks during the day shown by the sonde. The impact of seasonal differences is also difficult to spot when taking monthly samples, for example, there are only a few samples during the summer when dilutions in the brook are low.



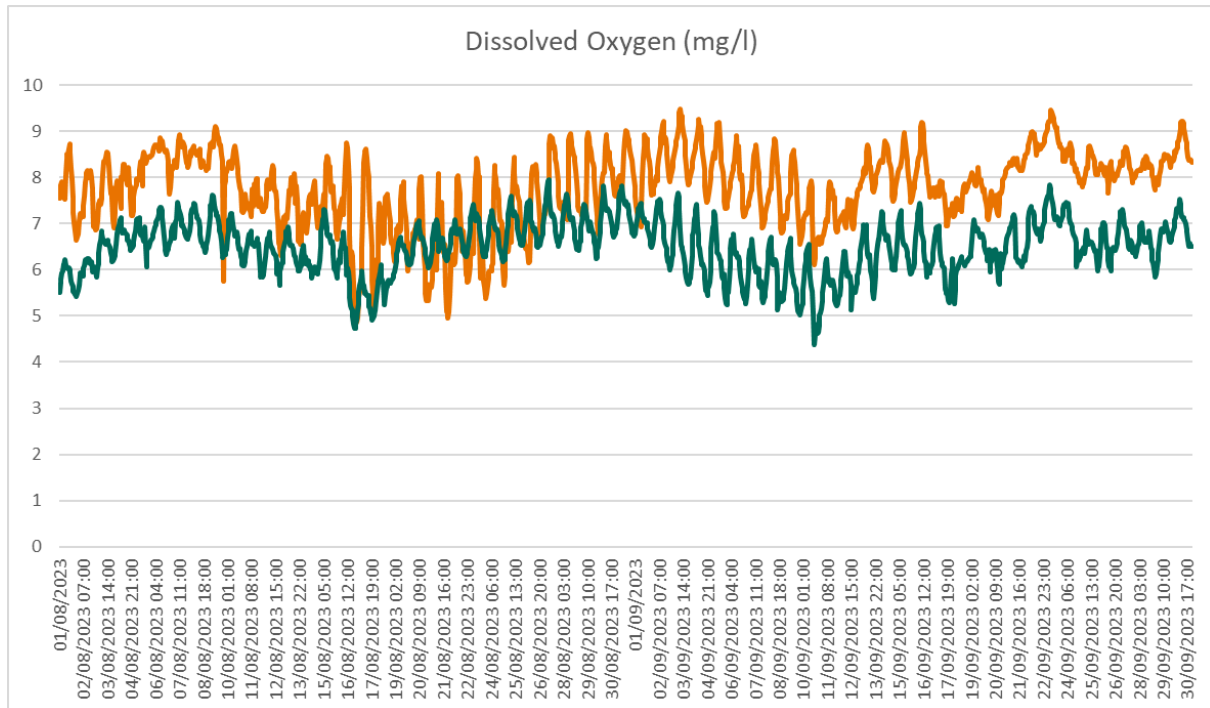
**Figure 6-7 Spot samples of O<sub>2</sub> (mg/l) as measured by the EA at Meadow Lane bridge.**

We see from the sonde results that dissolved oxygen levels are lower downstream of MuW STW discharge than they are upstream (Figure 7-8). A daily fluctuation is seen as plants and algae produce O<sub>2</sub> during the day when they photosynthesise, and use up O<sub>2</sub> during the night as they respire. Bacteria also use up O<sub>2</sub> as they respire. There is also a distinct seasonal trend. (A fault with the downstream sonde can be observed in July 2022 in the downstream DO (mg/l) trace and these data are omitted from the assessment.)



**Figure 6-8 O<sub>2</sub> (mg/l) readings from the sondes.**

We can see from the trace for July to September 2023 (Figure 7-9), that in the warmer temperatures of the summer months, DO levels do dip below this 5mg/l threshold, especially at periods during the daily cycles and are likely to stress species that would survive in a healthy stream.



**Figure 6-9 O<sub>2</sub> (mg/l) readings from the sondes Aug/Sep 2023.** This analysis shows that there are periods when oxygen levels in the Littlestock Brook downstream of the STW fall to levels that would stress some of the species that should live there. These periods are missed by the periodic sampling carried out by the EA.

## 6.5 Biochemical Oxygen Demand

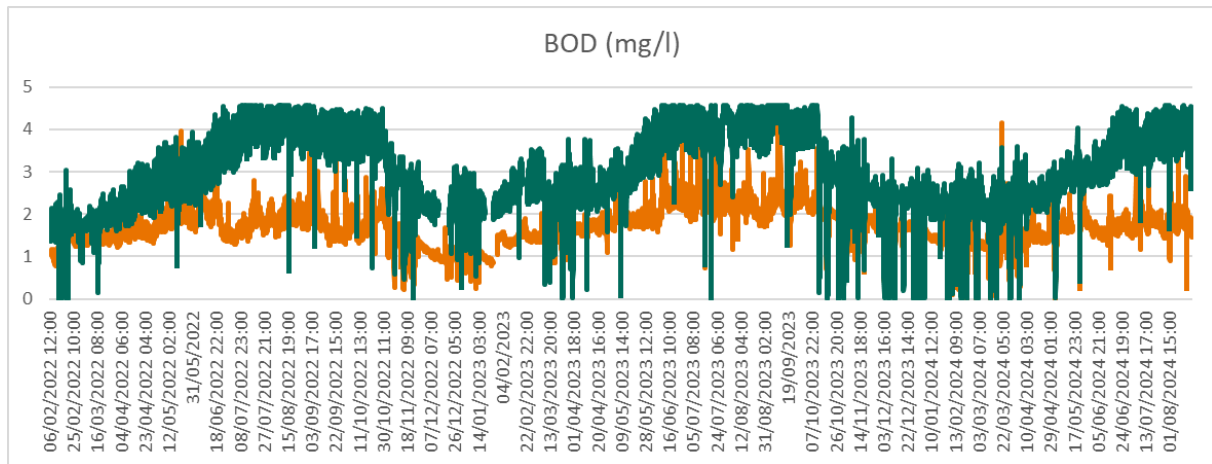
Biochemical Oxygen Demand (BOD) is a measure of the organic content of the watercourse and can be increased by the presence of agricultural wastes such as manure, or sewage discharges. It is one of the chemical components that the EA have specified in the MuW STW permit conditions (see Chapter 7).

As with dissolved oxygen, BOD is an important measure of the health of a river: when organic content breaks down, it reduces oxygen levels, and stresses the aquatic life in the watercourse. The organic matter measured as BOD also encourages algal growth, which can further deplete oxygen levels.

The BOD limits set in the Water Framework Directive (WFD) are as follows:

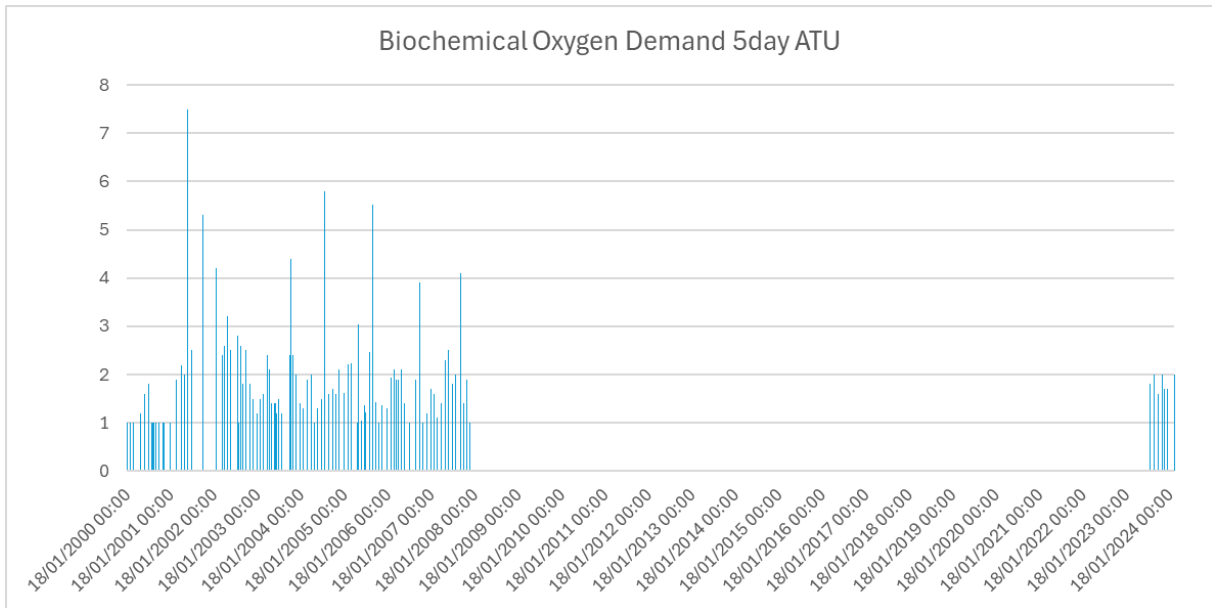
Classification	Biochemical Oxygen Demand (mg/l) 90 percentile
High	<4
Good	5
Moderate	6.5
Poor	9

**Table 3 WFD class thresholds for Biochemical Oxygen Demand (mg/l) for rivers**



**Figure 6-10 BOD readings from the sondes.**

The downstream sonde consistently reads higher than the upstream probe illustrating the influence of MuW STW discharge (Figure 7-10). There is also an obvious seasonal trend both upstream and downstream. The more exaggerated downstream trend reflects the impact of the discharge from MuW STW and the lower dilutions available in the brook during the summer when river flows are low. The picture is incomplete due to the sonde failing to read above ~4.5 mg/l. The reasons for this are being investigated.



**Figure 6-11 BOD Measurements recorded by the EA at Meadow Lane Bridge.**

Unfortunately, there is a gap in the EA samples between 2008 and 2023, so there is only a limited dataset with which to compare (Figure 7-11). The sonde BOD readings are roughly double those measured by the EA. BOD is a calculated determinant in the sonde rather than measured directly, so it is difficult to have confidence in these absolute numbers reported, though the trend daily and annual trends are obvious. Unfortunately, we have not been able to establish a good correlation between the sonde and the EA samples, due to the small number of coincident samples.

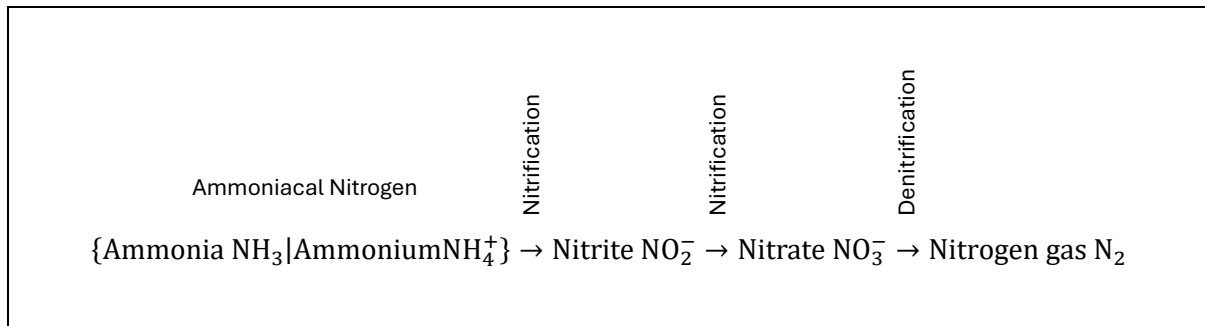
Historically, the EA have recorded elevated levels of BOD but in recent years, readings have been below 2mg/l. It is difficult to draw firm conclusions from these results, except that the intermittent sampling carried out by the EA during office hours is likely to have missed the full range of BOD fluctuations in the brook.

## 6.6 Ammonia, nitrates and nitrites

Ammonia, nitrates and nitrites are essential plant nutrients, but elevated levels can cause significant water quality problems. Sources of these nutrients in the brook include sewage and run-off from agricultural land. Excess levels can cause eutrophication leading to accelerated growth of algae and other plants. As noted, this would lead to extreme fluctuations in dissolved oxygen. During daylight hours, photosynthesis by algae and other plants can generate oxygen. However, at night, dissolved oxygen may decrease to very low levels as a result of oxygen consuming bacteria feeding on the organic matter in the stream, dead or decaying algae and other plants. This can stress fish and aquatic invertebrates, leading to a reduction in the number of healthy species present. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); However, in the effluent from STWs, it can range up to 30 mg/L.

These nitrogen compounds form part of the nitrogen cycle. A well-designed STW should accelerate the nitrogen cycle, so that the harmful components are broken down to less harmful

ones by the time they are released to the environment. A brief overview of the mechanisms involved in the nitrogen cycle is shown below.



### 6.6.1 Ammonia

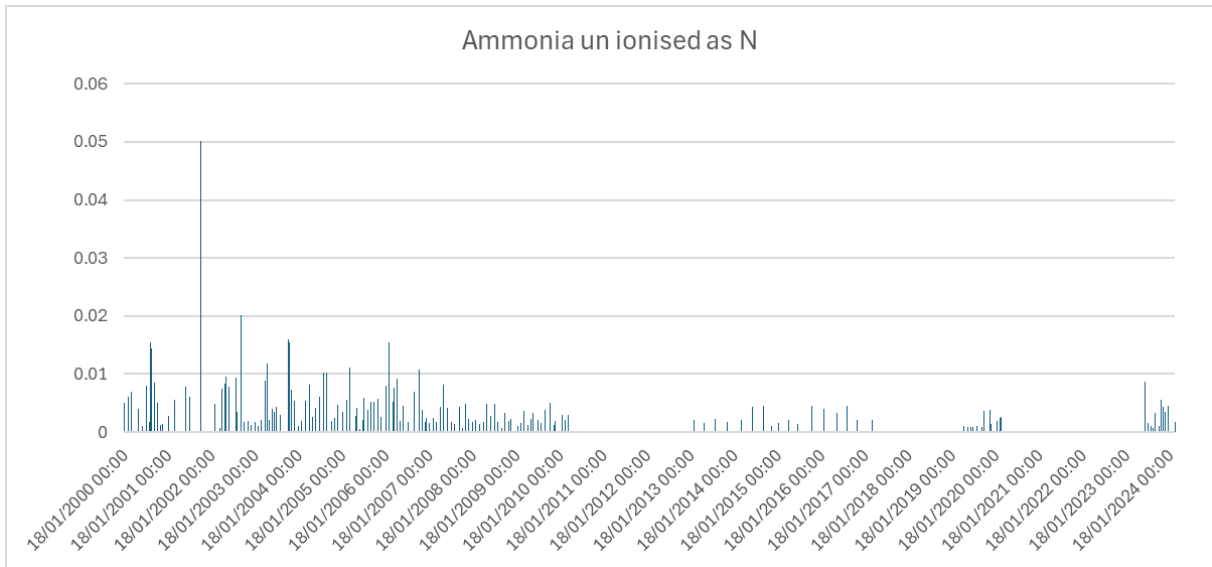
There are limits specified in the Water Framework Directive for ammonia, as listed in the table below.

Classification	Total ammonia as nitrogen (N) (mg/l) 90 percentile
High	<0.3
Good	0.6
Moderate	1.1
Poor	2.5

**Table 4 WFD class thresholds for ammonia (N) for rivers (Alkalinity 204 mg/l, 100mAOD)**

The sonde measures ammonia, but results have been excluded from this analysis as the readings are typically accurate for ~ a week to 10 days after calibration, but then tend to drift very quickly. The sonde measures ammonia by Ion Selective Electrode. Unfortunately, the Ion Selective Electrode is notoriously difficult to maintain within calibration. The data needs further processing before we can confidently report the ammonia levels from the sonde. To improve this situation, we now calibrate the sonde on a more frequent basis.

Ammonia is measured by the EA at Meadow Lane bridge and the results are presented in Figure 7-12.

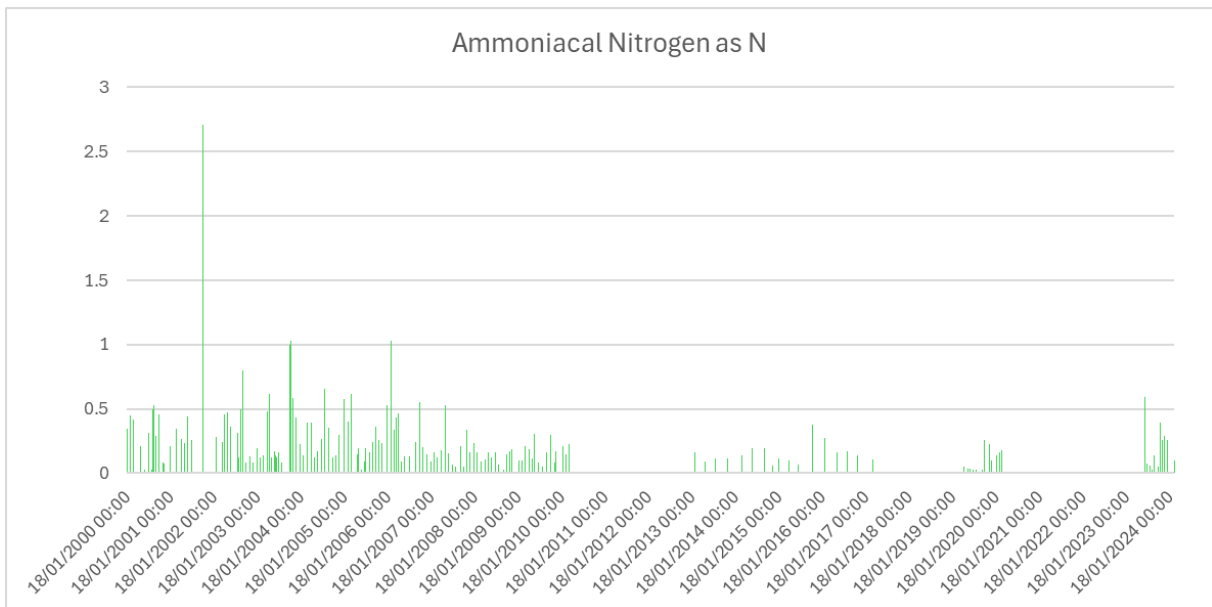


**Figure 6-12 Ammonia Measurements recorded by the EA at Meadow Lane Bridge.**

The samples taken by the EA are well below the level set by the WFD.

### 6.6.2 Ammoniacal nitrogen

Ammoniacal nitrogen includes ammonia ( $\text{NH}_3$ ) and the ammonium ion ( $\text{NH}_4^+$ ). There is no environmental quality standard set for ammoniacal nitrogen. The discharge permit limit from MuW STW is set at 4mg/l of ammoniacal nitrogen as N (see Chapter 7). The EA also measure ammoniacal nitrogen as N at Meadow Lane bridge. The EA sample results are shown in Figure 7-13.



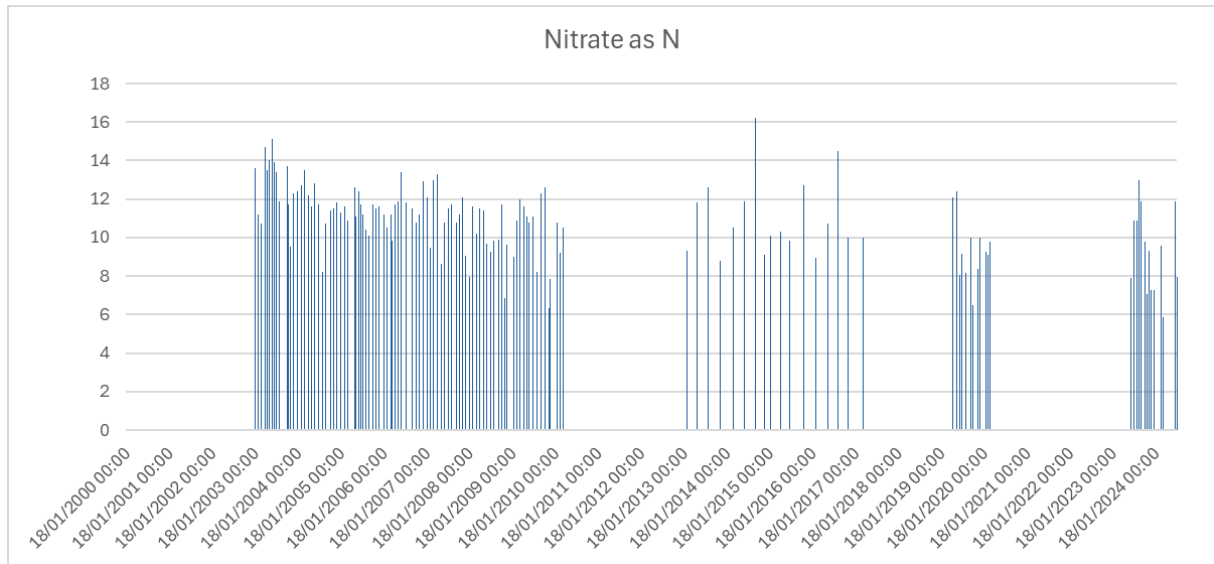
**Figure 6-13 Ammonia measurements recorded by the EA at Meadow Lane Bridge.**

The sample results show slightly elevated levels of ammoniacal nitrogen as N in Littlestock Brook, especially in historical samples. More recently the samples have typically been below 0.5mg/l. In 2023/2024 these samples have averaged 0.21mg/l, i.e., approximately 1/3 of the level measured in the discharge from MuW STW (0.61mg/l).

### 6.6.3 Nitrate

There are currently no formal nitrate standards for freshwaters within the WFD, but generally, nitrates concentrations between below 1mg/l are considered unpolluted. Nitrate concentrations between 1mg/l-2mg/l are considered moderately polluted and concentrations above 5 mg/l are considered to be polluted.

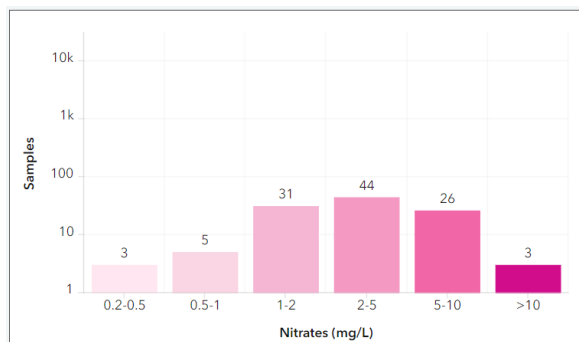
Both the EA and citizen scientists measure nitrate at Meadow Lane Bridge. The EA samples typically show nitrate concentrations of ~6 – 12mg/l.



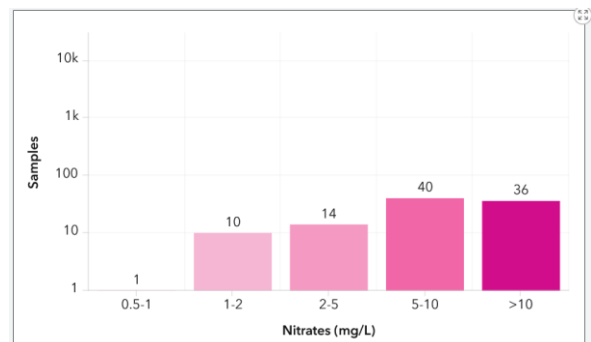
**Figure 6-14 Nitrate Measurements recorded by the EA at Meadow Lane Bridge.**

Comparing the EA’s nitrate data (Figure 6-14) with the citizen scientists’ nitrate data (Figure 7-15, right hand chart), we see that the two sets of results are consistent, and that the majority of the results downstream of the STW are in the more polluted range (‘5-10mg/l’ and ‘>10mg/l’).

The benefit of the citizen scientist FWW samples is the ability to compare upstream and downstream concentrations. Although there are some high results upstream, there is a marked increase in the frequency of high results that were recorded downstream of MuW STW. Of the 104 samples taken by citizen scientists below MuW STW, 76 showed high levels of nitrates (40+36).



citizen scientist FWW samples taken upstream of MuW STW



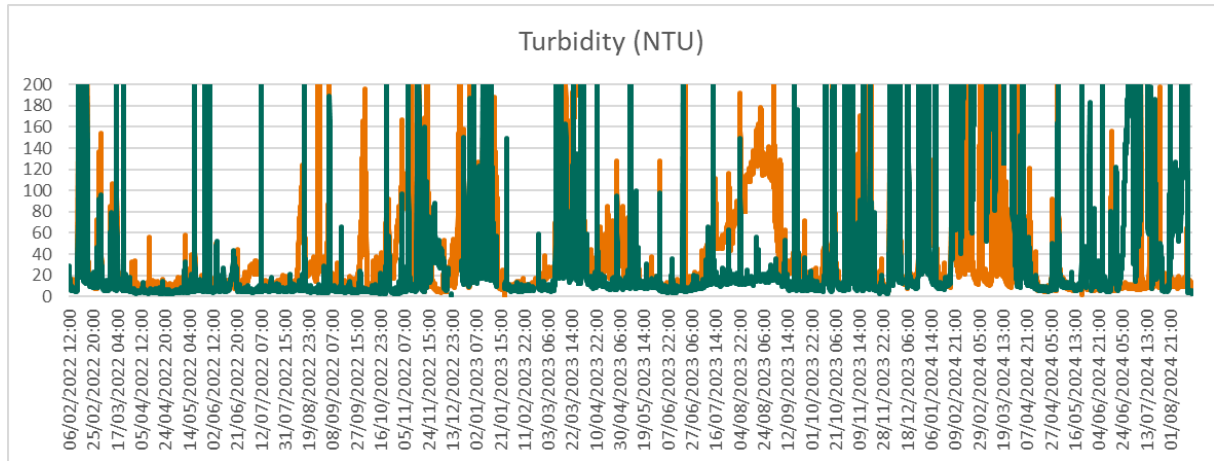
Citizen scientist FWW samples taken at Meadow Lane bridge downstream of MuW STW

**Figure 6-15 Citizen scientist samples taken upstream and downstream of MuW STW**

The results reported for ammoniacal nitrogen suggest that there is too little dilution for the STW discharge. The levels of nitrate reported suggest that there is significant nutrient pollution from

the STW. Thus, the influence of the STW can be seen in the results reported for other nitrogen species despite the low, WFD-compliant ammonia readings recorded in the Littlestock Brook.

## 6.7 Turbidity



**Figure 6-16 Turbidity readings from the sondes**

Turbidity is a measure of the “murkiness” or muddiness of the water and is measured by how much light is absorbed by particulate matter as it passes through the water. This could include for example algae, or silt from soil runoff in the catchment. Whilst rivers require some sediment for healthy functioning, excess fine sediment can settle on the river bed, reducing available habitat and smothering the species living there. Unfortunately, during storm events, the levels of sediment suspended in the watercourse can quickly overwhelm the turbidity sensor in the probe.

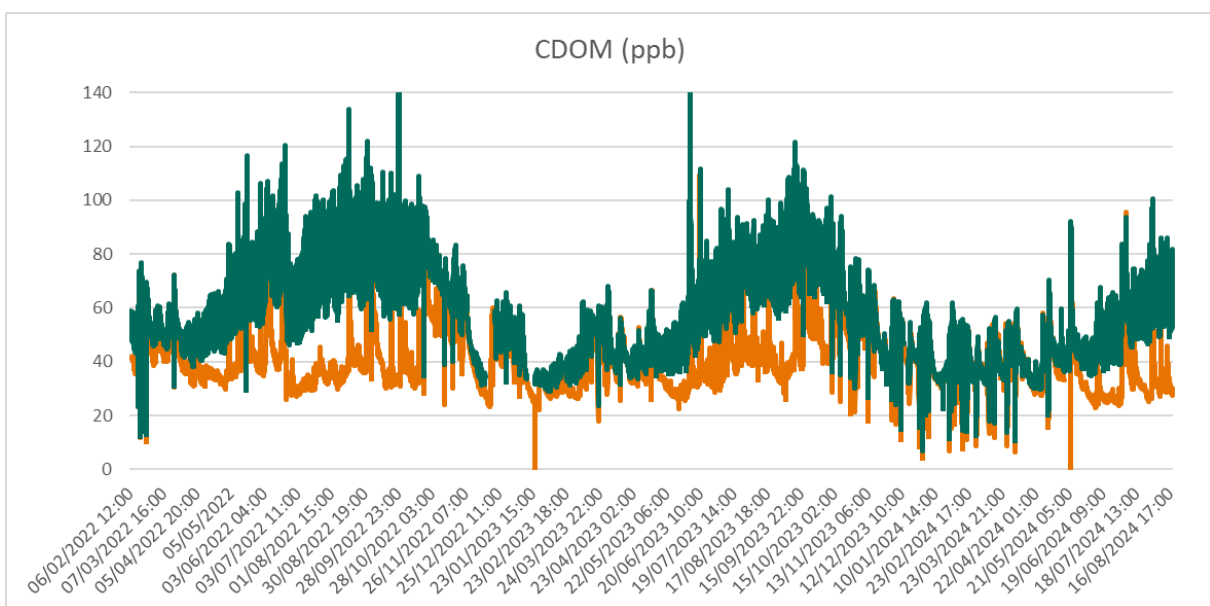
Turbidity is heavily influenced by rainfall and run-off from farmland upstream. Although significant work has already been done by farms in the area to capture this surface water run-off, these results show that further work is required to trap run-off and allow sediment to be deposited before discharge to the stream. Figure 7-17 illustrates the effects of sediment on the Littlestock Brook during a rainfall event.



**Figure 6-17 Discolouration of the Littlestock Brook upstream of MuW STW during rainfall**

### 6.8 Colorised Dissolved Organic Matter (CDOM)

CDOM is also a proxy of organic matter, similar to tryptophan. However, it relates more to fulvic-like/carbon components of the total organic matter load in the water. The sonde directly measures this component by optical means, with straightforward and well understood technology providing data at a high confidence level. There are no environmental quality standards for CDOM, but the trace shows the familiar seasonal and daily pattern discussed earlier (Figure 7-18), with the downstream trace (green) showing elevated levels of CDOM compared to upstream (orange trace). It confirms that MuW STW is a significant source of organic matter in the Littlestock Brook, and therefore the most significant contributor to the poor water quality.



**Figure 6-18 CDOM readings from the sondes.**

## 7 Milton under Wychwood STW compliance with permit

MuW STW receives sewage from the surrounding villages and treats it before discharging the final effluent to the Littlestock Brook (Figure 8-1).



**Figure 7-1 The discharge point from MuW STW into Littlestock Brook**

The discharge has to comply with a permit issued by the EA ('Control of Pollution Act' consent number 2361 – issued by the EA). This consent permit has been the subject of several variations, but the key variation of interest to this report is the one issued in 2005, which sets the following limits;-

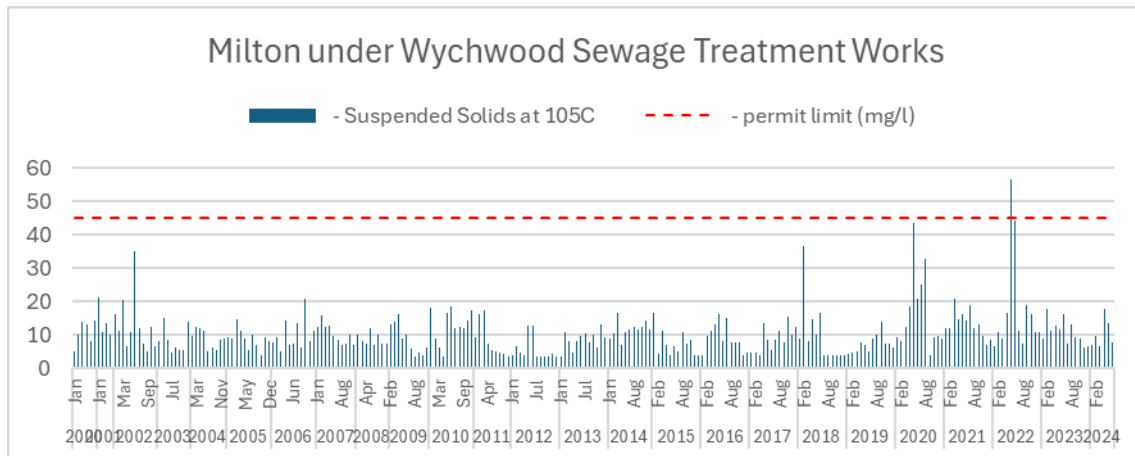
- |    |      |   |
|----|------|---|
| 7. | a)   | Subject to paragraph (b) below the Discharge shall not contain more than;   |
|    | i)   | 45 milligrammes per litre of suspended solids (measured after drying at 105° C)   |
|    | ii)  | 15 milligrammes per litre of biochemical oxygen demand (measured after 5 days at 20° C with nitrification suppressed by the addition of allyl-thiourea) |
|    | iii) | 4 milligrammes per litre of ammoniacal nitrogen (expressed as N);   |

There are other criteria in the permit, which allow Thames Water to exceed these limits under certain circumstances, but on the whole, the sewage works complies with this permit (see below).

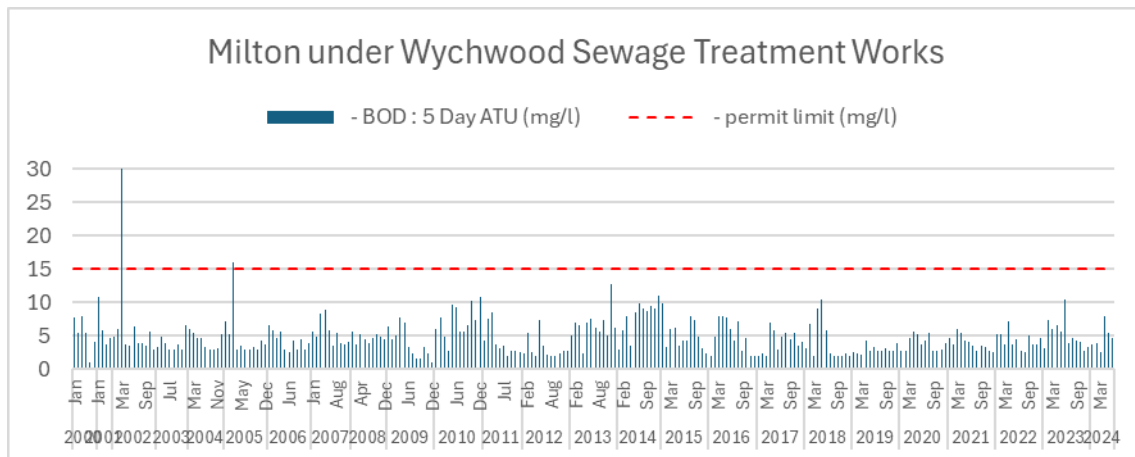
There is though one significant omission from the permit;- this is the chemical determinand phosphate - which is known to be a problem in the brook, and one of the criteria used to determine that the brook has 'Poor Chemical Status' .

Sample results for 'Biochemical Oxygen Demand' (BOD), ammoniacal nitrogen and suspended solids and how they compare to the permit limits are shown in Figures 8-2 to 8-4. Although there

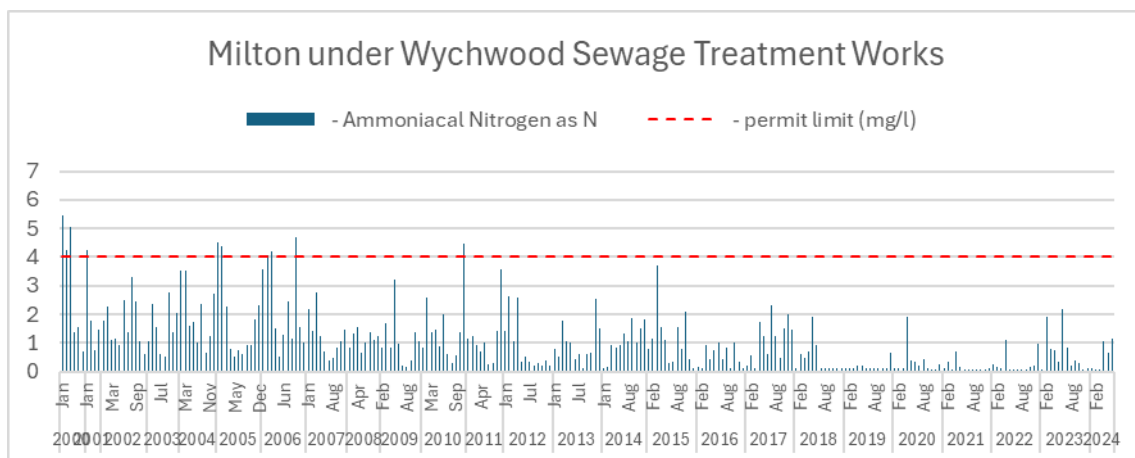
are some exceedances of the limit, on the whole the discharge is compliant with the specified conditions.



**Figure 7-2 Final effluent suspended solids (limit 45mg/l).**



**Figure 7-3 Final effluent BOD (limit 15mg/l).**



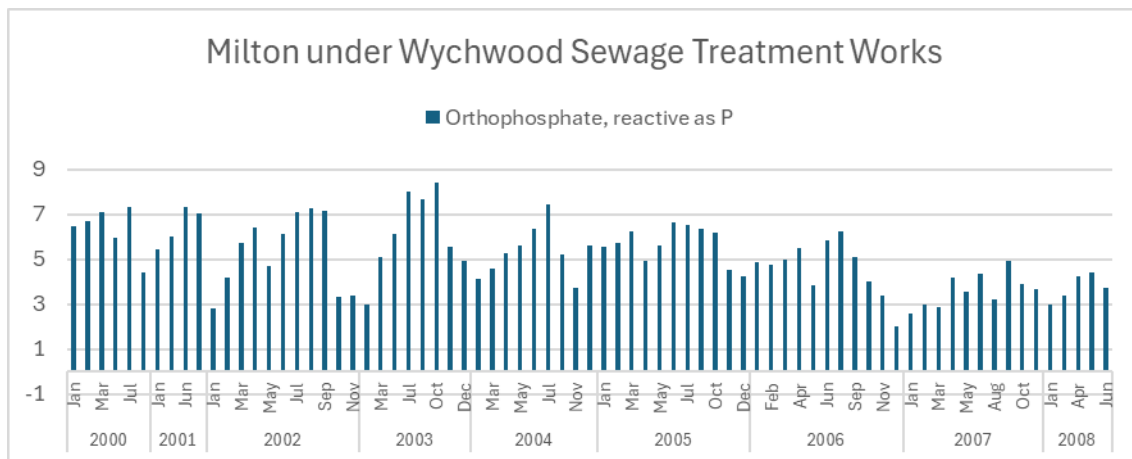
**Figure 7-4 Final effluent Ammoniacal Nitrogen as N (limit 4mg/l).**

## 7.1 Phosphate from MuW Sewage Treatment Works

As mentioned above there is no EA permit limit for phosphate from the STW.

Thames Water had previously agreed to include phosphorous stripping upgrades in their draft business plan (PR24). Upgrades to 13 sewage treatment works were included in the draft plan as recently as summer 2023. These plans were dropped from their most recent business plan that has now been formally submitted to the Ofwat for scrutiny. Thames Water's business plan (PR24) now contains **no** new sewage treatment works upgrades for the Evenlode catchment for phosphorus stripping or to meet their legal commitments under the WFD. Thames Water has also postponed 105 previously funded improvement schemes across its network, including those for Moreton-in-Marsh and MuW STW, until the 2025 – 2029 period.

There are sample results recorded from the discharge for orthophosphate as phosphate(P). Orthophosphate is sometimes referred to simply as “phosphate” or “reactive phosphorus”. In this instance (Figure 8-5), as it is reported as P, we can use that as a direct indication of the phosphate levels discharged to the Littlestock Brook.



**Figure 7-5 Final effluent Orthophosphate, reactive as P (no limit set).**

The lack of a limit for phosphates in the permit is a significant oversight by the EA, and as can be seen from results presented in this report, the STW discharge is a major source of phosphates in the catchment.

During the summer months, we are measuring phosphate levels of 1.0mg/l~1.5mg/l at Meadow Lane bridge, which is above the 0.898mg/l threshold for ‘poor water quality’ set by the WFD. Therefore, it is reasonable to conclude that the STW discharge is the main contributor to Littlestock Brook’s poor water quality status classification.

**We recommend that the EA reviews the permit and sets a phosphate limit at a concentration that protects the water quality of the brook.**

## 8 Untreated ‘Storm Overflow’ discharges from Milton under Wychwood STW

The MuW sewerage system serves a population equivalent of 4,183 with a predominantly separate sewerage network totaling some 42km in length excluding private drains and sewers. The extent of the catchment includes the villages of Idbury, Fifield, MuW, Shipton-under-Wychwood, Lyneham, Ascott-under-Wychwood and Chilson (information from Thames Water).

The STW has a consent to discharge untreated sewage during storm conditions (Permit number Temp 2776). There are three variations to this permit, the most recent issued in 2010. The permit is a common permit which applies to MuW STW Storm Overflow and 418 other such discharges operated by Thames Water. This discharge is referred to as 'Milton under Wychwood Storm Overflow' by Thames Water.

The parts of the Storm Overflow consent conditions that are of interest to this study are the three extracts from the permit (pasted below). Although the permit is not specific to the MuW Storm discharge, it is believed to consist of a 'storm tank' and 'Combined Sewer Overflow', in which case, it should only release 'storm sewage effluent resulting from rainfall or snowmelt'.

**1. Discharge from Combined Sewer Overflow or Storm Tank**

1.1 A discharge from a Combined Sewer Overflow ("CSO") or storm tank shall consist of storm sewage effluent resulting from rainfall or snowmelt into the sewerage system.

**2. Restrictions on Discharges from Combined Sewer Overflow or Storm Tank**

2.1 The discharge or discharges from a CSO or storm tank shall not so far as reasonably practicable cause significant visual or aesthetic impact due to deposit of solids on the bed or banks of the receiving watercourse, estuary or a beach, or growth of sewage fungus on the bed of the receiving watercourse.

**3. Maintenance of Combined Sewer Overflow or Storm Tank**

3.1 The overflow, and any screening system, of a CSO or storm tank shall be maintained in an effective and efficient operational condition.

3.2 Where an alarm or telemetry system is installed to provide warning of screen failure or abnormal operation of the CSO or storm tank, it shall be maintained in working order.

3.3 Where the discharge from a CSO or storm tank results in unsatisfactory solid matter being visible in the receiving waters or on the banks of the receiving waters, beach, or shoreline, in the vicinity of the outfall, the Permit Holder shall take all reasonable steps to collect and remove such matter as soon as reasonably practicable after the discharge has been reported.

#### 4. Discharges from Emergency Overflows

##### 4.1 Nature

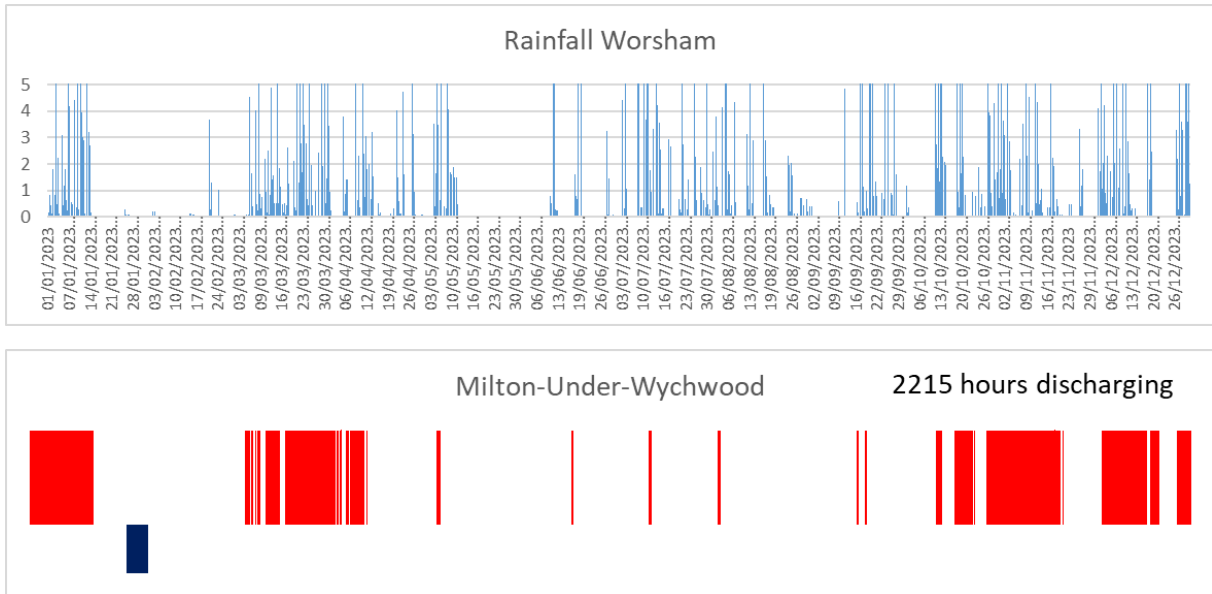
- (a) The discharge from a Pumping Station Emergency Overflow ('PSEO') shall not occur other than in an emergency and when the sewage pumping station is inoperative as a result of one or more of the following:
- (i) electrical power failure or electronic control failure not due to the act or default of the Permit Holder, its agents, representatives, officers, employees or servants;
  - (ii) mechanical breakdown of duty and standby pumps;
  - (iii) rising main failure;
  - (iv) blockage of the downstream sewer not due to the act or default of the Permit Holder, its agents, representatives, officers, employees or servants;

and it is not reasonably practicable to dispose of the sewage otherwise.

- (b) There shall be no undue delay on the part of the Permit Holder in remedying any such failure or breakdown as set out in 4.1(a) above, and any storage provided for use in an emergency shall be fully utilised before a discharge occurs.

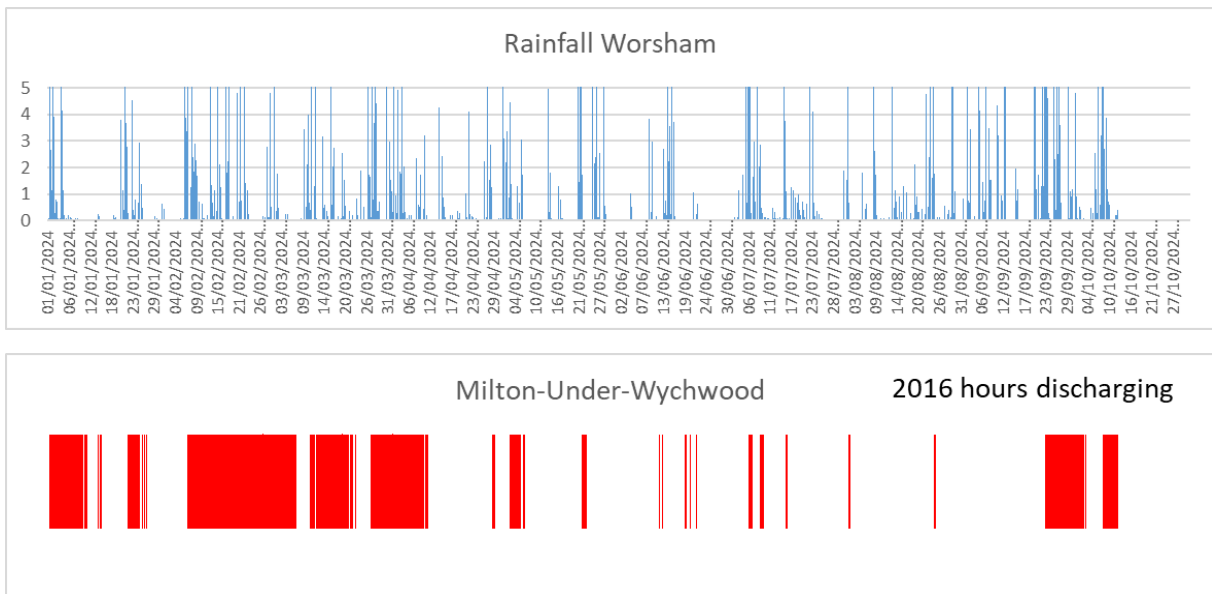
Since the end of 2022, water companies have been required to install and maintain 'Event Duration Monitors', which record how frequently and for how long (in hours) they discharge. Thames Water have made this information available on their website (<https://www.thameswater.co.uk/about-us/performance/river-health>) which shows in real time when untreated sewage is being discharged. Unfortunately, there is no indication from these monitors of the *quantity* of untreated sewage discharged, which would be useful in order to fully understand the impact of these releases.

From Figures 9-1 and 9-2 it is obvious that this storm sewage overflow operates far more frequently than would be expected. The overflow operated for over 2,200 hours in 2023 and over 2,000 hours between January and October 2024. The MUW storm sewage overflow has the highest number of discharge hours in the Evenlode catchment. The Storm Overflow discharges untreated sewage far more frequently than could be explained by 'storm sewage effluent resulting from rainfall or snowmelt'.



**Figure 8-1 Storm Overflow operation during 2023.**

Dates are aligned vertically between Rainfall at Worsham mill and MuW STW Storm Overflow discharge operation (Red bars indicated untreated sewage being discharged, blue bars indicate that the 'Event Duration Monitor' was offline).



**Figure 8-2 Storm Overflow operation from January 2024 to October 2024.**

Dates are aligned vertically between Rainfall at Worsham mill and MuW STW Storm Overflow discharge operation (Red bars indicated untreated sewage being discharged, blue bars indicate that the 'Event Duration Monitor' was offline).

Thames Water claims in their “Milton under Wychwood Groundwater Impacted System Management Plan”<sup>2</sup>.that the Storm Overflow discharges far more frequently than designed because of ‘Groundwater Infiltration’ inundating the sewers. The relevant text is shown below.

*“In conclusion, we believe it is likely that groundwater infiltration in the Milton-under-Wychwood catchment is the most probable cause of incidences where the sewage treatment works has not been able to cope with all incoming flows, triggering spills to the storm tanks in periods of dry weather.*

*On occasions, where the incoming flow has exceeded treatment capacity for sustained periods, the storm tanks have become overloaded and spill to river has occurred on both wet and dry days.*

*Anticipated unavoidable discharges*

*Within recent years there have been unplanned unconsented unavoidable discharges in the network as a result of surcharging manholes causing pollution incidents. This has been as a direct result of the influence of groundwater infiltration.*

*We anticipate that this situation may continue until such time we are able to implement a long-term solution.”*

This statement seems at odds with the requirements of the storm overflow permit conditions, but does not appear to have resulted in any formal action being taken by the EA. The final paragraph also suggests that Thames Water do not feel any urgency in needing to make the investment required to rectify the situation and protect the Littlestock Brook.

**If there is insufficient capacity in the sewerage system and sewage works to prevent these frequent discharges of untreated sewage, we would expect Thames Water to do work to rectify the situation. There should certainly not be any further development in the area until this work is done, as further development would continue to exacerbate the situation.**

**We expect the EA to enforce the conditions of the Storm Overflow Permit.**

## **9 Conclusions**

The classification of Littlestock Brook as being of ‘poor water quality’ is confirmed by this analysis. The main reason for this classification is elevated levels of phosphates in the brook, and the main source of these phosphates is identified as WuW STW. This is despite MuW STW being able to comply with the environmental permit conditions set by the EA.

There is insufficient dilution available in the brook to absorb the flow and concentration of pollutants that are discharged from the STW, even when all of the flow to the works is processed and treated to the permit standards. This situation is exacerbated in the summer months when the flow in the brook is low but the STW discharge remains steady. The EA environmental discharge permit conditions for the treated sewage effluent discharge from the STW are too lax to protect the water quality of Littlestock Brook and need to be tightened to protect the brook.

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<sup>2</sup> <https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-reports/groundwater-infiltration-management-plans/milton-under-wychwood-groundwater-infiltration-management-plan.pdf>

Specifically, the environmental discharge permit conditions for the treated sewage effluent discharge from MuW STW do not contain any limits for phosphate, and this is a significant omission for the protection of the brook.

As well as the treated sewage effluent discharge, the works also has a permit to release untreated sewage in storm conditions. There is insufficient capacity in the sewerage system and sewage works to treat the full flow to the STW and this leads to frequent use of the storm overflow to release untreated sewage into the Littlestock Brook. These untreated sewage discharges exceed 2,200 hours per year, with some of these hours of spilling in dry weather, which is non-compliant with the permit (i.e. discharging illegally). The capacity of the STW needs to be increased, so that the full flow to the works can be treated.

On the basis of the findings of this report, we recommend that;

- **There should not be any further development in the area served by MuW STW, until the STW is upgraded to treat all of the flow, and the treatment process is enhanced to ensure that the quality of the effluent discharged does not harm the brook.**
- **The EA reviews the permit and sets tighter limits that protect the water quality and ecology of the brook. This will require enhancements to MuW STW, to include improved quality and quantity of treatment.**
- **The EA sets a phosphate limit in the STW discharge permit at a level that protects the water quality of the brook. This will require enhancements to MuW STW, to include phosphate stripping.**
- **The EA to enforce the conditions of the Storm Overflow Permit in order to ensure Thames Water makes the required improvements to the sewage system and the STW to stop the unpermitted untreated sewage discharges.**

## 10 References

- 1) Evenlode Catchment Partnership annual water quality report for 2023
- 2) <https://miltonunderwychwood-pc.gov.uk/wp-content/uploads/2021/08/MuW-NP-Appendix-12-EA-review-of-Littlestock-Brook-1.pdf>
- 3) Robotham, J., Old, G., Rameshwaran, P., Sear, D., Trill, E., Bishop, J. et al. (2023) Nature-based solutions enhance sediment and nutrient storage in an agricultural lowland catchment. *Earth Surface Processes and Landforms*, 48(2), 243–258. Available from: <https://doi.org/10.1002/esp.5483258> ROBOTHAM ET AL .
- 4) Water Framework Directive implementation in England and Wales: new and updated standards to protect the water environment May 2014. <https://assets.publishing.service.gov.uk/media/5a7f00e740f0b62305b84861/river-basin-planning-standards.pdf>
- 5) [https://oxfordrivers.ceh.ac.uk/data/understanding-the-data/water\\_quality](https://oxfordrivers.ceh.ac.uk/data/understanding-the-data/water_quality)

## 11 Appendices

**Appendix 1 UK TAG 'Water Framework Directive implementation in England and Wales: new and updated standards to protect the water environment May 2014'**

**Table 5.1a: Summary of existing and revised standards for phosphorus in rivers**

Type (for existing standards)	Annual mean of reactive phosphorus ( $\mu\text{g}$ per litre)							
	High		Good		Moderate		Poor	
	Existing	New	Existing	New	Existing	New	Existing	New
Lowland, low alkalinity	30	19 (13-26)	50	40 (28-52)	150	114 (87-140)	500	842 (752-918)
Upland, low alkalinity	20	13 (13-20)	40	28 (28-41)	150	87 (87-117)	500	752 (752-851)
Lowland, high alkalinity	50	36 (27-50)	120	69 (52-91)	250	173 (141-215)	1000	1003 (921-1098)
Upland, high alkalinity	50	24 (18-37)	120	48 (28-70)	250	132 (109-177)	1000	898 (829-1012)

**Notes:**

- The revised standards illustrated are the medians from, respectively, 456 lowland, high alkalinity sites; 129 upland high alkalinity sites; 137, lowland, low alkalinity sites; and 97 upland, low alkalinity sites. The numbers in parentheses are the upper and lower 5th and 95th percentiles of the standards for the sites in each type.
- "Lowland" means less than or equal to 80 metres above mean sea.  
"Upland" means more than 80 metres above mean sea level.  
"Low alkalinity" with a concentration  $\text{CaCO}_3$  of less than 50 mg per litre.  
"High alkalinity" with a concentration  $\text{CaCO}_3$  of greater than or equal to 50 mg per litre.

## Appendix 2 Citizen Scientist Riverfly data



<b>Species abundance (score) trends 2018 - 2023</b>						
<b>Upstream</b>	date	score	<b>Downstream</b>	date	score	
2017	03/10/2017	<b>3</b>	2017	02/10/2017	<b>1</b>	
				06/08/2017	<b>3</b>	
		<b>3</b>	divided by 1 = <b>3</b>		<b>4</b>	Divided by 2 = <b>2</b>
<b>Upstream</b>	date	score	<b>Downstream</b>	date	score	
2018	31/12/2018	<b>4</b>	2018	31/12/2018	<b>7</b>	
	31/10/2018	<b>4</b>		29/10/2018	<b>2</b>	
	17/08/2018	<b>5</b>		17/08/2018	<b>1</b>	
	30/06/2018	<b>6</b>		30/06/2018	<b>2</b>	
	29/04/2018	<b>7</b>		26/04/2018	<b>6</b>	
	02/02/2018	<b>8</b>		01/02/2018	<b>7</b>	
		<b>34</b>	divided by 6 = <b>5.66</b>		<b>25</b>	divided by 6 = <b>4.16</b>
<b>Upstream</b>	date	score	<b>Downstream</b>	date	score	
2019	30/12/2019	<b>5</b>	2019	30/12/2019	<b>5</b>	
	31/10/2019	<b>7</b>		31/10/2019	<b>5</b>	
	23/08/2019	<b>4</b>		23/08/2019	<b>5</b>	
	30/06/2019	<b>7</b>		30/06/2019	<b>5</b>	
	27/04/2019	<b>10</b>		26/04/2019	<b>5</b>	
	23/02/2019	<b>5</b>		23/02/2019	<b>3</b>	
		<b>38</b>	divided by 6 = <b>6.33</b>		<b>28</b>	divided by 6 = <b>4.66</b>
<b>Upstream</b>	date	score	<b>Downstream</b>	date	score	
2020	14/11/2020	<b>6</b>	2020	13/11/2020	<b>4</b>	
	01/09/2020	<b>5</b>		31/08/2020	<b>3</b>	
	25/06/2020	<b>5</b>		15/07/2020	<b>2</b>	
	30/04/2020	<b>6</b>		29/04/2020	<b>4</b>	
		<b>22</b>	divided by 4 = <b>5.5</b>		<b>13</b>	divided by 4 = <b>3.25</b>

<b>Upstream</b>	date	score	<b>Downstream</b>	date	score	
2021	29/09/2021	<b>5</b>	2021	26/09/2021	<b>2</b>	
	31/03/2021	<b>5</b>		01/04/2021	<b>5</b>	
		<b>10</b>	Divided by 2 = <b>5</b>		<b>7</b>	Divided by 2 = <b>3.5</b>
<b>Upstream</b>	date	score	<b>Downstream</b>	date	score	
2022	25/07/2022	<b>4</b>	2022	25/07/2022	<b>1</b>	
	16/01/2022	<b>8</b>		25/07/2022	<b>2</b>	
				16/01/2022	<b>6</b>	
<b>Upstream</b>	date	score	<b>Downstream</b>	date	score	
2023	12/09/2023	<b>4</b>	2023	11/09/2023	<b>5</b>	
	21/04/2023	<b>7</b>		21/04/2023	<b>5</b>	
	30/01/2023	<b>7</b>		30/01/2023	<b>6</b>	
		<b>18</b>	divided by 3 = <b>6</b>		<b>16</b>	divided by 3 = <b>5.33</b>