RECLAIM OUR RIVERS:

MILL MEADOWS, HENLEY-ON-THAMES

Citizen Science Water Quality Sampling Final Report 2023

Photo credit: Ryan Davies

Prepared by Aggie Hodges, Thames21, reviewed by colleagues at Thames21

The Reclaim our Rivers Project is kindly funded by Garfield Weston Foundation and The Fishmongers' Company, with sampling services provided by Thames Water.

Contents

Executive Summary

What is the Henley-on-Thames Bathing Waters Project?

More people than ever are connecting with their local waterways and greenspaces, with a countrywide rise in the number of people taking to their local river for recreation and exercise. The health of our inland waterways has garnered increasing media attention in recent years, leading to an awareness that open waters may not provide safe swimming spaces due to poor water quality. Meanwhile, there is a lack of information available to the public providing up-to-date, localised water quality results. This has been evident in Henley-on-Thames and the surrounding areas of South Oxfordshire. The river Thames is a treasured cultural and natural asset to the town: there is a long history of river swimming and rowing and a large presence of tourist boat tours as well as mooring boat users. Thousands of competitors also compete in annual regatta and swimming races, such as the Club to Pub race which takes swimmers on a route directly through the proposed bathing water site at Mill Meadows, and has taken place since 2014, when participant numbers reached 154. The event has grown in popularity, with tickets selling out within days, and participant numbers reaching 545 in 2023. This event is part of a long history of river swimming in Oxfordshire, and locals across the county have shown demand for a cleaner, healthier river, as evidenced by the successful Bathing Water designation at Port Meadow in Oxford in 2022.

Bathing Water Designations are a means to create more clean, safe outdoor swimming and bathing sites. Such sites are tested weekly throughout the bathing season, allowing users to better understand the risks and make informed choices. Designation also helps to increase pressure and direct investment from water companies for improvements required for healthier rivers. Thames21 has worked with the local authorities and the local community throughout 2023 to prepare and put forward an application to attain bathing water status for the popular swimming destination of Mill Meadows, Henley-on-Thames. This project involved weekly sampling at six sample points between Henley-on-Thames and Reading, community and stakeholder consultations, and user surveys taken throughout the bathing season. The principal goal of the water quality sampling was to assess the prospective bathing water site as well as the 5 other sample points, mostly upstream, against the Bathing Water Regulations (2013) standard for FIO ('Faecal Indicator Organisms') levels in inland waters, which the Environment Agency uses to assess and classify designated bathing water quality. The results of this rigorous water quality sampling are also likely to provide clues to the primary sources of the FIOs (e.g. diffuse agricultural inputs, treated sewage effluent, untreated sewage discharges).

This report presents the findings of the 2023 bathing water quality sampling, evaluates the potential causes of pollution, and recommends further action needed to ensure our rivers are healthy enough to swim in.

Water Quality Sampling 2023

Water quality sampling during the bathing season monitored levels of 'Faecal Indicator Organisms' (FIOs), here meaning the bacteria Escherichia coli (EC) and Intestinal Enterococci (IE). These bacteria indicate faeces and urine of warm-blooded animals and are a significant threat to human health. The most common risks being gastrointestinal illnesses, and infections of the eyes, ears, skin, and kidneys, caused by ingestion or intake of polluted water through open cuts and wounds.

Key findings

1. Average levels of EC were higher than the recommended safe levels at all sample points except sample point F – Reading which was 'Sufficient'. The worst results were at sample point D – Loddon with an average of over 23 times higher than considered safe according to the public health standards set out in Bathing Waters Directive (2013)
2. Average levels of IE were higher than the minimum standard of sufficient at all sample points. Once again, sample point D – Loddon saw the worst results with an average of over 7 times higher than the minimum sufficient standard.
3. Increases in FIO levels mainly correlated with rainfall events and event duration monitoring (EDM) spills and showed hallmarks of point source impacts, yet continued presence of FIO levels even during dry periods suggest diffuse inputs are also affecting all sample point sites.

Recommendations

- Wargrave Sewage Treatment Works (STW), where a particularly heavy load of FIOs have been identified in the river, likely to be caused by treated effluent (23 times the level sufficient for bathing), should be investigated further and asset improvements prioritised.
- Following the designation of Mill Meadows, Henley-on-Thames as a designated bathing site, we recommend higher resolution sampling to determine sources of FIOs affecting this site e.g. simultaneous sampling at several sample points between Henley-on-Thames and Reading, including tributaries and distributaries. This could incorporate both spot sampling and real time probes, and eDNA tracing would also help to evidence source apportionment.

Project Methodology

Sampling locations

6 sample points (figure 1) were chosen to best identify the possible sources of pollution, such as sample point D – Loddon Drive Bridge, just downstream of the Wargrave Sewage Treatment Works, and sample point E – Sonning Bridge which is downstream of stormwater discharge outfalls at Blakes Lock and Caversham in Reading. Where possible, bridges were chosen to allow access to sample the centre of the river channel.

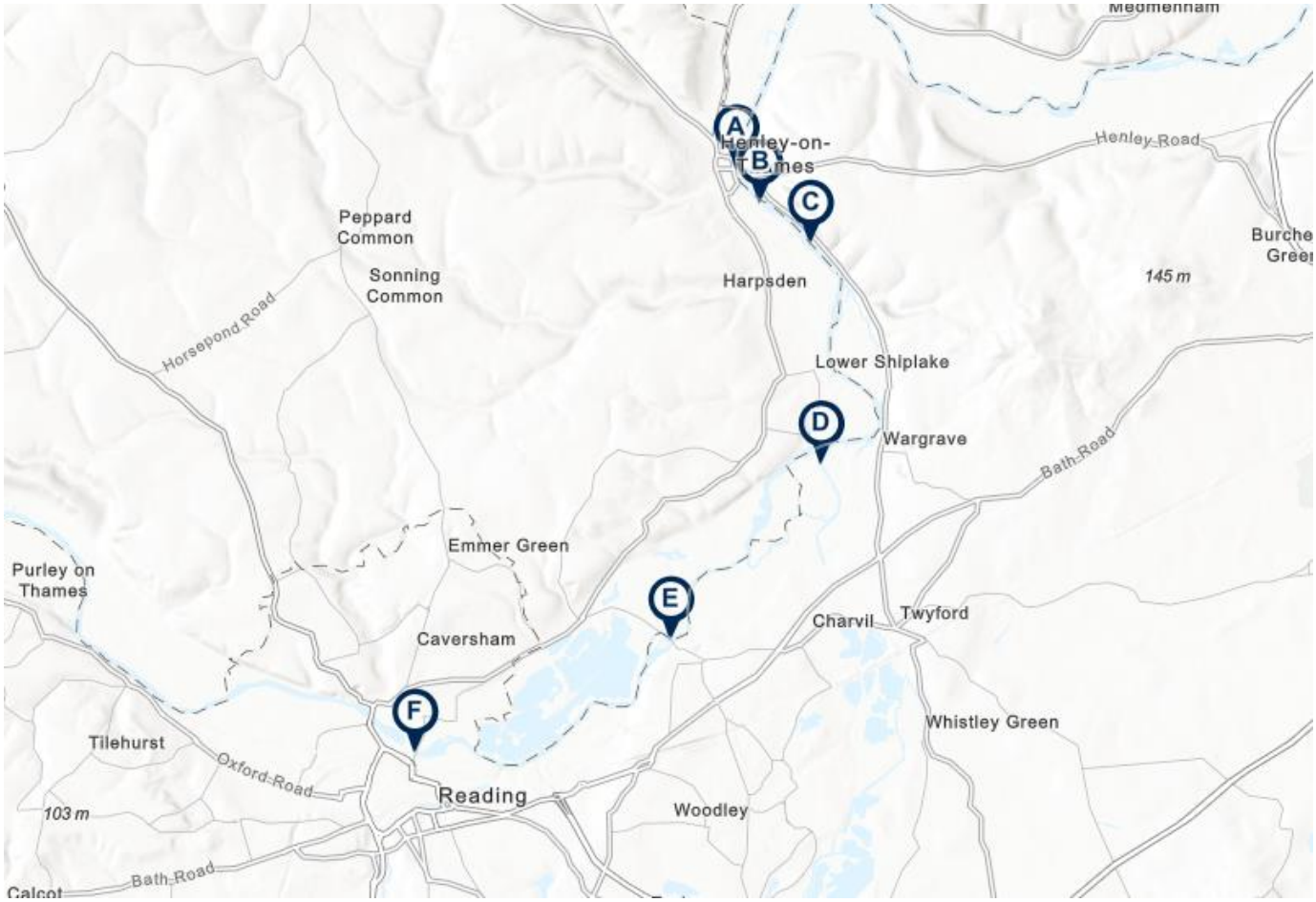


Figure 1 - Locations of sampling points

Sampling frequency and methodology

Weekly sampling was carried out at the 6 sample points by trained citizen scientists during the bathing water season (15th May - 30th September 2023). Citizen scientists were trained in 2023 to use an aseptic sampling protocol developed by TH Environmental Ltd for The Rivers Trust (see appendix 1). Samples were analysed at Thames Water's accredited laboratory in Reading using a standard culturing method for bacteria species E Coli and intestinal enterococci. The results obtained were compared to the standards for bathing waters set out in the Bathing Waters Directive (2013) as shown in Table 1.

Table 1 - Standards for inland bathing waters (Harris 2022; Sargaduy et al. 2019)

Parameter	"Excellent"	"Good"	"Sufficient"
Intestinal enterococci[1]	200[2]	400[2]	330[3]
Escherichia coli[1]	500[2]	1,000[2]	900[3]

(1) Colony forming units per 100 millilitres ("cfu/100 ml").
(2) Based upon a 95-percentile evaluation
(3) Based upon a 90-percentile evaluation

Levels of rainfall, as well as the ratio of E.Coli (EC) and Intestinal Enterococci (IE) are important factors in understanding the origins of the FIOs for each sample point. Due to the different survival rates of Intestinal

Enterococci (IE) and Escherichia coli (EC), in this study an EC:IE ratio of 2:1 to 4:1 is assumed to be indicative of point source inputs (e.g. untreated sewage, either from storm overflows or partially treated final effluent) whereas a EC:IE ratio closer to 1:1 is associated with diffuse inputs (e.g. livestock excreta, misconnections). These ratios can help point towards an indication of the source of the faecal indicator organisms, although further monitoring and research is needed to better evidence those sources (Harris 2022).

Sample analysis

All samples were analysed for presence of Total Coliforms (TC), the bacteria Escherichia coli (EC) and Intestinal Enterococci (IE) at Thames Water's accredited laboratory using methods laid out in the Microbiology of Drinking Waters (2018). The method used to analyse samples for EC and TC was the multiple tube method 'Colilert' producing a confirmed result within 18-24hrs. The method used to analyse samples for IE was a 0.45-micron membrane filtration onto selective media (Slanetz & Bartley 1957), producing a confirmed result within 40-48hrs. All samples were carefully handled, and analysed on the same day as they were sampled as per requirements laid out in the Bathing Water Regulations (2013) (Harris 2022).

Statistical analysis

All results obtained are required to be statistically analysed and converted to a "percentile value" based on a percentile evaluation of the log10 normal probability density function of microbiological data used for the assessment as detailed in the Bathing Water Regulations (2013).

To be able to derive a percentile value the following method (Harris 2022) was followed:

a) take the log10 value of all bacterial concentrations in the data sequence to be evaluated or, if a zero value is obtained, take the log10 value of the minimum detection limit of the analytical method used.
b) calculate the arithmetic mean ("μ") of the log10 values taken under paragraph (a);
c) calculate the standard deviation ("σ") of the log10 values taken under paragraph (a);
d) derive the upper 90-percentile point of the data probability density function from the following equation: upper 90-percentile = antilog (μ + 1.282 σ); and
e) derive the upper 95-percentile point of the data probability density function from the following equation: upper 95-percentile = antilog (μ + 1.65 σ).

The conversion to a "percentile value" is done on all collated EC and IE results obtained from the sample point over a defined period, the obtained result is then compared against the outlined water quality (table. 2).

Table 2 - Bathing water quality designations (Source: Harris, T 2022)

	E.coli		
	BW status	**Levels**	**Percentile**
	Excellent	500	95
	Good	1000	95
	Sufficient	900	90
	Poor	>900	90
	Enterococci		
	BW status	**Levels**	**Percentile**
	Excellent	200	95
	Good	400	95
	Sufficient	330	90
	Poor	>330	90

Results & Analysis

Rainfall impact

Rainfall can negatively impact FIO levels in rivers. Heavy rainfall can increase agricultural inputs entering the river, cause storm overflow and combined sewers overflows (CSO) to spill, and negatively impact sewage treatment works' capacity.

The highest rainfall recorded this bathing season at Reading University rainfall monitor was on 20.09.23 at 33.46mm. The month with the highest total rainfall recorded at Reading University was July with total rainfall at 102.19mm and a daily average of 3.30mm (see table 5).

Table 3- monthly precipitation recorded at Reading University rainfall monitor (DEFRA N.D)

Monthly precipitation (mm)	Averages	Totals
May	0.01	0.19
June	1.91	57.36
July	3.30	102.19
August	2.25	69.64
September	2.83	84.75

To assess the impact of rainfall events on sampled FIO levels in rivers, rainfall data must be analysed to determine whether precipitation occurred up to 72 hrs before the sampling was done. Prior to 72hrs before the sampling, the impact of a rainfall event is negligible on FIO levels due to their lifespan within the river. EC and IE have variable survival periods when outside of the host body, with EC surviving between 36-48 hrs and IE between 72-96 hrs in both a terrestrial and aquatic environment when variables such as solar degradation and temperatures are accounted for (Harris 2022).

As table 4 depicts, rainfall events of varying precipitation levels occurred shortly before or during sampling on 13 out of 20 dates. Notable rainfall events include 04.07.23, on which 28.99mm precipitation occurred, 1.08.23, when 14.92mm precipitation occurred in the 72 hours preceding and on the sampling date, and finally on 21.09.23, which saw 34.5mm precipitation in the preceding 72 hours and 4.6mm precipitation on the day of sampling. As figures 2-13 demonstrate, these rainfall events correlate regularly with increases in FIO levels at all sample points. Given that the closest rainfall monitor to the 6 sample points was at Reading University, it is likely that the most accurate correlation of rainfall events to FIO and spill data is at sample point F, Christchurch Bridge.

Table 4 - Rainfall event details correlating to sampling dates

Precipitation (mm)		
Sampling date	Preceding 72 hrs	On sampling day
16.6.23	0	0.01
19.6.23	0.23	16.32
4.7.23	0.04	28.99
12.7.23	2.87	0
21.7.23	0.02	0.06
28.7.23	13.6	0
1.8.23	10.4	4.52
9.8.23	6.24	0
14.8.23	4.68	0.24
2.9.23	10.1	0
15.9.23	7.98	0
21.09.23	34.5	4.6
29.9.23	8.66	0

Spill correlation

Thames Water event duration monitoring (EDM) data was plotted against rainfall data and FIO levels during the bathing water sampling period. When looking for correlation of spills, spill data was assessed against the following criteria:

- Was the spill no more than 72 hours before the date of sample?
- Did the correlation pattern show a significant increase in EC and IE levels, causing bathing water (BW) status to fall to 'Poor'?

EDM spills at Friday St CSO, Wargrave STW and Reading STW correlate closely with the rainfall events described above. This is especially true for 20.09.23 on which heavy rain appeared to trigger spills at all 3 sample points (see figures 2-13).

Sample point A: Henley Bridge

Table 5– Sample point A: overall bathing water status at 90th & 95th percentile

E.coli			overall status
90 PERCENTILE	6164.48	Poor	Poor
95 PERCENTILE	9936.94	NA	

Enterococci			overall status
90 PERCENTILE	917.52	Poor	Poor
95 PERCENTILE	1476.30	NA	

Table 6 – Sample point A: weekly breakdown of results

Sample ID	Date	Sample Point	E.coli (EC) MPN/100ml	Enterococci cfu/100ml	Weekly E.coli status	Weekly Enterococci status
F10591974	15/05/2023	A	727	190	Good	Good
F10591979	24/05/2023	A	548	74	Good	Good
F10591985	01/06/2023	A	260	23	Good	Good
F10591991	06/06/2023	A	543	47	Good	Good
F10592000	16/06/2023	A	921	50	Good	Good
F10592006	19/06/2023	A	816	55	Good	Good
F10592012	27/06/2023	A	980	95	Good	Good
F10592018	04/07/2023	A	1733	88	Poor	Good
F10582024	12/07/2023	A	100	87	Good	Good
F10592032	21/07/2023	A	2000	172	Poor	Good
F10592060	28/07/2023	A	4000	161	Poor	Good
F10592066	01/08/2023	A	2000	820	Poor	Poor
F10592072	09/08/2023	A	5000	550	Poor	Poor
F10592078	14/08/2023	A	4000	1750	Poor	Poor
F10592037	22/08/2023	A	2420	160	Poor	Good
F10591997	02/09/2023	A	3000	970	Poor	Poor
F10592089	06/09/2023	A	100	370	Good	Good
F10592046	15/09/2023	A	517	38	Good	Good
F10592052	21/09/2023	A	20000	2000	Poor	Poor
F10592059	29/09/2023	A	1300	250	Poor	Good

At sample point **A**, FIO levels deteriorated as the season continued, with heavy rainfall in late September appearing to cause a dramatic increase in both bacteria on 21.09.23. This, and the upwards spike in FIO levels on 09.08.23 also appear to correlate to EDM spills at Wargrave and Reading STWs, with the ratio of EC:IE showing hallmarks of point source impacts heavily affecting water quality. Although this sample point is upstream of the combined sewage overflow (CSO) at Friday Street, it is within 100m distance so likely to impact water quality, especially given the frequent boat traffic and consequent flow turbulence, and this appears to be the case on 02.09.23. Overall EC levels were over 6x the minimum sufficient standard at the 90th percentile. IE levels at this sample point were over 3x the sufficient standard.

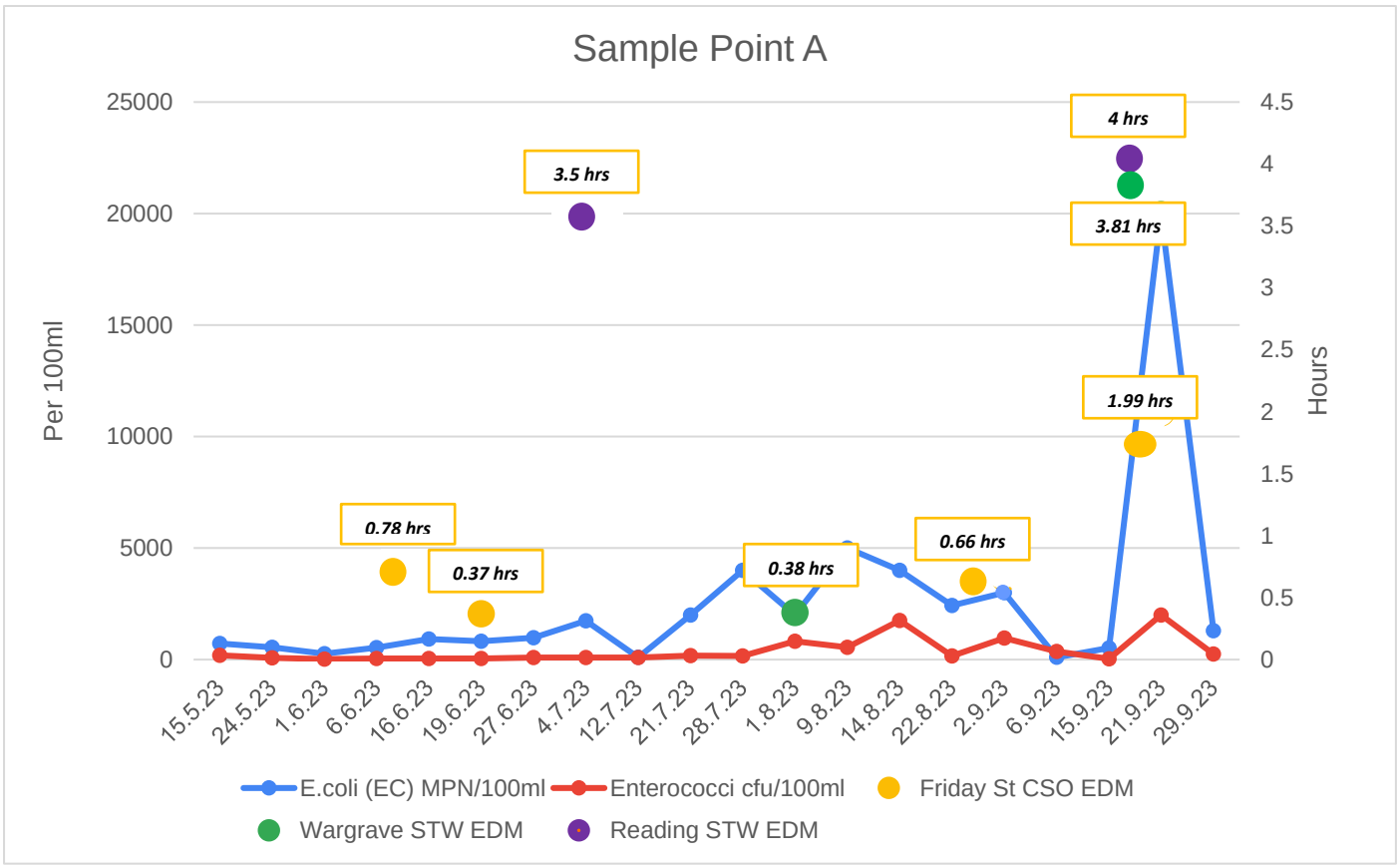


Figure 2- FIO Levels with EDM spill correlations, sample point A

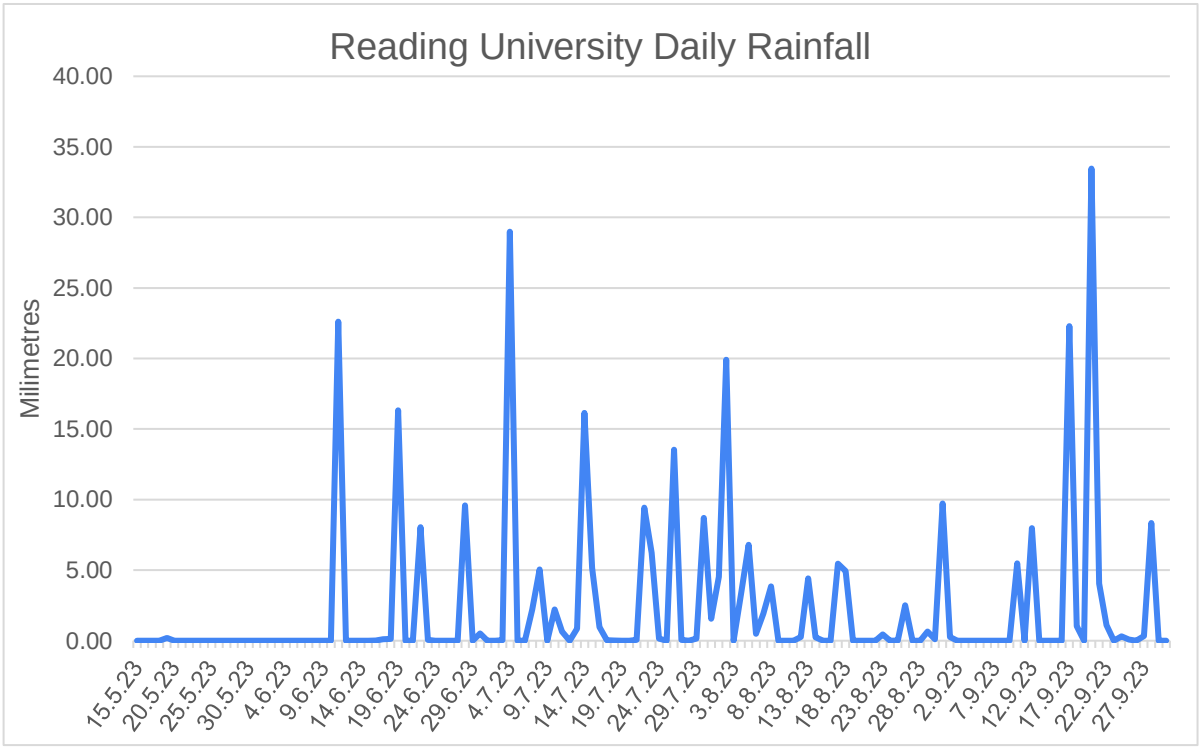


Figure 3 - Daily rainfall at Reading University rainfall monitor

Sample point B: Mill Meadows Bathing Water Site

Table 7 - Sample point B: overall bathing water status at 90th & 95th percentile

E.coli			overall status
90 PERCENTILE	5196.68	Poor	Poor
95 PERCENTILE	7160.17	NA	

Enterococci			overall status
90 PERCENTILE	844.46	Poor	Poor
95 PERCENTILE	1297.73	NA	

Table 8 - Sample point B: weekly breakdown of results

Sample ID	Date	Sample Point	E.coli (EC) MPN/100ml	Enterococci cfu/100ml	Weekly E.coli status	Weekly Enterococci status
F10591973	15/05/2023	B	980	260	Good	Good
F10591980	24/05/2023	B	1046	89	Poor	Good
F10591986	01/06/2023	B	345	35	Good	Good
F10591992	06/06/2023	B	387	47	Good	Good
F10592001	16/06/2023	B	727	48	Good	Good
F10592007	19/06/2023	B	866	79	Good	Good
F10592013	27/06/2023	B	1045	109	Poor	Good
F10592019	04/07/2023	B	3000	106	Poor	Good
F10582025	12/07/2023	B	2420	132	Poor	Good
F10592029	21/07/2023	B	2420	78	Poor	Good
F10592062	28/07/2023	B	2000	149	Poor	Good
F10592067	01/08/2023	B	2420	780	Poor	Poor
F10592073	09/08/2023	B	8000	730	Poor	Poor
F10592079	14/08/2023	B	2000	400	Poor	Poor
F10592038	22/08/2023	B	2000	680	Poor	Poor
F10591998	02/09/2023	B	4000	870	Poor	Poor
F10592088	06/09/2023	B	2420	170	Poor	Good
F10592047	15/09/2023	B	1120	59	Poor	Good
F10592053	21/09/2023	B	11000	2000	Poor	Poor
F10776758	29/09/2023	B	1414	490	Poor	Poor

At sample point **B**, FIO levels deteriorated as the season progressed, becoming predominantly 'Poor' in the final 9 weeks. Rainfall events in the 72 hours preceding 09.08.23 and on 20.09.23 appear to have caused significant increases in both bacteria levels, which also appear to correlate to EDM spills at Wargrave and Reading STWs. Overall EC levels were over 5x the minimum sufficient standard at the 90th percentile. IE levels at this sample point were almost 3x the sufficient.

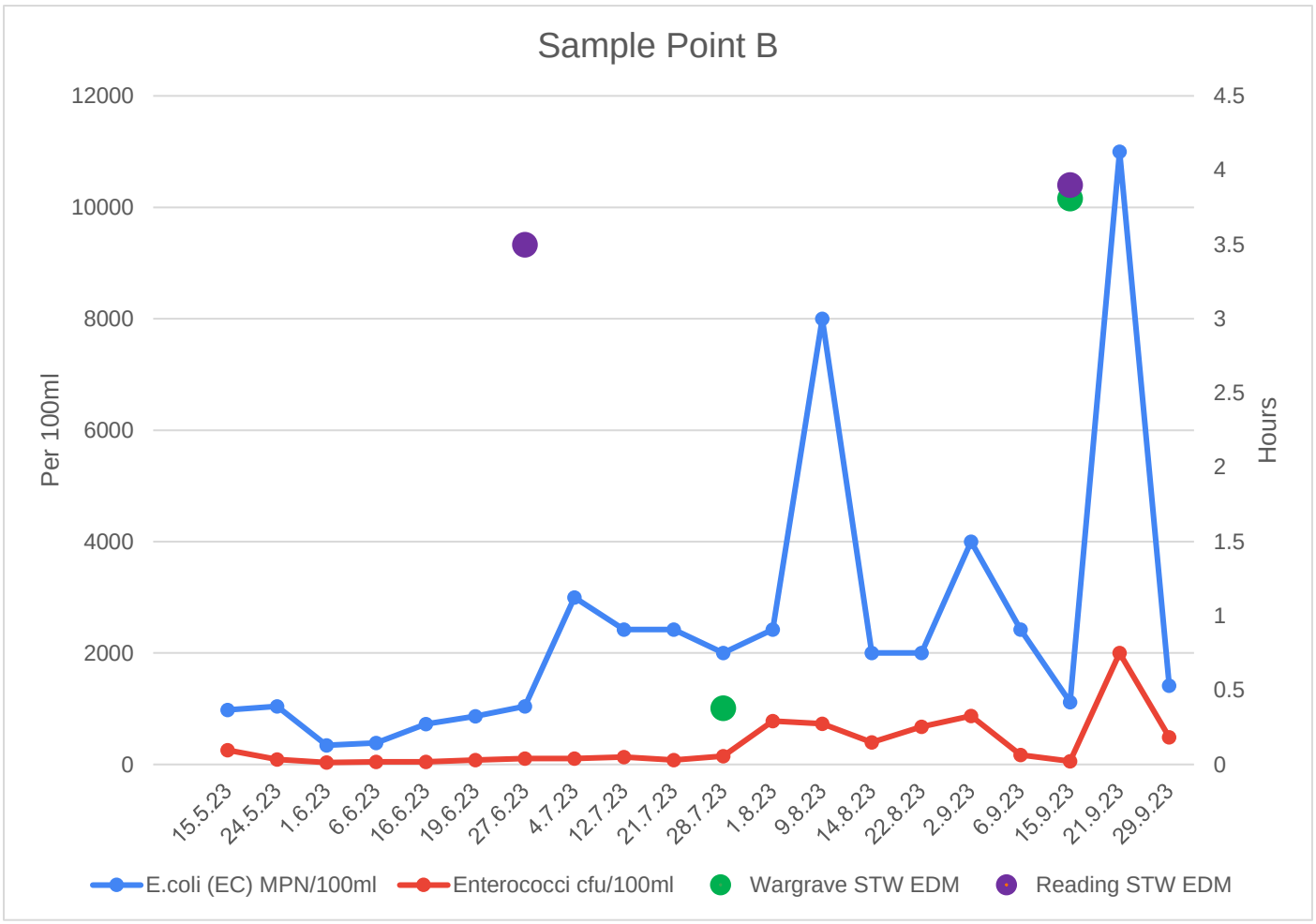


Figure 4 - FIO Levels with EDM spill correlations, sample point B

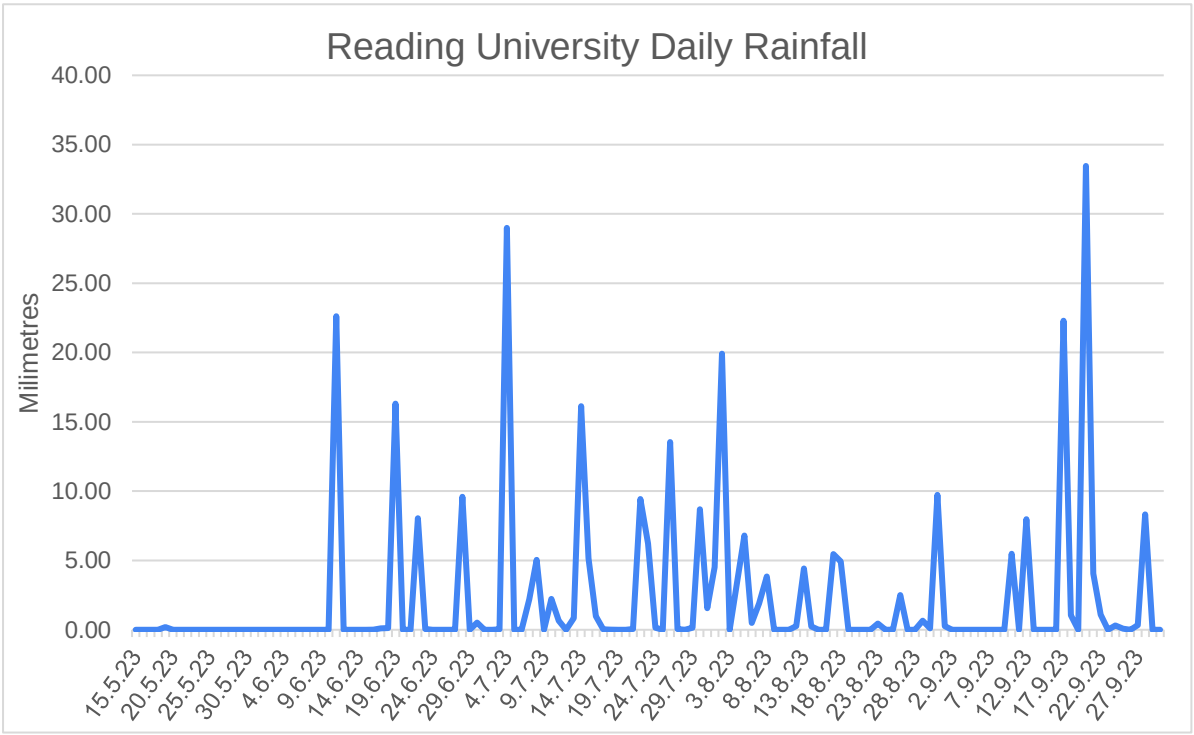


Figure 5 - Daily rainfall at Reading University rainfall monitor

Sample point C: Marsh Lock Bridge (Henley-on-Thames)

Table 9 - Sample point C: overall bathing water status at 90th & 95th percentile

E.coli			overall status
90 PERCENTILE	6419.64	Poor	Poor
95 PERCENTILE	9951.93	NA	

Enterococci			overall status
90 PERCENTILE	874.58	Poor	Poor
95 PERCENTILE	1370.67	NA	

Table 10 - Sample point C: weekly breakdown of results

Sample ID	Date	Sample Point	E.coli (EC) MPN/100ml	Enterococci cfu/100ml	Weekly E.coli status	Weekly Enterococci status
F10591972	15/05/2023	C	980	96	Good	Good
F10591981	24/05/2023	C	579	77	Good	Good
F10591987	01/06/2023	C	291	40	Good	Good
F10591993	06/06/2023	C	345	43	Good	Good
F10592002	16/06/2023	C	411	47	Good	Good
F10592008	19/06/2023	C	1300	77	Poor	Good
F10592014	27/06/2023	C	1753	84	Poor	Good
F10592020	04/07/2023	C	100	91	Good	Good
F10582026	12/07/2023	C	1986	113	Poor	Good
F10592033	21/07/2023	C	1000	180	Poor	Good
F10592064	28/07/2023	C	1000	124	Poor	Good
F10592068	01/08/2023	C	2000	710	Poor	Poor
F10592074	09/08/2023	C	7000	890	Poor	Poor
F10592080	14/08/2023	C	3000	720	Poor	Poor
F10592039	22/08/2023	C	2000	430	Poor	Poor
F10591999	02/09/2023	C	4000	840	Poor	Poor
F10592086	06/09/2023	C	4000	510	Poor	Poor
F10592048	15/09/2023	C	1733	39	Poor	Good
F10592055	21/09/2023	C	20000	2000	Poor	Poor
F10776757	29/09/2023	C	1553	300	Poor	Good

At sample point **C**, similarly to point B, FIO levels deteriorated in the latter half of the bathing season, with EC levels falling to 'Poor' for the final 12 sample dates, and IE levels falling to 'Poor' for the majority of the final 9 weeks of sampling. Rainfall events and EDM spills appear to have negatively impacted the results in a similar pattern to sample point B, with the biggest increases in FIO levels seen on 09.08.23 and 21.09.23 The ratio of EC:IE on these dates show hallmarks of point source impacts heavily affecting water quality at both sample points B & C. Overall EC levels were over 6x the minimum sufficient standard at the 90th percentile. IE levels at this sample point were almost 3x the sufficient.

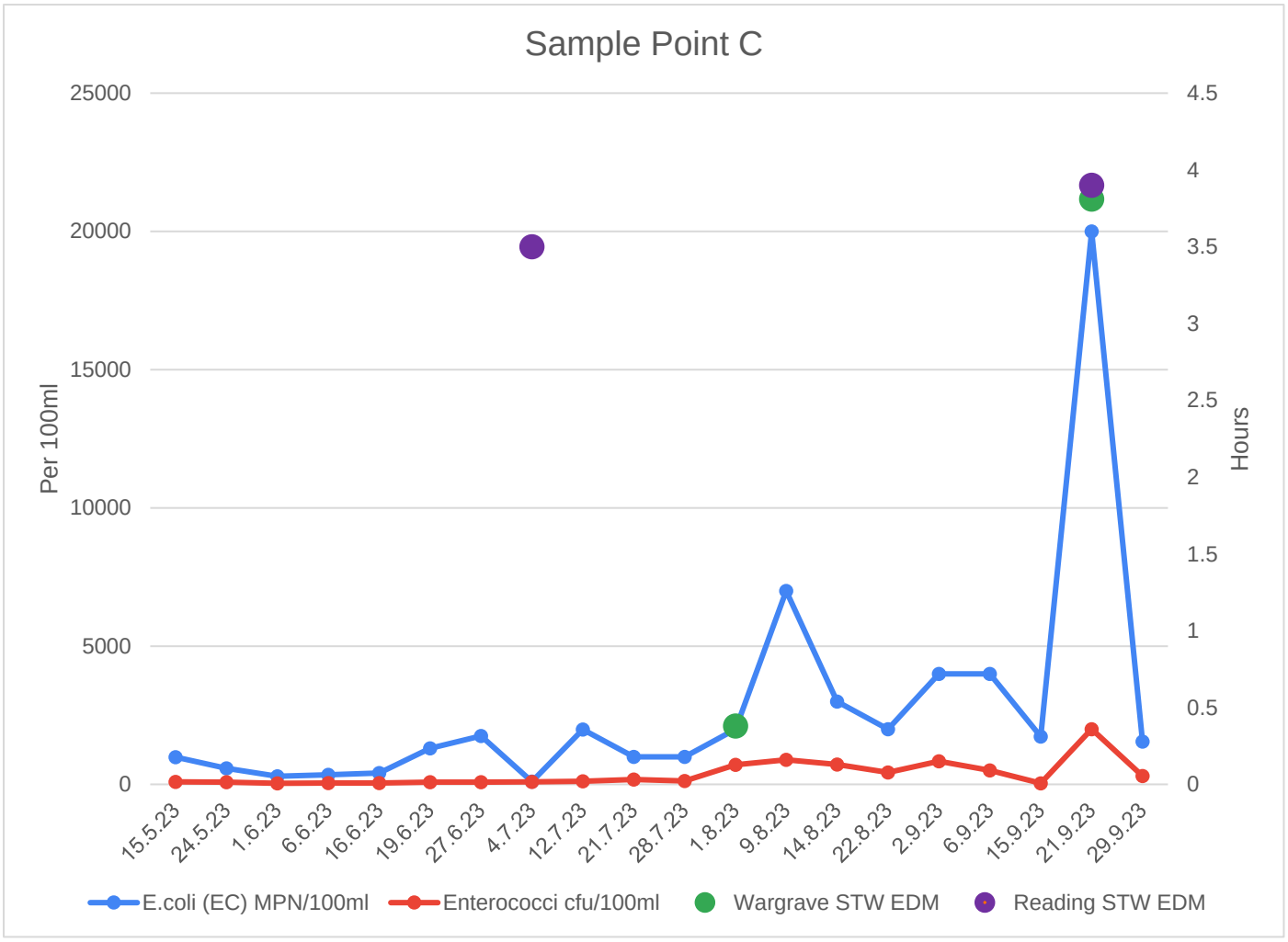


Figure 6 - FIO Levels with EDM spill correlations, sample point C

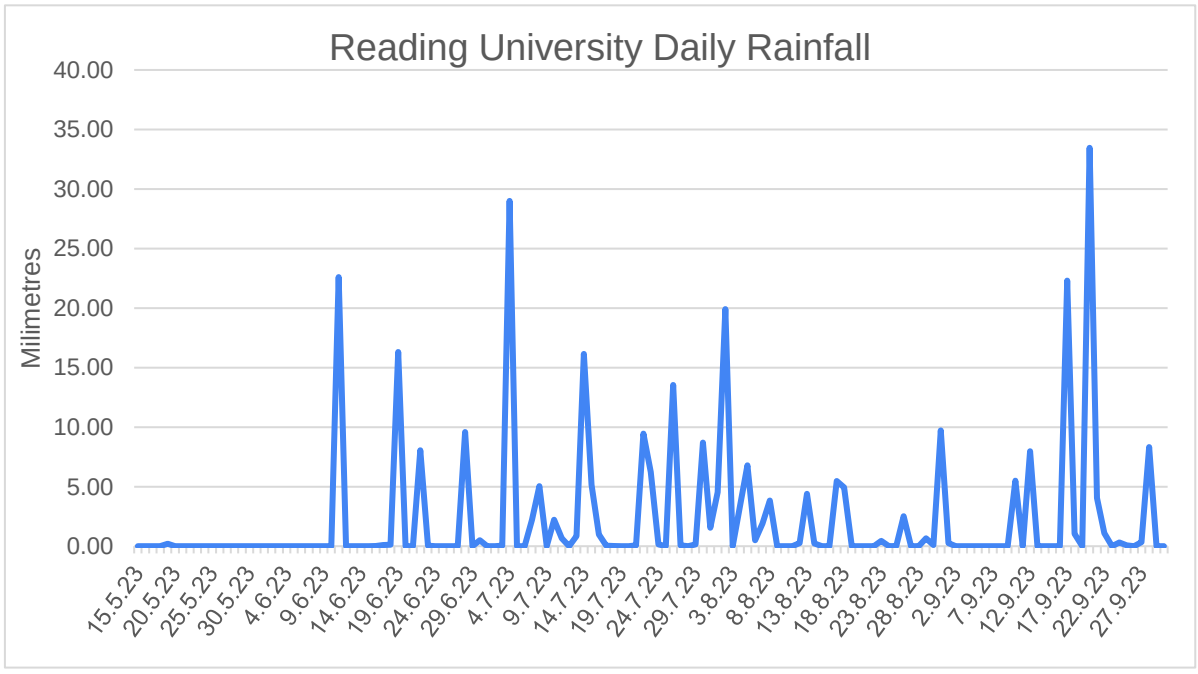


Figure 7 - Daily rainfall at Reading University rainfall monitor

Sample point D: Loddon Drive Bridge

Table 11 - Sample point D: overall bathing water status at 90th & 95th percentile

E.coli			overall status
90 PERCENTILE	21547.71	Poor	Poor
95 PERCENTILE	32616.77	NA	

Enterococci			overall status
90 PERCENTILE	2352.27	Poor	Poor
95 PERCENTILE	3632.57	NA	

Table 12 - Sample point D: weekly breakdown of results

Sample ID	Date	Sample Point	E.coli (EC) MPN/100ml	Enterococci cfu/100ml	Weekly E.coli status	Weekly Enterococci status
F10591976	15/05/2023	D	272	38	Good	Good
F10591982	24/05/2023	D	2420	280	Poor	Good
F10591988	01/06/2023	D	1300	550	Poor	Poor
F10591994	06/06/2023	D	1414	290	Poor	Good
F10592003	16/06/2023	D	2000	400	Poor	Poor
F10592009	19/06/2023	D	2000	117	Poor	Good
F10592015	27/06/2023	D	11000	650	Poor	Poor
F10592021	04/07/2023	D	8000	191	Poor	Good
F10582027	12/07/2023	D	9000	1130	Poor	Poor
F10592035	21/07/2023	D	10000	200	Poor	Good
F10592061	28/07/2023	D	3000	380	Poor	Good
F10592069	01/08/2023	D	3000	960	Poor	Poor
F10592075	09/08/2023	D	21000	2000	Poor	Poor
F10592081	14/08/2023	D	23000	2000	Poor	Poor
F10592040	22/08/2023	D	6000	1010	Poor	Poor
F10592043	02/09/2023	D	11000	1630	Poor	Poor
F10592087	06/09/2023	D	16000	1220	Poor	Poor
F10592049	15/09/2023	D	9000	73	Poor	Good
F10592056	21/09/2023	D	14000	2000	Poor	Poor
F10776759	29/09/2023	D	6000	2000	Poor	Poor

At sample point **D,** weekly results of EC were 'Poor' every week except the first, with IE results deteriorating further as the season progressed, with sharp rises seen from August onwards. The most significant increase in EC levels was seen on 09.08.23, which, although did not correlate with the highest levels of precipitation seen during the season, was preceded by 5 days of consistent rainfall, during which Wargrave STW discharged for 0.38 hours. As seen at the above sample points, the ratio of EC:IE during the most significant increases of FIO at sample point D show the hallmarks of point source impacts heavily affecting water quality. Overall EC levels were over 23x the minimum sufficient standard at the 90th percentile. IE levels at this sample point were over 7x the sufficient. Sample point D as expected appears to be directly impacted by the final effluent discharges of Thames Waters' Wargrave STW site. At present, the sewage is legally only treated to environmental and not public health standards, under the conditions of the Bathing Water designation this would change with all WwTW sites impacting the designated stretch legally bound to treat the sewage to public health standards.

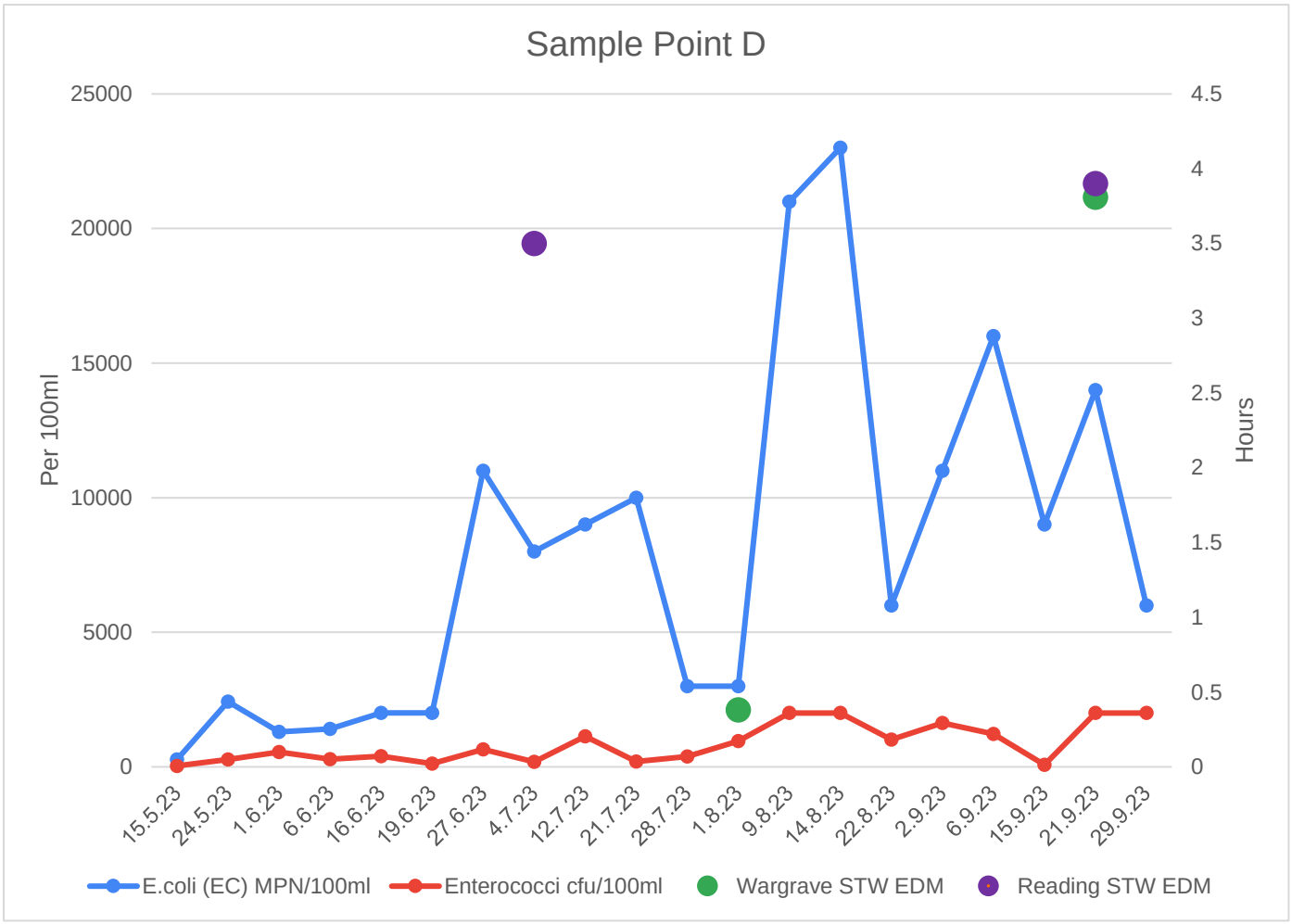


Figure 8 - FIO Levels with EDM spill correlations, sample point D

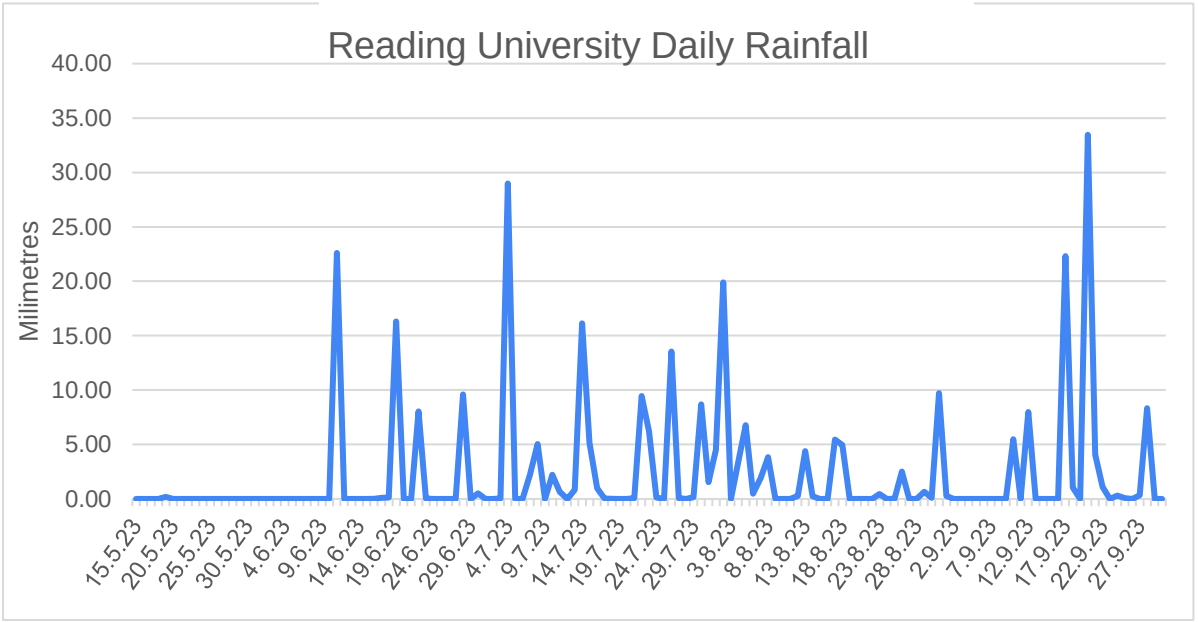


Figure 9 - Daily rainfall at Reading University rainfall monitor

Sample point E: Sonning Bridge

Table 13 - Sample point E: overall bathing water status at 90th & 95th percentile

E.coli			overall status
90 PERCENTILE	1438.87	Poor	Poor
95 PERCENTILE	1950.78	NA	

Enterococci			overall status
90 PERCENTILE	434.83	Poor	Poor
95 PERCENTILE	701.01	NA	

Table 14 - Sample point E: weekly breakdown of results

Sample ID	Date	Sample Point	E.coli (EC) MPN/100ml	Enterococci cfu/100ml	Weekly E.coli status	Weekly Enterococci status
F10591977	15/05/2023	E	135	11	Good	Good
F10591983	24/05/2023	E	308	11	Good	Good
F10591989	01/06/2023	E	184	26	Good	Good
F1051995	06/06/2023	E	236	41	Good	Good
F10592004	16/06/2023	E	248	39	Good	Good
F10592010	19/06/2023	E	326	41	Good	Good
F10592016	27/06/2023	E	326	48	Good	Good
F10592022	04/07/2023	E	276	38	Good	Good
F10582028	12/07/2023	E	387	63	Good	Good
F10592034	21/07/2023	E	411	78	Good	Good
F10592063	28/07/2023	E	1000	66	Poor	Good
F10592070	01/08/2023	E	2420	420	Poor	Poor
F10592076	09/08/2023	E	1000	150	Poor	Good
F10592082	14/08/2023	E	548	230	Good	Good
F10592041	22/08/2023	E	345	78	Good	Good
F10592044	02/09/2023	E	770	510	Good	Poor
F10592085	06/09/2023	E	488	99	Good	Good
F10592050	15/09/2023	E	517	34	Good	Good
F10592057	21/09/2023	E	2420	930	Poor	Poor
F10776760	29/09/2023	E	1986	940	Poor	Poor

At sample point **E**, weekly results deteriorated somewhat towards the end of the bathing season, enough to push the overall status for both FIO levels to 'Poor'. Significant increases in FIO levels appear to correlate with rainfall events such as in the 72 hours preceding sample dates 28.07.23 and 21.09.23. These increases also appear to correlate to EDM spill events at Reading STW and the ratio of EC:IE once again displays the hallmarks of point source impacts. Overall EC and IE levels were over the minimum sufficient standard at the 90th percentile.

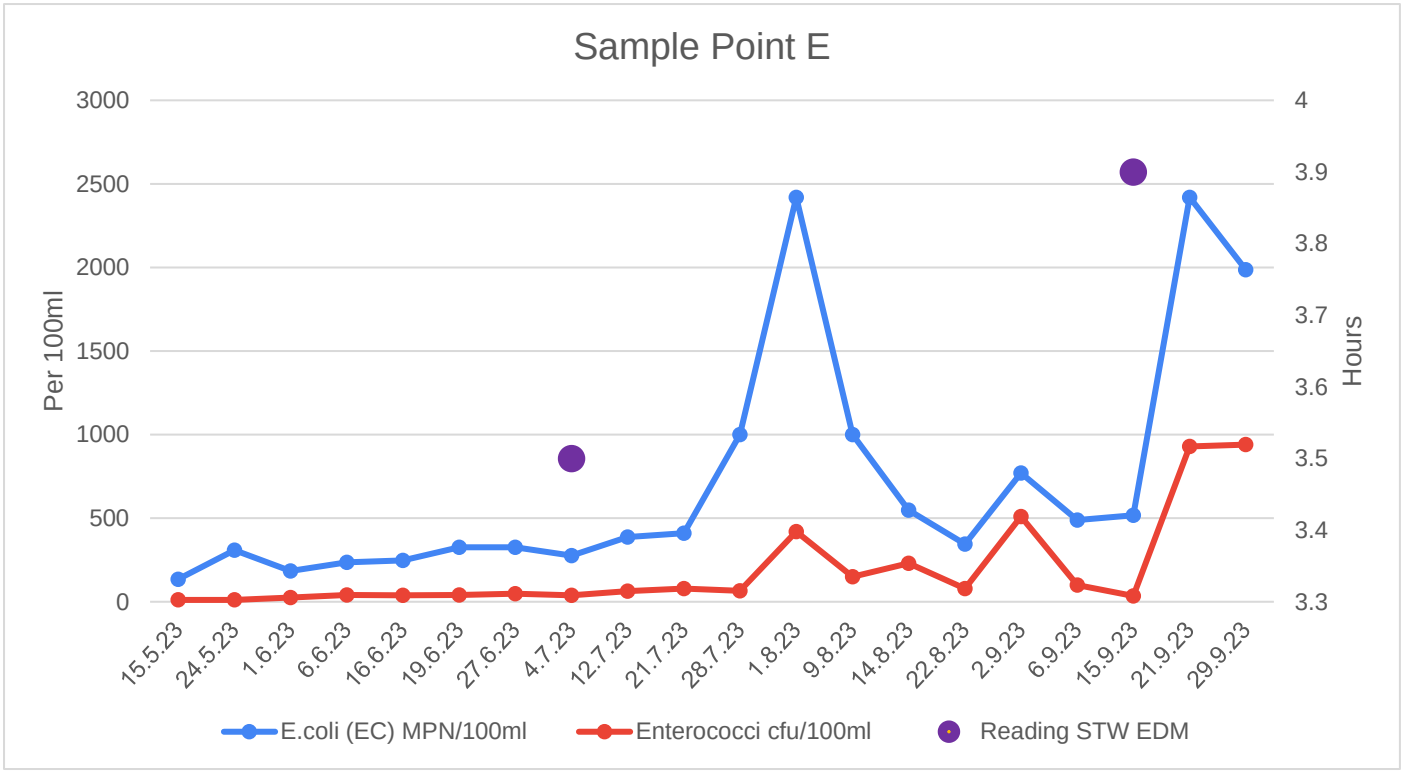


Figure 10 - FIO Levels with EDM spill correlations, sample point E

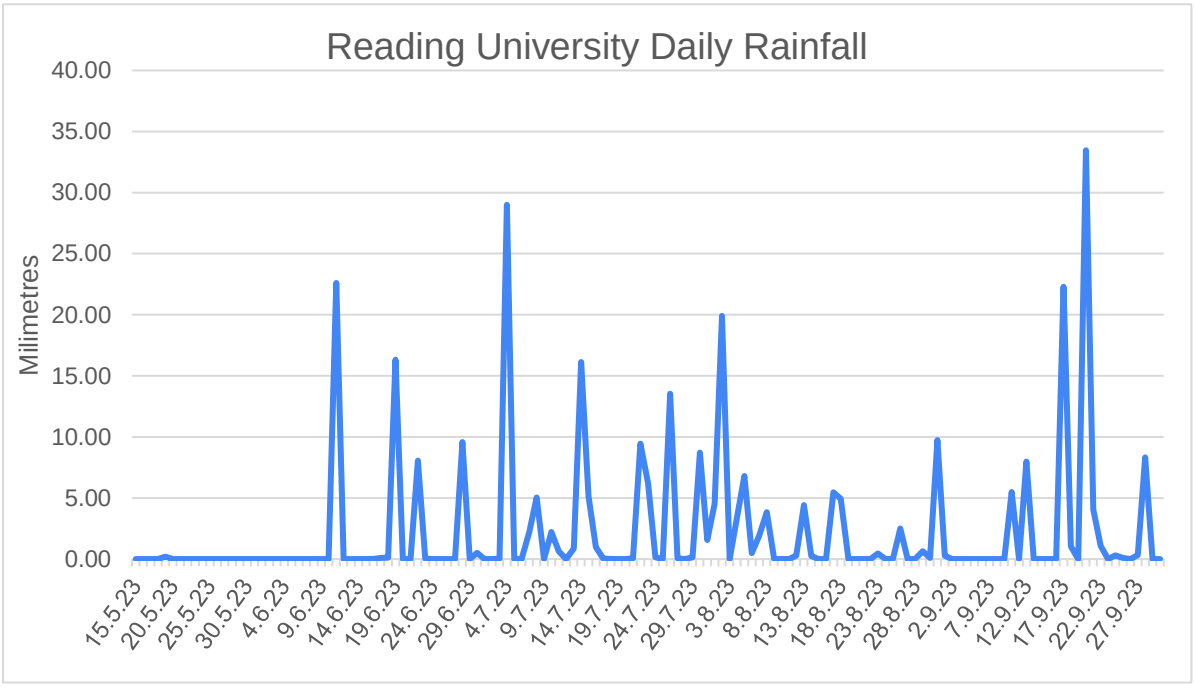


Figure 11 - Daily rainfall at Reading University rainfall monitor

Sample point F: Christchurch Bridge (Reading)

Table 15 - Sample point F: overall bathing water status at 90th & 95th percentile

E.coli			overall status
90 PERCENTILE	840.74	Sufficient	Sufficient
95 PERCENTILE	1161.42	NA	

Enterococci			overall status
90 PERCENTILE	346.51	Poor	Poor
95 PERCENTILE	516.93	NA	

Table 16 - Sample point F: weekly breakdown of results

Sample ID	Date	Sample Point	E.coli (EC) MPN/100ml	Enterococci cfu/100ml	Weekly E.coli status	Weekly Enterococci status
F10591078	15/05/2023	F	1986	450	Poor	Poor
F10591984	24/05/2023	F	61	15	Good	Good
F10591990	01/06/2023	F	105	27	Good	Good
F10591996	06/06/2023	F	135	27	Good	Good
F10592005	16/06/2023	F	199	38	Good	Good
F10592011	19/06/2023	F	291	54	Good	Good
F10592017	27/06/2023	F	236	43	Good	Good
F10592023	04/07/2023	F	548	93	Good	Good
F10582030	12/07/2023	F	194	73	Good	Good
F10592036	21/07/2023	F	225	180	Good	Good
F10592065	28/07/2023	F	100	56	Good	Good
F10592071	01/08/2023	F	127	156	Good	Good
F10592077	09/08/2023	F	214	49	Good	Good
F10592083	14/08/2023	F	365	280	Good	Good
F10592042	22/08/2023	F	201	54	Good	Good
F10592045	02/09/2023	F	308	107	Good	Good
F10592084	06/09/2023	F	291	115	Good	Good
F10592051	15/09/2023	F	461	32	Good	Good
F10592058	21/09/2023	F	1733	1170	Poor	Poor
F10776762	29/09/2023	F	649	310	Good	Good

At sample point **F**, as table 13 depicts, bathing water quality status according to the Bathing Water Regulations (2013) at sample point F were 'Good' for the majority of the bathing season, with the only 'Poor' results occurring at either end of the season. As figures 12 & 13 demonstrate, the increase in FIO levels at the end of the season correlate closely with heavy rainfall events on 20.09.23 and the preceding 72 hours, as well as EDM spills at Reading STW on 20.09.23. EC levels were just under the minimum sufficient standard at the 90th percentile. IE levels at this sample point were just over the sufficient.

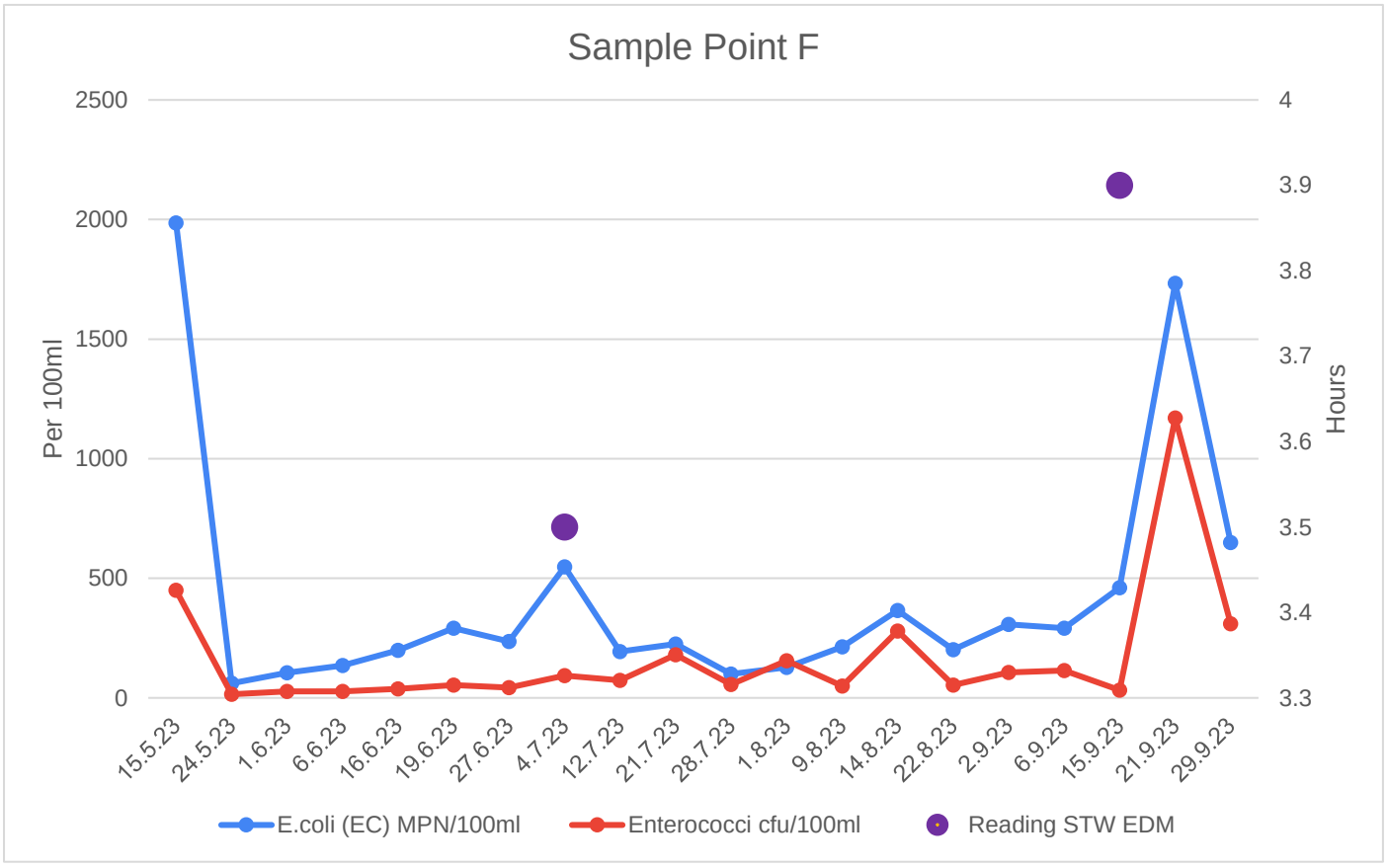


Figure 12 - FIO Levels with EDM spill correlations, sample point F

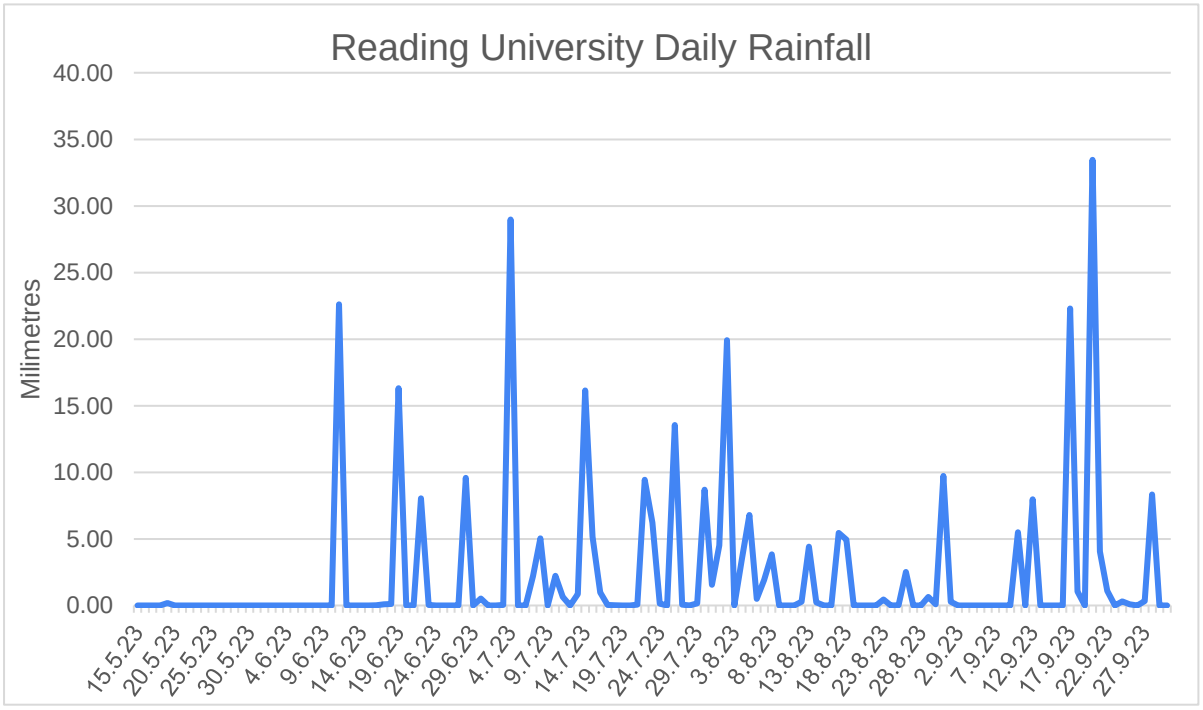


Figure 13 - Daily rainfall at Reading University rainfall monitor

Conclusion

As indicated in tables 5-16, none of the sample points except point F (Reading) met bathing water standards for E.Coli, with sample point F only recording Sufficient status at the 90th percentile. None of the six sample points met bathing water standards for IE.

The timing of EDM spill data and the EC:IE ratio during increases in FIOs would indicate that all sample points are being impacted by point source inputs most likely from storm overflows and partially treated final effluent released at upstream sewage treatment works. More sampling and evidence gathering will be required to confirm this, something that a Bathing Water Designation at Mill Meadows will initiate as all sample points are within the zone of influence.

The continued presence of considerable levels of both EC and IE throughout the sampling period at sample point D even during dry periods such as in late May and early June suggest diffuse inputs such as livestock excreta, sceptic tanks, and misconnections, all of which can pose a serious risk to public health. The continued presence of EC and IE were at lower levels at the five other sample points during these dry periods but would still suggest negative impacts to water quality from diffuse inputs. We would recommend further investigations, such as through use of eDNA to evidence source apportionment at all sample points.

Climate change is likely to continue to trigger extreme and sporadic weather events, such as heavy rain during the bathing season, meaning the poor conditions seen towards the end of the 2023 season may be seen more frequently throughout future seasons. Therefore, improvements and upgrades to wastewater treatment systems at Reading, Wargrave and Henley-on-Thames should be prioritised to mitigate against the impacts of climate change, improve river health and reduce risks to recreational users. In addition, greater awareness and transparency of current water quality data should be publicly available to allow for informed choices to be made when using the river.

References

DEFRA. (N.D). Hydrology Data Explorer [Online], available: https://environment.data.gov.uk/hydrology/station/1ad8ff76-625d-4ff1-82bd-9efcc5d41b2f_264254TP.

European Parliament & Council of the European Union. (2013). Council Directive 2013/64/EU of 17 December 2013 concerning the management of bathing water quality and repealing Directive, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006L0007-20140101&qid=1696340287897.

Harris, T. and Walker, M. (2022). Oxford Rivers Project: Citizen Science Water Quality Sampling Final Report, https://www.thames21.org.uk/wp-content/uploads/2023/05/Oxford-Rivers-project-final-report.pdf.

River Levels. (N.D). River Thames at Benson Lock [Online], available: https://riverlevels.uk/thames-brightwell-cum-sotwell-benson-lock.

Sagarduy M, Courtois S, Del Campo A, Garmendia JM, Petrau A. (2019). Differential decay and prediction of persistence of Enterococcus spp. and Escherichia coli culturable cells and molecular markers in freshwater and seawater environments. *International Journal of Hygiene and Environmental Health*. 222(4):695-704.

Slanetz, L. W., and Bartley, C. H. (1957). Numbers of enterococci in water, sewage, and feces determined by the membrane filter technique with an improved medium. *Journal of Bacteriology*, *74*(5), 591-595.

Appendix 1: Sampling Protocol

1. Take samples as close to the centre of the stream as it is possible to safely do. Take samples upstream where possible.

2. Before taking sample, check for river users e.g. passing boats.

3. To take a sample, put gloves on, fill up and empty the sampling bucket in the river water a minimum of 3 times to rinse bucket.

4. Then fill sampling bucket once more, this time ensuring bucket is as full as possible.

5. Fill the red-lidded microbiology bottles up to the lowest ridge on the side of bottle (see diagram).

6. **Label the bottles carefully.** Labels **must not go round corners or on lids**, please place them portrait on the bottle.

7. **Very important:** send message with details of sample: photo clearly depicting sample number (**F number**), time and sample point. Notepad will be kept in bag if preferred for keeping record, but images will still need to be sent.

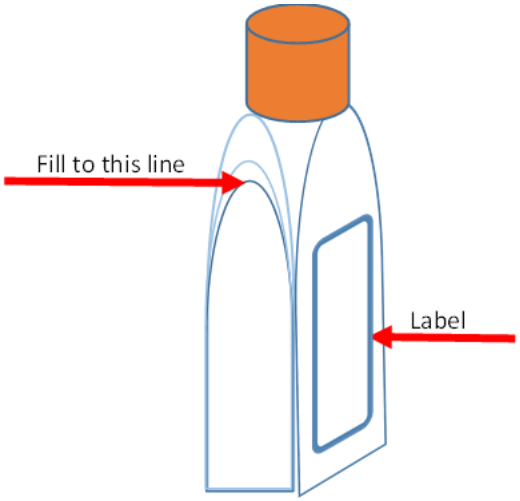
8. Using a disinfectant wipe clean sample bottle and all surfaces of the sampling bucket and the first few feet of the sample
   rope thoroughly making sure all are covered and then allow to air dry/dry with kitchen roll.

9. After the sample is taken, put sample in bag as soon as possible to minimise sunlight.

10. Change gloves between sampling points. Used gloves, wipes and other rubbish can be placed in the rubbish zip lock bag
    provided, to be disposed of at the end of the day in regular rubbish bin.

11. Repeat steps 1-10 for each of the next sampling points. For sample point **B** – bathing water site, take note of visuals
    (see box 1)

12. Once all samples are taken the sampling bucket is to be cleaned by using virkon spray bottle and kitchen roll.



BOX 1 - VISUALS

Only at point B: Mill Meadows by River & Rowing Museum:

Please make note of any or all of the following visual water qualities:

-Flow speed
-Water height
-Algal blooms
-Plastic or other litter pollution
-Physical signs of sewage
-Tar-like residues
-Animal faeces