WASP Review Part 5

Effective regulation of untreated sewage discharges needs volumetric and catchment-based monitoring

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May 2023

CONTENTS

Disclaimer

The analysis in this report is based on data provided by water companies, either directly in response to requests under Environmental Information Regulation legislation or indirectly via online archives of data the companies have themselves submitted to regulatory bodies.

The author has made every effort to ensure accuracy but cannot guarantee the validity of third-party data.

Acknowledgement

While this report has benefited from discussion with WASP colleagues Eileen Boothroyd, Vaughan Lewis, Victoria Marsh, Ash Smith, Geoff Tombs and Soraya Wooller, the author accepts full responsibility for errors of analysis.

Background

In previous reports, WASP used AI/machine learning techniques[1] and simple spreadsheets[2,3,4] to document illegal discharges of untreated sewage by water companies. This study arose from continued dissatisfaction with the inadequate reporting and regulation of storm overflow discharges:

a) the summary of overflow activity solely in terms of just annual spill frequency and spilling hours;
b) the rejection by the UK government of volumetric monitoring of storm overflows;
c) the continued citing of “heavy rainfall” to excuse spills without clarification or precision;
d) the lack of attention given to cumulative effects of sewage pollution across river catchments;
e) a flawed target in the government’s Storm Overflows Discharge Reduction Plan.

Much of the media discussion of untreated sewage discharges has relied on reporting annual spill frequency and spilling hours, because these are the only summary data immediately available. Fortunately, there is enough photographic and videographic evidence to counter any notion that storm overflows merely dribble untreated sewage intermittently. But, we don’t know how much untreated sewage ends up in our closest river or at our local beach?

The Rivers Trust Sewage Map[5] shows how often and for how many hours storm overflows discharged untreated sewage, as far back as 2019. Online maps and ‘phone alerts provided by Surfers Against Sewage[6] and water companies show when there are discharges to coastal waters[7,8]. Since January 2023, Thames Water’s online sewage map has provided near real-time information showing when their own storm overflows are, or were recently, active[9]. There is still no data readily available showing the **volume** of untreated sewage discharges. Water companies have some idea, but the regulators (Ofwat and the environment agencies in England and Wales) and the government (The Department for Environment, Food and Rural Affairs - Defra) probably have no idea. Sewage detritus in rivers, on beaches and in seas offers clues but may not reflect the volume of discharges.

Executive summary

In January 2021, the installation of volume meters on storm overflows was recommended by the House of Commons Environmental Audit Committee (EAC) in its report “Water Quality in Rivers” [10]. Sadly, this and other EAC recommendations were ignored and omitted from the Environment Act that had its first reading in January 2020 and received Royal Assent in November 2021[11].

In this report, WASP describes three ways to determine volumes of untreated sewage discharges and has applied them to a small sample of STWs with the following summary results:

[1] **Detection of untreated sewage discharges to watercourses using machine learning** Hammond et al NPJ Clean Water 4 (1), 1-10, 2021
[2] WASP REVIEW OF UNPERMITTED SPILLS FROM SEWAGE TREATMENT WORKS – Part 1 Thames Water
[3] WASP REVIEW OF UNPERMITTED SPILLS FROM SEWAGE TREATMENT WORKS – Part 2
[4] WASP REVIEW OF UNPERMITTED SPILLS FROM SEWAGE TREATMENT WORKS – Part 3 EDM SUBMISSIONS
[5] https://theriverstrust.org/sewage-map
[6] https://www.sas.org.uk/water-quality/sewage-pollution-alerts/
[7] https://www.southernwater.co.uk/water-for-life/our-bathing-waters/beachbuoy
[8] https://www.southwestwater.co.uk/environment/waterfit/waterfitlive/
[9] https://www.thameswater.co.uk/edm-map
[10] https://committees.parliament.uk/work/891/water-quality-in-rivers/
[11] https://www.gov.uk/government/news/world-leading-environment-act-becomes-law

- **11 billion litres of untreated sewage** were discharged from just **30 STWs** in 2020
- This is equivalent to **4,372 Olympic Pools'** worth over 13,748 hours
- Number of **Olympic Pools** of untreated sewage discharged to 6 catchments in the study for which lower bounds can be determined
    - River Thames from 1 STW : **2,768** (2020) **2,964** (2021)
    - River Tame from 2 STWs : **488** (2020) **190** (2021)
    - River Nidd from 4 STWs : **317** (2020) **146** (2021)
    - River Wharfe from 3 STWs : **102** (2020)
    - River Conwy from 1 STW : **34** (2020) **15** (2021) **9** (2022)
    - Chichester Harbour from 2 STWs : **43** (2020) **19** (2021)

In order to do this, WASP obtained detailed data from water companies and regulators on precisely when and where sewage spills occurred using Environmental Information Regulation requests. Volume *estimation*, of course, is not the answer but even this limited review of just 30 STWs has revealed some disturbingly gross discharges of untreated sewage, often from relatively small STWs and often in breach of permitted conditions and hence illegal.

WASP has produced **visualizations of individual spills and volume estimates that represent both their temporal sequence and their location along a river course**. Only then, is it possible to appreciate fully the simultaneous and cumulative exposure to sewage pollution across a river catchment and the gap left by our ignorance of discharge volume.

WASP also shows that **the *Storm overflows discharge reduction plan*[1] to reduce the frequency of storm overflow discharges is based on a metric that is not robust** enough to resist strategies that water companies can adopt to achieve targets. Furthermore, WASP shows, in this report, that **even if spill frequency is reduced to the declared target level, there could still be unacceptably large spills and continued illegal spilling**.

Had parliamentarians had a better idea of the volume and cumulative effect of storm overflow discharges on river catchments, they may not have rejected the EAC's recommendation. With the current public appetite for change of behaviour by both the water industry[12] and the regulatory bodies, now is the time to reconsider volumetric monitoring of storm overflows and in addition move towards a river catchment framework for more effective regulation.

Motivation and methods

Reasons for measuring the volume of untreated sewage discharges

1 Untreated sewage includes human waste (urine, faeces, toilet paper, drug residues, bugs), wet wipes, cotton buds, sanitary products, condoms, residues of cleaning products, microplastics, groundwater, rainwater surface runoff, tyre and road residues, etc. The volume is unknown.

2 Storm overflows may trickle for months or may issue torrents of untreated sewage in an hour. To compare the effects on flora and fauna of both exposures, quantitative analysis is needed.

3 The volume of untreated sewage discharges could be a valid basis for tariffs and for fines.

[12] https://www.water.org.uk/news-item/apology-transformation-programme/

4 Volumetric data will inform the debate on discharge dilution by surface runoff and river flow[13].
5 Water companies, whose activity involves such an intimate relationship with our inland and coastal waters, must understand the cumulative burden of untreated sewage discharges before they can claim to be ethical businesses[14].

Volumetric measurement of untreated sewage discharges has many potential benefits: most importantly for the environment and aquatic wildlife, but also for the water industry, regulatory bodies, recreational water users and public health.

Three approaches to determining the volume of untreated sewage discharges

The study was largely limited to 2020 because the early committee and reporting stages of the Environment Act took place that year and 2020 has been chosen for baseline data comparison. Sewage treatment flow data at a resolution of 15-minute intervals and individual spill start-stop times were provided by water companies in response to requests under Environmental Information Regulation legislation. The 30 STWs reported here are operated by 9 of the 10 water companies in England and Wales and serve 2.8 M people, about 4.6% of the population. None of the STWs operated by Anglian Water for which 2020 data were available were suited to the following volume estimation methods employed: (see Appendix A for a more detailed description)

a) Direct measurement with a volume meter fitted to a storm overflow (1 STW).
b) Indirect estimation from the difference between metered flows at an STW inlet and its treated sewage outlet, either annually or during individual spills (1 STW).
c) Indirect estimation from the difference between the fixed inflow when an inlet storm overflow weir is active and the metered flow to full treatment or final effluent outflow during simultaneous spilling from a storm tank overflow (28 STWs).

The first method provides the greatest accuracy and relies on data from a single meter. The second relies on two meters[15] and an optional overflow Event Duration Monitor (EDM) recording spill start-stop times. The third relies on 2 EDM devices and 1 flow meter, but more importantly does not cover discharges at the inlet overflow so will always underestimate total spill volume. Clearly, deployment of individual volume meters on each storm overflow is ***optimal***.

An approach to grading levels of daily rainfall

In an attempt to clarify the notion of "heavy rainfall" and "exceptional situations", WASP proposes a 10 grade classification of daily rainfall based on an approach published 20 years ago by the Met Office and university academics[16]. The issue then is where to draw the line to define the *exceptional situations* for spills during rainfall to be lawful as decreed by the European Court of Justice in 2012[17].

Spatio-temporal representation of sewage discharges across a river catchment

Visualisations of individual spill start-stop times relative to upstream/downstream location were constructed to illlustrate simultaneous, multiple spills and the cumulative exposure across a river

[13] https://www.sussexexpress.co.uk/news/people/sewage-discharge-alerts-in-seaford-up-to-95-rainwater-3931321
[14] https://www.ofwat.gov.uk/vision-waterstories/news/7-things-you-need-to-know-about-ethical-business/
[15] The metered flow from one or more terminal or last-in-line sewage pumping stations is an alternative.
[16] Osborne et al, Observed trends in the daily intensity of UK precipitation. Int J Climatol. 20: 347-364 (2000).
[17] https://curia.europa.eu/juris/document/document.jsf?docid=128650&doclang=EN

catchment. The presentation shows both the upstream-downstream location of storm overflows but also a timeline indicating start-stop times of individual spills.

Summary results for estimation of spill volume

Table 1 shows 2020 spill volume estimates for the 30 STWs in this study producing an estimated overall volume of **11 billion litres**. Such a large number may be easier to comprehend as an equivalent of **4,352 Olympic sized swimming pools**[18]. In the rest of the report, the performance of some of the 30 STWs is highlighted to illustrate the volume estimation methodology, to relate the discharges to permit compliance and to illustrate accumulated sewage exposure in river catchments.

Table 1: Minimum volumes of untreated sewage discharged from 30 STWs in 2020

STW	PE	Discharge (tonnes)	Olympic Pools	Hours	Spills	Water Company	River+ /Sea
Mogden*	2,100,000	6,920,000	2,768	413	43	Thames	Thames
Fairford**	5,268	259,063	104	2,492	130	Thames	Coln
Welshpool	11,164	10,099	4	31	28	Severn Trent	Severn
Tudhoe Mill	21,795	122,755	49	155	35	Northumbrian	Wear
Countess Wear	153,188	264,836	106	54	24	South West	Exe
Delabole	1,796	1,277	1	54	24	South West	Allen
Honiton	13,646	31,254	13	145	32	South West	Otter
Ivybridge	12,670	200,858	80	718	59	South West	Erme
Willand	5,068	21,696	9	216	27	South West	Culm
Chichester	41,943	106,183	42	94	7	Southern	Chich Harb
King's Somborne	6,615	32,596	13	218	8	Southern	Test
Oxted	14,809	42,700	17	71	13	Southern	Eden
Scaynes Hill	41,015	31,333	13	28	4	Southern	Ouse
Thornham	21,457	1,629	1	2	2	Southern	Chich Harb
Tunbridge Wells S	32,155	343,005	137	245	40	Southern	Grom
Ashton-u-Lyne	43,555	184,287	74	161	27	United Util	Tame
Hyde	79,294	1,035,016	414	567	104	United Util	Tame
Llanrwst	4,000	84,255	34	477	56	Welsh/DCWW	Conwy
Ruthin	6,500	53,111	21	231	29	Welsh/DCWW	Clwyd
Bowerhill	8,118	36,884	15	79	10	Wessex	Bristol Avon
Chippenham	38,031	2,158	1	2	3	Wessex	Bristol Avon
Coleford	2,048	8,996	4	149	24	Wessex	Mells
Danesmoor	6,615	36,863	15	111	194	Yorkshire	Rother
Darley	2,146	61,606	25	588	43	Yorkshire	Nidd
Harrogate North	41,856	120,842	48	63	21	Yorkshire	Nidd
Ilkley	15,545	214,216	86	481	35	Yorkshire	Wharfe
Kirk Hammerton	1,937	8,053	3	112	25	Yorkshire	Nidd
Otley	14,811	5,369	2	3	4	Yorkshire	Wharfe
Pateley Bridge	2,122	603,242	241	3,617	38	Yorkshire	Nidd
Pool	4,349	36,660	15	176	204	Yorkshire	Wharfe
TOTAL: 30 STWs	2,753,516	10,880,844	4,352	11,754	1,293		
	PE	**Tonnes**	**Pools**	**Hours**	**Spills**		

* Volume meter. ** Flow meters at inlet & outlet and EDM on storm tank. Otherwise, EDMs on inlet and storm tank overflows; flow meter for on treatment outlet for spills with both overflows in use. +directly receiving or indirectly via a tributary.

18 An Olympic Swimming Pool, 50m by 25m by 2m, has a volume of 2,500 m^3 or 2.5 million litres.

Detailed Analysis

1 Direct volumetric monitoring

Example Mogden STW (Thames Water)

Thames Water's Mogden sewage works stands out in terms of its treatment capacity, the volume spilled in 2020 (**2,768 Olympic Pools**) and in being the only STW in England and Wales known (to the author) to publish untreated sewage discharge volumes online[19]. It is not unique in terms of having a volume meter on its storm tank discharge overflow, but water companies generally do not disclose where such meters are fitted on storm overflows.

It is worth pointing out that size is not necessarily predictive of volume spilled. For example, Yorkshire Water's Pateley Bridge STW was estimated to discharge **241 Olympic Pools'** worth of untreated sewage in 2020 with only a fraction of Mogden STW's treatment capacity. The annual volume of Mogden STW's storm overflow discharges increased steadily between 2015 and 2021 even though the annual rainfall was relatively constant (**Fig**. 1). According to the Environment Agency, the decrease in spill frequency in 2022 was generally a result of reduced rainfall[20]. In the first 4 months of 2023, Mogden STW has already discharged a larger volume of untreated sewage than in the whole of 2022 (N.B. the rainfall figure for 2023 is part year).

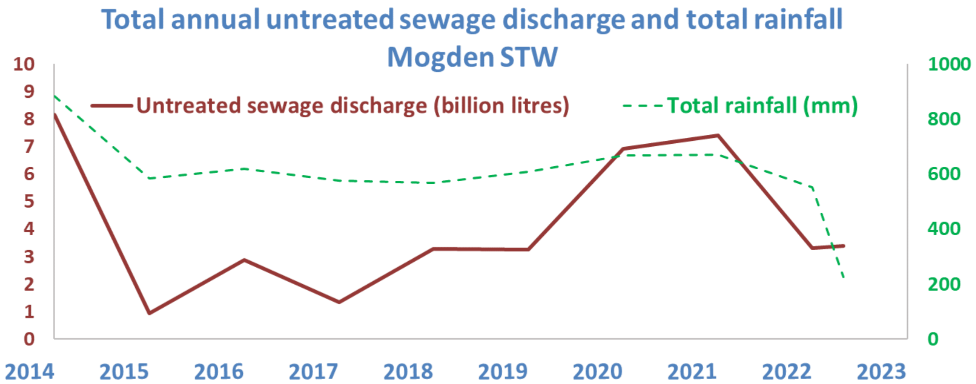

Figure 1: **annual volumes of untreated sewage** discharged from Mogden STW increased steadily between 2015 and 2021 compared to the **annual rainfall pattern** was relatively stable by comparison

The treatment data provided by Thames Water for 2020 suggest that all 6.92 billion litres (2,768 Olympic Pools) were **discharged while not treating at capacity and so were illegal** (**Fig**. 2).

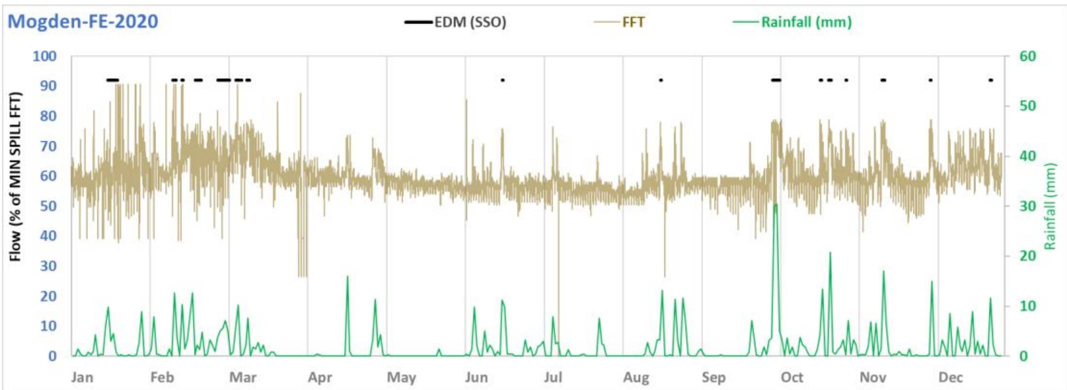

Figure 2: individual spills from Mogden STW in 2020 (**black** segments); during spills, the flow to full treatment (**brown** curve) should be above 92% capacity (8% meter error is allowed); all of the spills are illegal

[19] https://www.thameswater.co.uk/about-us/performance/mogden

[20] https://www.gov.uk/government/news/environment-agency-publishes-event-duration-monitoring-data-for-2022

2 Indirect estimation of volume using inflow and outflow metering

Example Fairford STW (Thames Water)

The data provided by Thames Water for Fairford STW included both untreated sewage inflow as well as treated sewage, or effluent, outflow. Fairford STW has always been a major spiller of untreated sewage, largely because of acknowledged ground water ingress via leaky pipes[21]. The Environment Agency does not permit groundwater infiltration to justify spilling and so **Fairford STW's untreated sewage discharges are often in breach of its permit and hence are illegal**[22].

The chart in **Fig**. 3 shows 3 months of almost continuous spilling of untreated sewage from Fairford STW at the beginning of 2020 (**black** horizontal segments). The treated effluent flow (**blue** curve) is above the required treatment level throughout the spills and so they are compliant with respect to the permit condition related to continued treatment at capacity. However, some of the spilling obviously occurs for days during no or very low rainfall and therefore should be considered illegal. The difference between the inflow (**brown** curve) and effluent outflow (**blue** curve) reflects the volume of untreated sewage being discharged via the storm tank overflow.

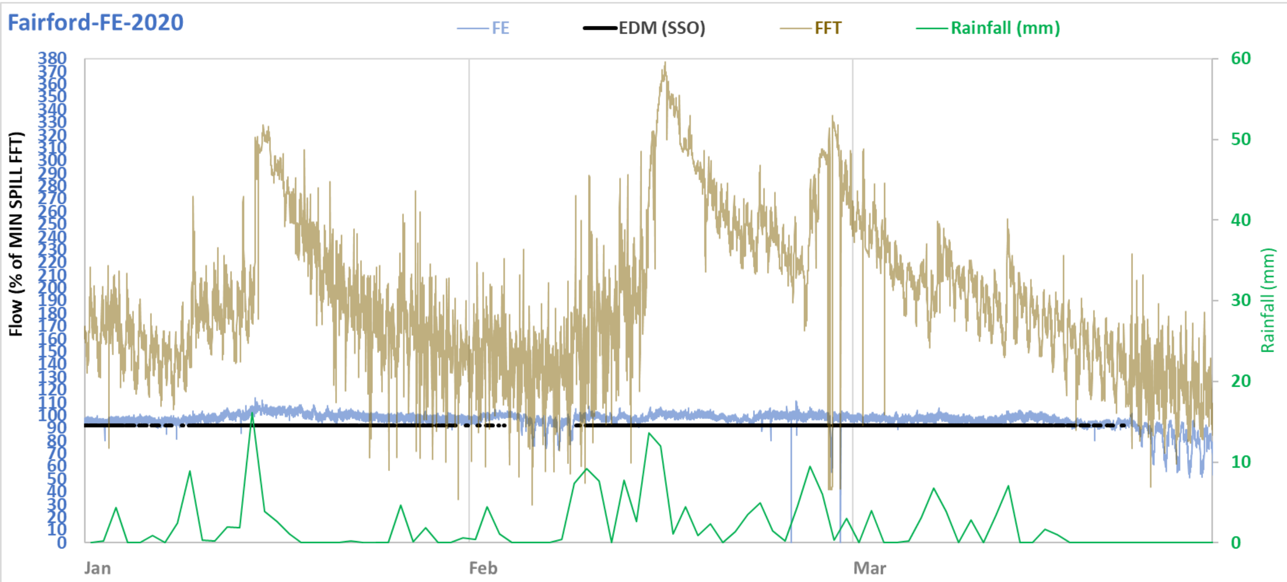

Figure 3: sewage flow arriving at Fairford STW (**brown** curve) and treated effluent leaving (**blue** curve) are shown for Jan-Mar 2020; the storm tank overflow (**black** segments) is almost continuously active; the area between the brown and blue curves during spills reflects the untreated sewage discharge)

During the first three months of 2020, an estimated 285 million litres or 114 Olympic Pools' worth of untreated sewage was discharged from Fairford STW via the storm tank overflow to the River Coln.

3 The storm overflows discharge reduction plan

Defra published its *Storm Overflows Discharge Reduction Plan*[23] in August 2022. It includes a variety of targets to be met by water companies with deadlines as far into the future as 2050. One target is to reduce the average annual spill rate per overflow to 20 by 2025 against baseline data for 2020.

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[21] https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-reports/groundwater-infiltration-management-plans/fairford-groundwater-impacted-system-management-plan.pdf

[22] *Discharges of untreated sewage due to groundwater infiltration alone are not permitted* quote from Environment Agency CEO Sir James Bevan in a letter to Cotswold MP Sir Geoffrey Clifton-Brown. June 2020.

[23] https://www.gov.uk/government/publications/storm-overflows-discharge-reduction-plan

The target of 20 spills per overflow per year is not a robust metric

In 2020, the average annual spill rate per overflow was 32.6. For 2021, it was 29.4 and, for 2022, it was 23. At first sight, this looks like an improvement. However, the average annual number of spills per storm overflow is not a robust metric for effective regulation as *it can be reduced* merely by manipulating the number of spills or the number of overflows, or both:

- It is widely recognised that water companies limit sewage inflow to STWs under pressure of spilling by using tankers to transfer load to an STW that is already spilling. Thus, a potential spill at one STW can be avoided by hiding it in a spill already occurring at another.
- One water company submitted annual spill data for **463** storm overflows in 2020 and **465** in 2021 with average spill rates per overflow of 40 and 31.9 respectively. Despite reporting in 2021 that all storm overflows had monitors, it "found" it had more storm overflows in 2022 and reported **777**, reducing its average spill rate to 17.

Large discharges could still occur even when meeting annual spill target rates

What is the potential discharge volume for 20 spills per overflow per year? As Mogden STW treats sewage for over 2M people and is known to discharge huge volumes of untreated sewage, it would be unfair to include such a large works in any average spilling rate calculation based on a small number of STWs. With Mogden excluded, the 2020 average discharge volume per spill for the remaining 29 STWs is 1.3 Olympic pools per STW per year. With Mogden included, it is much larger.

Hence, even if the government's *Storm Overflow Discharges Reduction Plan* target of 20 spills per overflow per year were to be achieved some STWs could still discharge 26 Olympic Pools of untreated sewage annually and Mogden STW could still discharge more than 1,280 Olympic Pools of untreated sewage annually – in fact, much more. That is completely against the spirit of the Environment Act.

Illegal discharges could still occur even when meeting annual spill target rates

In 2012, the EU Commission took the UK Gov to the European Court of Justice for allowing water companies to discharge untreated sewage into rivers at several UK locations. The court rejected the excuse of "heavy rainfall", said the spills were illegal and ruled that sewage overflows should only ever be used in "exceptional situations"[24].

According to the imprecise language of discharge permits issued by the environment regulators in England (Environment Agency) and Wales (Natural Resources Wales, spills from STWs are allowed if "due to rainfall" and sewage is treated to capacity throughout. The permits do not specify triggering levels of rainfall that cause an untreated sewage discharge to be considered in breach of a permit. Nor does either regulator mention "exceptional" rainfall as one might expect given the ECJ ruling.

When the Environment Agency does formally record permit breaches related to rainfall, the language used is vague[25]:

not in storm conditions, duration 3 months; minimal rain for seven days; in dry weather;
despite no rainfall failing in previous two days; outside of storm conditions

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[24] https://curia.europa.eu/juris/document/document.jsf?docid=128650&doclang=EN
[25] Response from the Evironment Agency to EIR THM184412.

Natural Resources Wales is a little more precise on timing but still ignores amount[26]:

not rained in the previous 48 hours; stopped raining about 8 hours and 10 minutes before; stopped raining over 11 hours before; stopped raining about 22 hours; stopped raining about 8 hours

A suggestion is offered here as one approach to defining exceptional rainfall using the Centre for Ecology and Hydrology's rainfall records[27] for more than 50 years up to 2017.

Figure 4a shows the daily rainfall pattern (in mm) between 1961 and 2017 at Ilkley, North Yorkshire. **Figure** 4b shows the same data reordered according to magnitude and partitioned into 10 grades of rainy days[28]. Total rainfall in each grade corresponds to 10% of all rainfall that fell between 1961 and 2017. Thus, grade 1 rainy days incurred 0.1 to 3.1 mm of rainfall, grade 2 between 3.1 and 5.2 mm etc. Grade 10 rainy days, the most exceptional, incurred over 29.6 mm.

A generous description of exceptional rainfall for Ilkley might be grades 8 to 10 producing **30%** of all rainfall in Ilkley. On average, during the 57 years of records for Ilkley, such exceptional rainfall occurred annually on only 17 days. This could push some of the 20 overflow reduction plan target spills to occur in non-exceptional situations, so incurring a permit breach and be illegal.

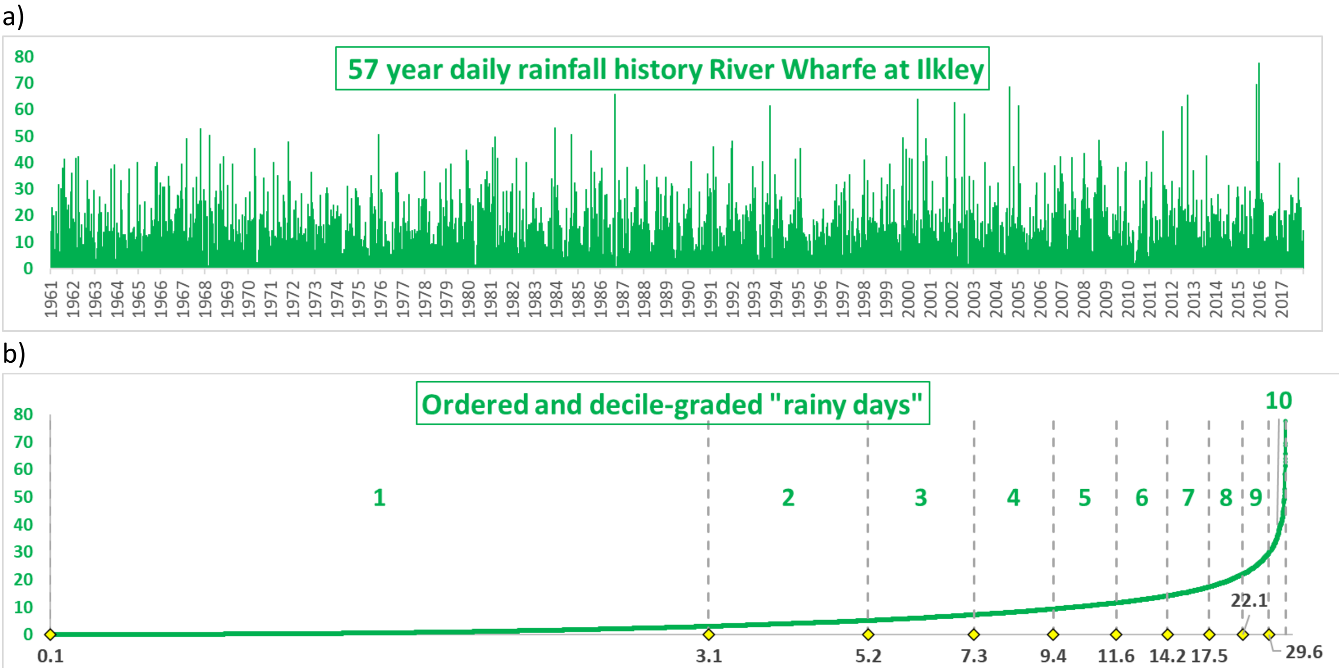

Figure 4 a) 57 years of daily rainfall (mm) at Ilkley, North Yorkshire; b) same rainfall data ordered according to magnitude and graded into deciles each of which accounts for 10% of the total rainfall in the 57 years.

Using a similar analysis of 56 years of rainfall data for West Oxfordshire, a less rainy area than Ilkley, rainy days graded 8 to 10 occurred on average 12-13 days per year. In order to account for the target 20 spills, the definition of exceptional rainfall may need to be extended to include as low a grade as 6 which has a threshold of 10mm daily rainfall. That could not be considered exceptional rainfall and so as many as 7 to 8 target spills could be illegal. For the location of Mogden STW, grade 8 to 10 rainy days occur on just 11 days per year on average. Once again, the 20 target spills may only be

[26] CAR_NRW0036849, CAR_NRW0037023, CAR_NRW0037041, CAR_NRW0037042, CAR_NRW0037024 downloaded from NRW Public Register: https://publicregister.naturalresources.wales/Search/Results?SearchTerm=trebanos

[27] https://nrfa.ceh.ac.uk/

[28] Osborne et al, Observed trends in the daily intensity of UK precipitation. Int J Climatol. 20: 347-364 (2000).

accounted for by including grade 6 rainy days which have a threshold of 9.1mm daily rainfall. So, on average, 9 of the 20 storm overflows discharge reduction plan target spills may be illegal.

4 Monitoring the catchment burden of untreated sewage

Individual rivers receive direct, simultaneous discharges of untreated sewage from multiple storm overflows on their journey from source to sea. So, during longer spills, the lower reaches of a river may already be polluted from upstream discharges when yet more overflows downstream discharge untreated sewage. Moreover, untreated sewage can be simultaneously discharged into tributaries across a river catchment, resulting in an aggregation of many tens of discharges in a day by the time river catchment flows reaches their coastal destinations. Three river catchments are considered below in more detail in order to illustrate the exposure from multiple storm overflows. In the remainder of the report, estimation of discharge volume uses the third approach described earlier.

Example The River Nidd in North Yorkshire

The River Nidd rises in Nidd Head Spring and flows for 95 km to its confluence with the River Ouse at Nun Monkten. Recent testing of water pollution in the River Nidd has shown E. coli levels to be 'concerningly high' and echoing levels found in 2020 and 2021[29,30,31].

The chart in Figure 5 shows the relative upstream-downstream locations of 20 storm overflows discharging untreated sewage directly to the River Nidd or via a tributary. For 18 of the 20, it shows individual spills from each overflow throughout 2020. (Data for two overflows was withheld by Yorkshire Water.) The total spilling for all 20 storm overflows in 2020 was 18,928 hours.

Individual spills or discharges of untreated sewage recorded by Event Duration Monitors (EDMs) are shown as horizontal segments along a monthly timeline. By illustrating the individual spills, the simultaneous discharge of untreated sewage along this stretch of the River Nidd is clearly seen, as is their seasonal nature between Autumn and Spring. The depiction of individual spills in this way demonstrates the inadequacy of the Environment Agency's current summary of storm overflow activity as just two figures: the total spilling hours and number of spills for a year.

The River Nidd receives untreated sewage discharges from more than 7 STWS between Pateley Bridge and Kirk Hammerton. For four of the STWs (Pateley Bridge, Harrogate North, Darley and Kirk Hammerton), it is estimated that in 2020 the **River Nidd received at least 317 Olympic Pools' worth of untreated sewage**.

Between 2016 and 2022, the analysis of earlier years suggests that the River Nidd received

- 1.131 billion litres of untreated wastewater in all (452 Olympic Pools)
- 59 million litres from Darley STW (24 Olympic Pools)
- 420 million litres from Harrogate North STW (168 Olympic Pools)
- 49 million litres from Kirk Hammerton STW (20 Olympic Pools)
- 603 million litres from Pateley Bridge (241 Olympic Pools)

[29] https://www.yorkshirepost.co.uk/news/environment/bacteria-linked-to-sewage-at-concerningly-high-levels-in-river-nidd-4068784
[30] https://www.cpreney.org.uk/news/sewage-pollution-in-north-yorkshire-what-can-we-do/
[31] https://thestrayferret.co.uk/river-nidd-fails-water-pollution-tests-due-to-raw-sewage/

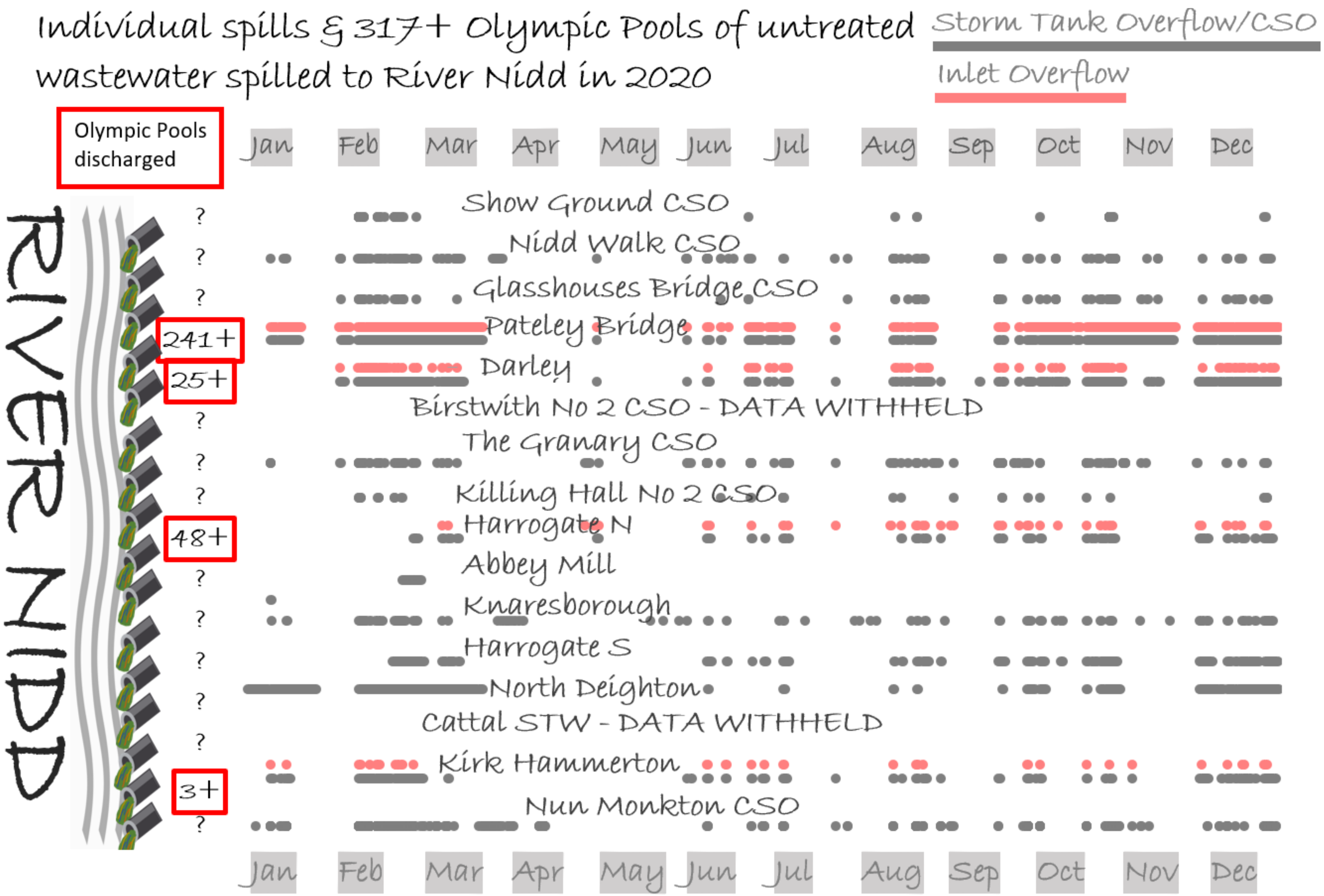

Figure 5: individual spills in 2020 to the River Nidd via 4 inlet overflows (pink segments), 7 CSOs and 7 storm tank overflows (grey segments) The 20 storm overflows spilled for a total of 18,928 hours but we can estimate the volume discharged for only 4, and even then that is a minimum value.

For three STWs (Harrogate South, Knaresbrough, North Deighton), the volume of untreated sewage discharges is unknown. However, it has been possible to use a combination of rainfall, sewage treatment and detailed spill start-stop data to identify more than 1,000 days between 2016 and 2021 where the data suggests illegal spills from all 7 STWs (Table 3).

Table 3: Number of days believed to involve illegal spills of untreated sewage to River Nidd

	TOTAL	2016	2017	2018	2019	2020	2021
Kirk Hammerton	315	*40*	*28*	*40*	*35*	92	80
Pateley Bridge	268	*91*	*29*	*42*	*38*	60	8
North Deighton	144	*58*	*16*	*1*	*3*	43	23
Knaresborough	163	*36*	*15*	*25*	*30*	30	27
Harrogate North	66	*0*	*0*	*0*	*0*	31	35
Darley	54	*2*	*2*	*9*	*8*	8	25
Harrogate South	49	*0*	*0*	*0*	*0*	44	5
	1059	227	90	117	114	308	203

2020 & 2021 results are based on EDM data supplied by Yorkshire Water. Figures in italics are estimates.

Pateley Bridge STW appears to spill large volumes of untreated sewage, often illegally. **Fig**. 6 shows a long, continuous spill of at least 44 days in February-March 2020 when an estimated 170 million litres or 68 Olympic Pools' worth of untreated sewage was discharged. A shorter spill was illegal between Feb 4 and 6, as were the 5 days of the long spill, 2 of which were doubly illegal. Notice that the river is not in full spate throughout the spill and so the dilution effect does vary.

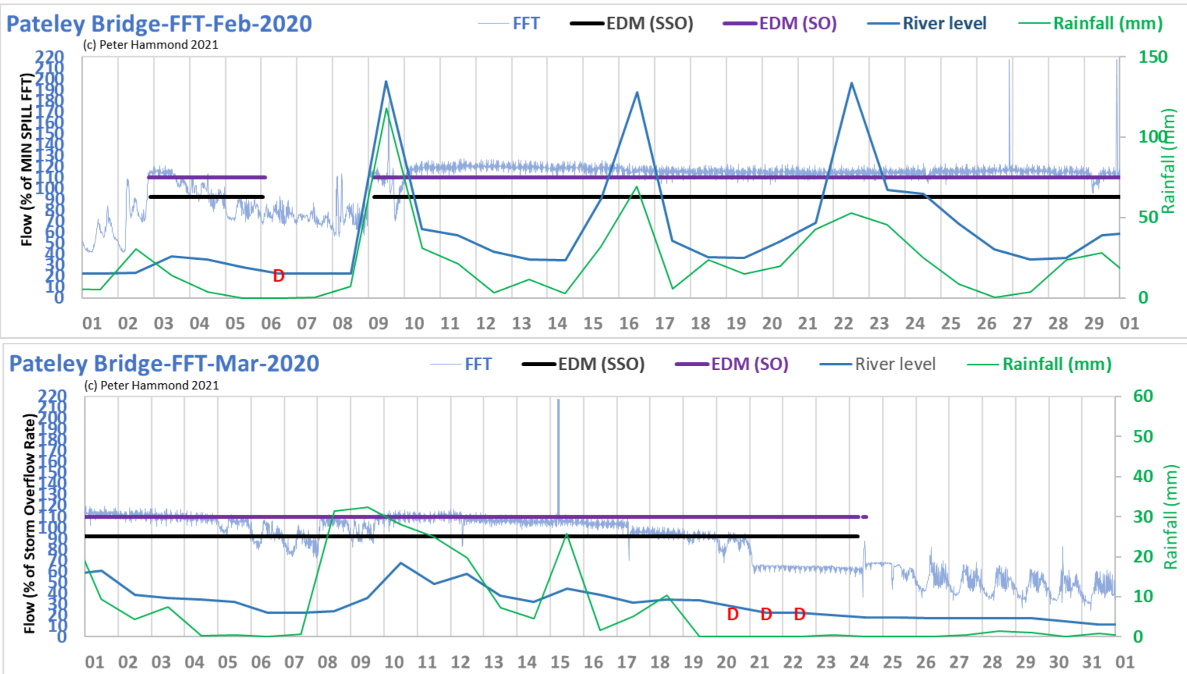

Figure 6 A long and largely permissible spill at both inlet and storm tank overflows at Pateley Bridge STW in Feb-Mar 2020 involving an estimated discharge of 170 million litres or 68 Olympic Pools'

Fig. 6 also shows the variation in level of the River Nidd during spills, demonstrating that the potential dilution factor of river flow varies considerably with potentially dry weather river flow levels throughout spills. This emphasizes the importance of knowing spill volume and spill start-stop times if scientific studies of diluted effects of untreated sewage are to be carried out.

Kirk Hammerton STW did not spill such large volumes. However, it appears, to be the worst offender in terms of illegal spilling. Examples of "early" spills (spilling while not treating to capacity) at Kirk Hammerton STW are shown in **Fig**. 7.

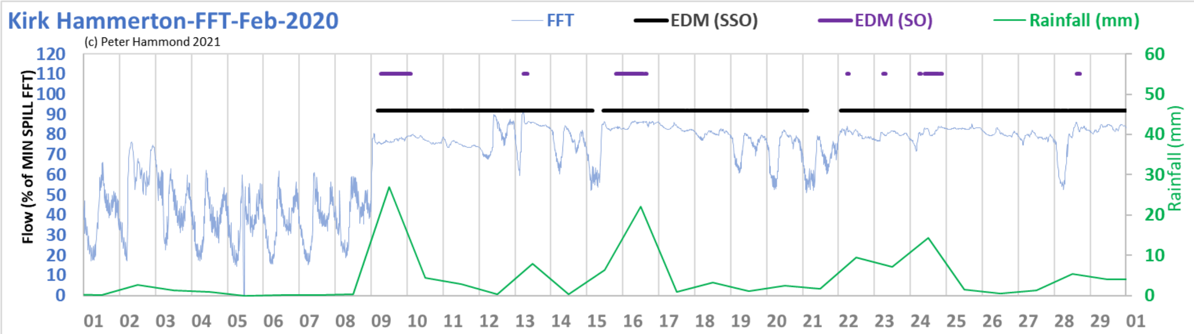

Figure 7: Sewage flow receiving full treatment (FFT) is below capacity during spills via the storm tank overflow (SSO). **Black** horizontal segments delineate the SSO spills and are set at 92% capacity to allow 8% meter error. When the inlet overflow is simultaneously active (**purple** horizontal segments) the estimated volume of illegal untreated sewage discharge was about 4 million litres or 1.6 Olympic Pools.

Example The River Wharfe in North Yorkshire

In December 2020, the River Wharfe at Cromwell, Ilkley was the first location in England to receive bathing water quality status. Since then, river quality there has remained poor[32]. The Rivers Nidd and Wharfe are tributaries to the Yorkshire Ouse. Indeed, given their proximity, the two rivers are often included in scientific studies and associated publications (**Fig**. 8).

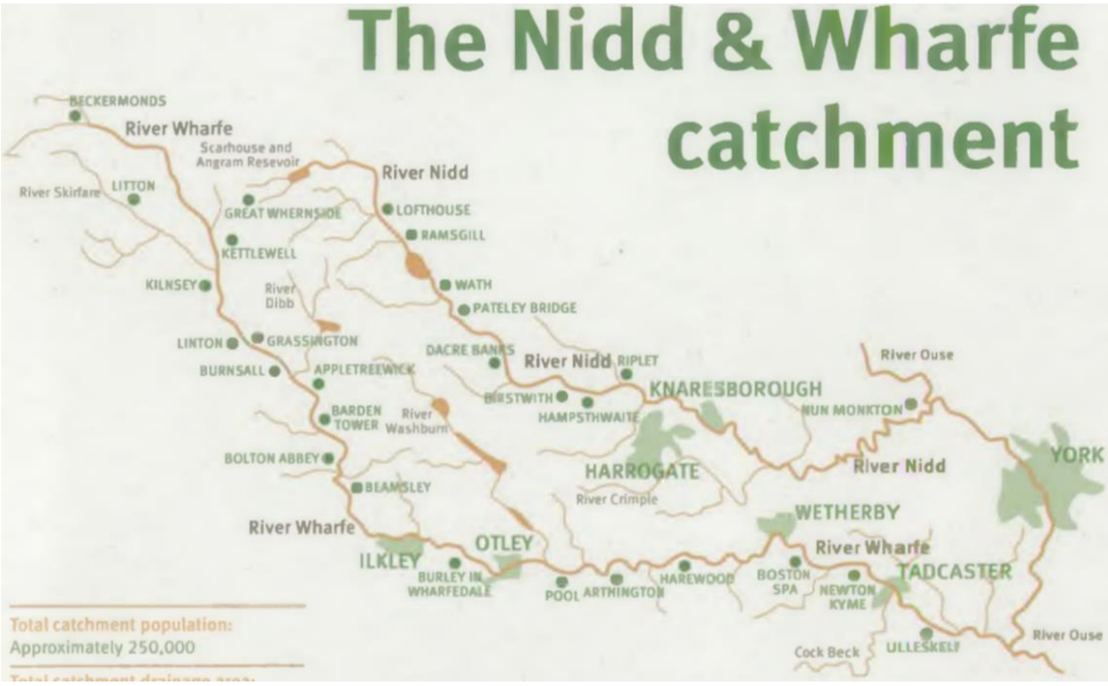

Fig. 8 A joint catchment map from a 2004 publication of the Environment Agency[33].

The chart in Figure 9 represents the upstream-downstream location of 26 storm overflows discharging directly or via tributaries to the River Wharfe between Kettlewell and Tadcaster on its journey to its confluence with the River Ouse. Yorkshire Water withheld the detailed spill data on several storm overflows, for example at Addingham.

32 https://environment.data.gov.uk/bwq/profiles/data-samples.html?site=uke4100-08901
33 http://www.environmentdata.org/archive/ealit:1290/OBJ/19001141.pdf

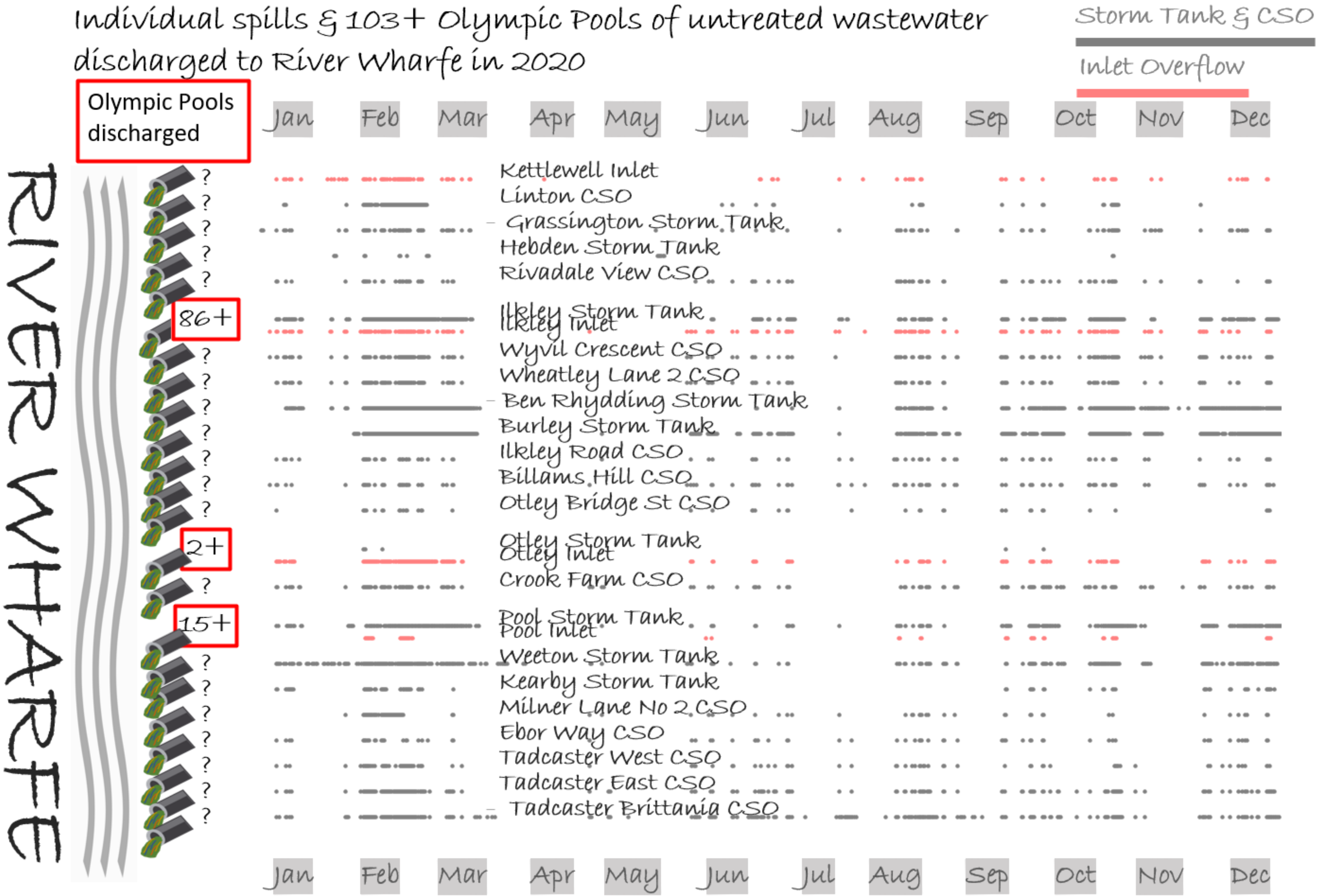

Figure 9: individual spills in 2020 to the River Wharfe via 4 STW inlets (pink segments), 13 CSOs and 9 storm tank overflows (grey segments)

The 26 storm overflows spilled for a total of 17,775 hours, but the volume of discharge can be estimated for only 3 – the estimates are for a minimum value only

The total spilling for all 26 overflows in 2020 was 17,775 hours. The River Wharfe received at least 103 Olympic Pools of untreated sewage in 2020 from just 3 STWs at Ilkley, Otley and Pool.

During the Ilkley Clean River campaign for bathing quality status, river quality testing was undertaken at multiple sites along the River Wharfe. On one particular day, October 29th 2020, there were extremely high levels of e-coli in the River Wharfe between Addingham and Ilkley. This is not surprising given the multiple, simultaneous spills in the first 2 weeks of October and from 25th October, shortly before the e-coli sampling (**Fig**. 10). Sampling on the following day might have shown even more extensive inflated e-coli values when 18 storm overflows were discharging.

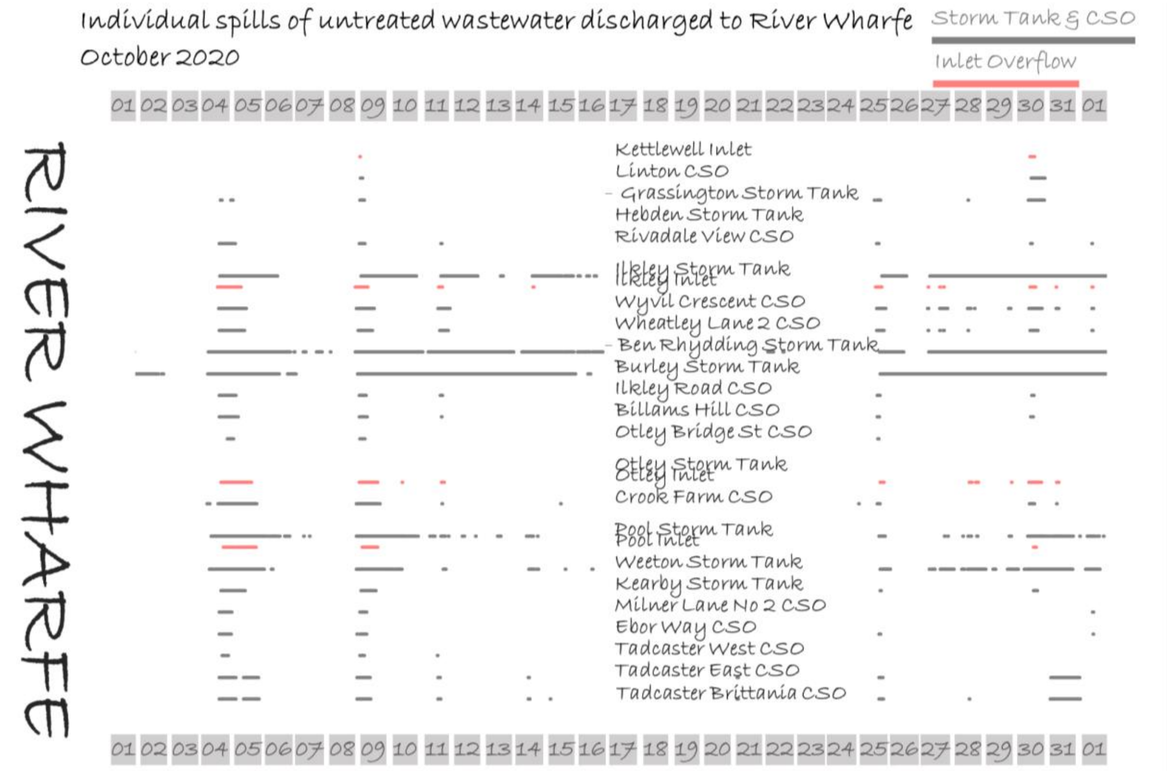

Figure 10: Storm overflow discharges to the River Wharfe contributing to high e-coli levels on Oct 29th 2020

Example The River Conwy in North Wales

The River Conwy rises on Migneint moor and is joined by the rivers Machno and Lledr before reaching Betws-y-Coed, where it is joined by the River Llugwy, and later by the River Hiraethlyn. It is considered an excellent sea trout river and is much monitored for water quality because its final destination, Conwy Bay, is important in the Mussel industry[34]. Incidents involving sewage pollution have recently generated public concern and media attention[35,36, 37, 38].

The chart in **Fig**. 11 shows the relative upstream-downstream locations of 25 storm overflows discharging directly or via tributaries to the River Conwy between Betwys Y Coed and Llandudno or on the adjacent coast as well as the individual spill intervals from each. The total spilling for all 25 storm overflows in 2020 was 22,729 hours.

Capel Curig CSO

Capel Curig CSO is in Snowdonia National Park and discharges to the River Llugwy, a tributary of the Conwy.

Of the 25 storm overflows listed in the chart in **Fig**. 11, it had the biggest spilling total for 2020 at 4,187 hours. There has been little improvement with 3,520 hours in 2021 and 3,393 hours in 2022.

Capel Curig STW has no storm storage capacity and no screen according to an improvement scheme document from March 2022 on NRW's Public Register[39], so whatever is flushed ends up in the river. A volume meter would at least have recorded the size of the discharge despoiling this beauty spot.

Eglwysbach STW

The next greatest spilling total was at Eglwysbach STW which discharges indirectly to the River Conwy via the River Hiraethlyn. It is small and has only one meter (on its storm tank overflow) and an EDM device recording spill start-stop times.

Unfortunately, the sewage treatment flow data and the EDM spill data do not look consistent. Either one or both of the treated sewage meter and spill monitor are faulty. Otherwise, for example, the tail-end of every spill of untreated sewage is in breach of permit because treatment capacity is not maintained (**Fig**. 12). The charts for 2021 and 2022 show exactly the same behaviour. A volume meter, assuming it was installed and maintained properly, would at least indicate the flow meter accuracy and size of the overflow problem.

[34] https://doi.org/10.1007/s11356-018-3261-y
[35] https://www.janetfinchsaunders.org.uk/news/finch-saunders-sorts-sewage-system-failure-llanrwst
[36] https://www.bbc.co.uk/news/uk-wales-47438182
[37] https://www.walesonline.co.uk/news/wales-news/raw-sewage-slurry-spilling-welsh-16207541
[38] https://www.northwalespioneer.co.uk/news/20065485.sewage-fault-potentially-causing-pollution-river-conwy-fixed/
[39] https://publicregister.naturalresources.wales/Search/Results?SearchTerm=Capel+Curig+CSO

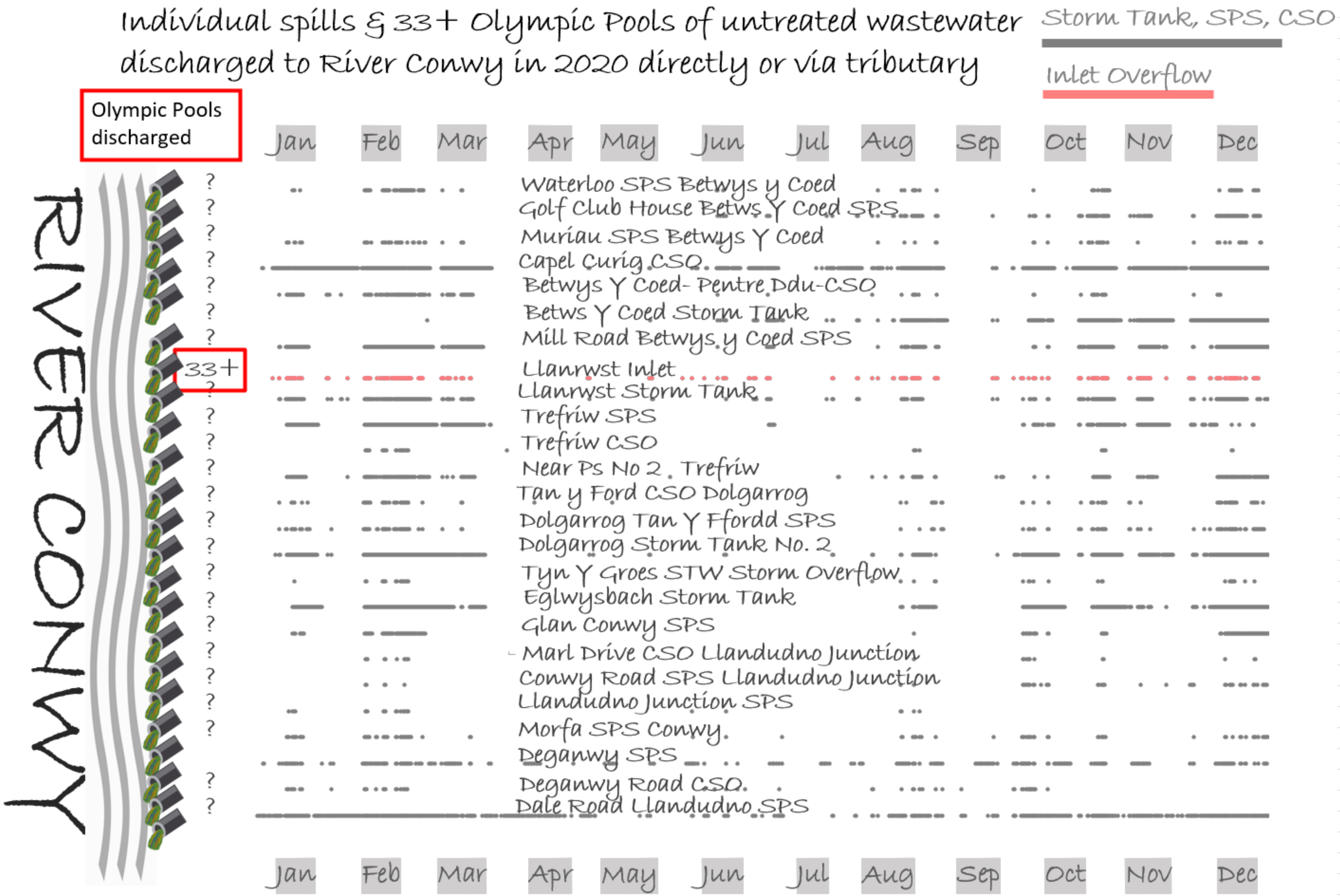

Figure 11: individual spills in 2020 to River Conwy via 1 STW inlet overflow (pink segments), 6 CSOs, 13 pumping stations, 5 storm tank overflows (grey segments) The total spilling hours for all 25 storm overflows was 22,729 hours but discharge volume estimation is only possible for one: Llanrwst Storm Tank overflow.

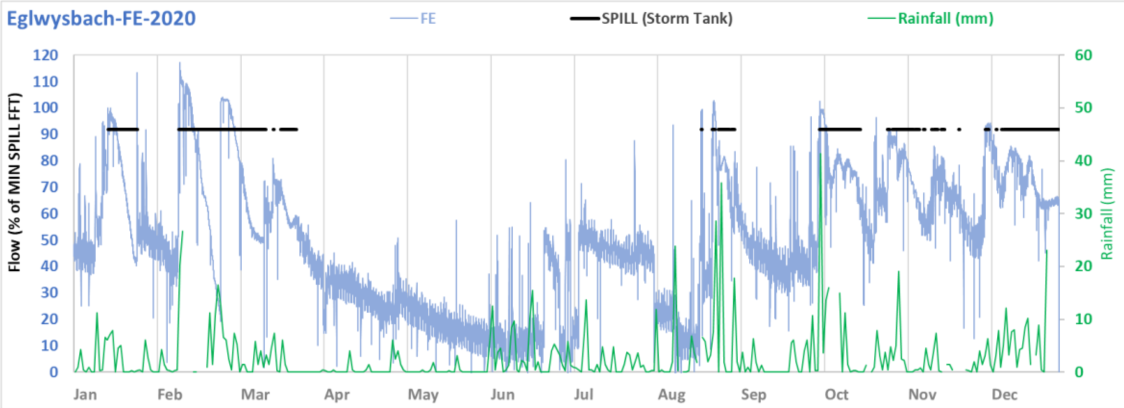

Figure 12: annual 2020 overview chart for Eglwysbach STW showing the treated effluent flow from the works(**blue** curve), rainfall (**green** curve) and individual spills (**black** segments)

Llanwrst STW

Llanwrst STW serves a population of about 4,000 people and discharges directly to the River Conwy. It has received recent media attention due to observation, video evidence and media reporting of pollution events recorded and stimulated by members of the public[40,41].

The chart in Fig. 11 includes an estimated 33 Olympic Pools of untreated sewage discharged from LLanwrst STW in 2020. Estimates for 2021 and 2022 were 15 and 9 respectively.

The sewage flow passed into the treatment process at Llanwrst STW is often extremely “choppy” and irregular, as is illustrated in early February in **Fig**. 13. Such behaviour can be associated with pump failure. Indeed, the Natural Resources Wales Public Register includes records of several incidents of pump failure at the works. An alternative explanation is the sporadic nature of supply by multiple sewage pumping stations serving the sewage works.

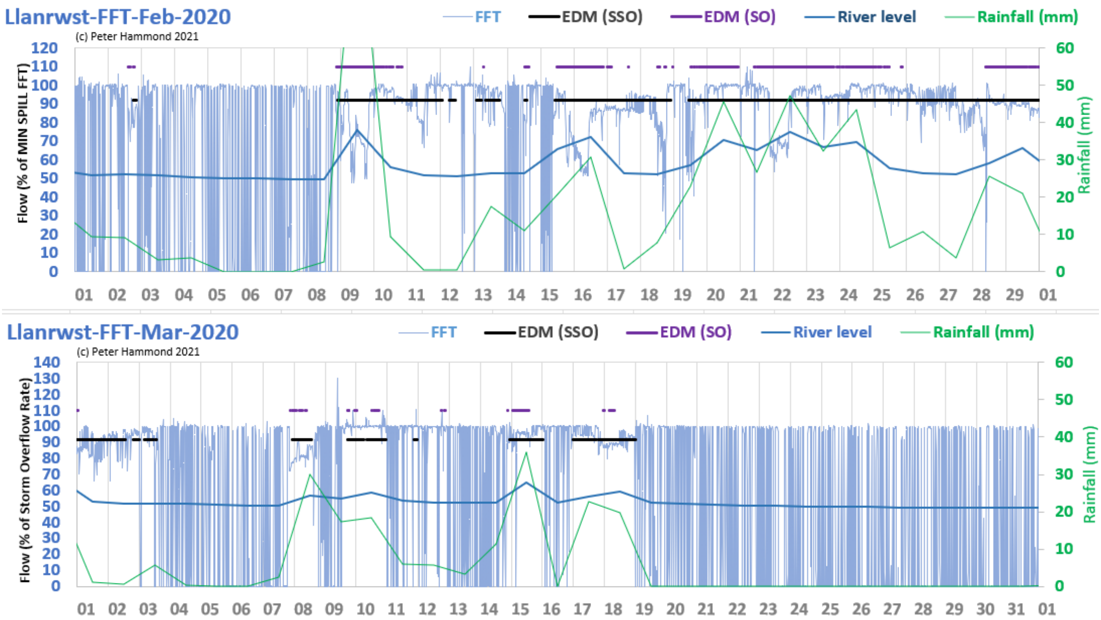

Figure 13: sewage flow (**blue** curve) passed into the treatment process (FFT); storm tank spills (**black** segments) and inlet overflow spills (**purple** segments). Spills on Feb 9,15,16, 18 were illegal.

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40 https://www.bbc.co.uk/news/uk-wales-47438182

41 https://www.northwalespioneer.co.uk/news/17678354.llanrwst-sewer-flooding-tackled-new-pumps-stop-block-campaign/

When both inlet and storm tank overflows were active, the **estimated discharge was 28.2 million litres or 11.3 Olympic Pools.**

Llanwrst STW spilled almost continuously in February-March 2020 for 24 days, during which the treatment flow was often as low as 50-60% of the works capacity. Therefore, for example, on February 9th, 15th, 16th, and 18th the spills would be considered in breach of permitted conditions and hence illegal.

Appendix: How the volumes of untreated sewage discharge were estimated

Mogden STW, operated by Thames Water, was straightforward to analyse as it is one of very few STWs with a volume meter on its storm overflow. Mogden is the only STW, known to the author, where storm discharge volume is published online[42].

Fairford, also operated by Thames Water, has flow meters at its inlet from pumping stations where raw sewage arrives and at its outlet where treated effluent is discharged to the River Coln. So, during spills, the volume of untreated wastewater discharged from its storm tank can be easily estimated as the difference between the two meters.

Pateley Bridge has 2 overflow weirs, one at its inlet limiting inflow to the works and another on its storm tanks implementing its statutory minimum flow to the STW's treatment process. Neither overflow has a volume meter installed. Pateley Bridge STW also has a flow meter recording the rate at which untreated sewage is passed forward for treatment. It is not possible to estimate the volume of the untreated sewage discharged to the River Nidd at the works inlet. However, it is possible to estimate the discharge via the storm tanks by subtracting metered flow to treatment from the fixed inflow when both overflows are active. There are additional discharges for which no volume estimate is possible when the storm tank overflow is active but the inlet overflow is not. Therefore, Pateley Bridge certainly discharges even more untreated wastewater than estimated here. The same double overflow analysis was used for the remaining 28 STWs listed in Table 1 and operated by Northumbrian Water (1); Severn Trent (1); South West Water (5); Southern Water (6); United Utilities (2); Welsh Water (2); Wessex Water (3); and, Yorkshire Water (8).

Obviously, deployment of a single volume meter, as at Mogden STW, is the simplest and gives the most accurate analysis. A pair of flow meters, at both inlet and outlet, and a storm tank EDM recording spill start and stop, as at Fairford, is workable but relies on 2 devices producing correct data. Dependence on correct settings of overflow weirs at both works inlet and storm tanks, two EDM recording start-stop times and a meter for flow to treatment[43], as at Pateley Bridge, is the least reliable. Moreover, this approach excludes untreated sewage discharges at the inlet as well as discharges when only the storm tank overflow is in operation and therefore is likely to underestimate storm discharge volume significantly.

[42] https://www.thameswater.co.uk/about-us/performance/mogden

[43] A meter recording of final treated effluent also be used but may slightly overestimate volume spilled as it ignores the generation of sewage sludge which is typically a few percent of raw sewage arriving at an STW.