River Yealm Water Quality Group: a focused assessment of past monitoring

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Disclaimer

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Summary

This report has been drafted to help inform The River Yealm Water Quality Group convened by Brixton Parish Council. Results presented draw upon environmental monitoring measures undertaken by both the Environment Agency (EA) and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), selecting those of interest to three historical concerns within the River Yealm catchment system that include:

(i) Tributyl tin from antifouling paints;
(ii) Suspended solids from quarrying and other activities; and
(iii) Faecal contamination from land run-off and sewage.

Data show how concentrations of tributyl tin (TBT) sampled in water at the bottom of estuary off Warren Point from 1999 to 2019 remained high (> 0.01 µg/l) for at least 12 years after exceptionally toxic effects on marine life had become appreciated in the early 1980's; but which concentrations, in response to the prohibition of TBT paints, have since fallen well below recommended environmental quality standards (< 0.002µg/l).

Concentrations of suspended solids sampled in water at Puslinch Bridge from 2007 to 2021 averaged (±95% confidence interval) 23.00 ± 4.00 mg/l. This was much higher than the associated average for Hele Cross (3.2 ± 0.2 mg/l) further upstream, indicating persistent contamination, and which long-term average at Puslinch Bridge is statistically ($p < 0.05$) similar to the EU Freshwater Fish Directive's Guideline Standard of 25 mg/l used by the Environment Agency to help set controls on discharges of inorganic material from quarries, open caste coal sites, and mines.

Data describing concentrations of intestinal enteroccoci and *Escherichia coli* (*E. coli*) were analysed as markers for the presence of human or animal faeces together with other organisms, such as viruses, also derived from faeces, which can cause illness.

Average values (± 95% confidence interval) for intestinal enteroccoci from 2007 to 2016 at Puslinch Gauging Station (1744 ± 455 cfu/100 ml) towards the bottom of River Yealm and Kitley Lake outflow (567 ± 162 cfu/100ml) from Silverbridge tributary that feeds the estuary further below were as much as 40 and 13 times the coincident average recorded at Hele Cross (44 ± 19 cfu/100ml) towards the top of River Yealm.

Average values (± 95% confidence interval) for *E. coli* from 2007 to 2021 at Puslinch Gauging Station (6543 ± 682 cfu/100 ml) and Kitley Lake outflow (1117 ± 210 cfu/100ml) were as much as 25 and 4 times the coincident average recorded at Hele Cross (263 ± 188 cfu/100ml).

Average values for both intestinal enteroccoci and *E. coli* from 2007 to 2016 and 2021, respectively, were both consistently and very significantly ($p<0.05$) above their respective "sufficient" Environment Agency water quality environmental thresholds for inland bathing waters, associated classifications being "Poor".

Average concentrations of intestinal enterococci and *E. coli* at Puslinch Gauging Station were 3 and 6 times greater than at Kitley Lake outflow, respectively. Given greater average water flow past Puslinch compared with through Kitley Lake, the

great majority of faecal contamination within the catchment as a whole must therefore have occurred through inputs to the River Yealm.

Shellfish harvesting areas are classified by CEFAS (Centre for Environment, Fisheries and Aquaculture Science) according to the extent of faecal contamination as shown by monitoring of *E. coli* in shellfish flesh, when the resulting classification dictates what treatment processes may be required before shellfish can be marketed.

Comparison of *E. coli* content in Pacific oyster tissues from the same Fox Cove site over the last 22 years shows no statistically significant change ($p>0.05$) over time, consistent with EA water quality data since 2006, and throughout which time most often resulted in classifications requiring significant treatment processes before shellfish could be marketed.

Collective findings indicate there has not been any improvement in concentrations of *E. coli* as a key marker of faecal contamination within the River Yealm over the past two decades.

The present report concludes by suggesting 2 outstanding questions:
1. How can we best help everyone improve how they use water and discharge waste to water bodies; engaging accordingly with water companies, planners, farmers and the public?
2. How can we best help ensure appropriate environmental measures to underpin evidence-backed arguments for change, most especially through a capability for immediate sampling in response to evident pollution, with community engagement such as through the Westcountry Rivers Trust “Citizen Science Investigation” (CSI) programme.

2. Introduction

The stated purpose of the Environment Agency (EA) is: “to protect or enhance the environment, taken as a whole” so as to promote “the objective of achieving sustainable development”. This protection includes threats such as pollution and flooding. More than 135,000 measures have been made by the EA for the purposes of monitoring water quality throughout the River Yealm catchment over past 20 years, and which are available from the EA Water Quality Archive (https://environment.data.gov.uk/water-quality/view/download/new).

Those measures have been made at various locations that include among others:

- RIVER YEALM - LOWER ESTUARY (STEER POINT)
- RIVER YEALM 100M D/S INTERNATIONAL PAINT
- NEWTON STREAM AT BRIDGEND (U/S TRIBS)
- SILVERBRIDGE LAKE AT BRIXTON
- NEWTON STREAM D/S NEWTON FERRERS STW
- SILVERBRIDGE LAKE AT KITLEY HOTEL
- COFFLETE STREAM AT COMBE
- COFFLETE STREAM AT FORDBROOK
- SILVERBRIDGE LAKE @ KITLEY LAKE OUTFLOW
- RIVER YEALM AT PUSLINCH GAUGING STN

- RIVER YEALM AT PUSLINCH BRIDGE
- RIVER YEALM AT YEALM BRIDGE
- RIVER YEALM AT POPPLE'S BRIDGE
- LONG BROOK D/S WESTLAKE STW
- LONG BROOK AT YEALM BRIDGE
- LEE MILL STREAM AT LOWER CULVERT
- PIALL AT ALMSHOUSE BRIDGE
- RIVER PIALL AT SLADE BRIDGE
- RIVER PIALL AT MARKS BRIDGE
- RIVER YEALM D/S PIALL/RIDGECOT LAKE
- RIVER YEALM AT FARDEL MILL FARM BRIDGE
- RIVER YEALM AT HELE CROSS

A map of the River Yealm catchment, detailing the above locations, is illustrated in Figure 1 (refer Section 5 below, containing all Figures), taken from the Environment Agency's' River Yealm Final Salmon Action Plan dated 2020 (http://www.environmentdata.org/archive/ealit:1392).

Different measures of water quality have been made at approximately monthly intervals at above locations, but with different measures made at different locations, including over different lengths of time, some locations only being sampled for 3 months or less, whereas others have been sampled intermittently for 20 years. Collectively, those measures include among others:

- Temperature
- Salinity, by Conductivity
- pH
- Oxygen, Dissolved as O2
- Hardness, Total as CaCO3
- Hardness, Magnesium
- BOD : 5 Day ATU
- Aluminium
- Barium
- Boron
- Cadmium
- Copper
- Lithium
- Tetraphenyl Tin
- Tributyl Tin
- Zinc
- Aluminium
- Chromium
- Manganese
- Nickel
- Strontium
- Lead
- Nickel
- Potassium
- Arsenic
- Calcium
- Magnesium
- Dieldrin
- Mercury
- DDT
- Ammonia un-ionised as N

- Ammoniacal Nitrogen as N
- Nitrogen, Kjeldahl as N
- Nitrogen, Total Inorganic : (Calculated)
- Nitrogen, Total Oxidised as N
- Nitrate as N
- Nitrite as N
- Phosphorus, Total as P
- Phosphate :- {TIP}
- Orthophosphate, reactive as P
- Solids, Suspended at 105 C
- Orthophosphate, reactive as P
- Enterococci: Intestinal: Confirmed: MF
- Streptococci : Faecal : Presumptive : MF
- Streptococci : Faecal : Confirmed : MF
- *Escherichia coli* : Confirmed : MF
- *Escherichia coli* : Presumptive : MF
- Coliforms, Faecal : Presumptive : MF
- Coliforms, Total : Presumptive : MF

The way in which the Environment Agency use the above measures to monitoring and classify the ecological and chemical status of the River Yealm is described on their Catchment Data Explorer (https://environment.data.gov.uk/catchment-planning/OperationalCatchment/3555/Summary).

For simplicity and practicality, this report compares a small subset of the above measures, selecting those of interest to three historical local concerns that include:

(iv) Tributyl tin from antifouling paints;
(v) Suspended solids from quarrying and other activities; and
(vi) Faecal contamination from land run-off and sewage.

3. Findings

(i) Tributyl tin

Tributyltin (TBT) is a highly toxic biocide that has been used extensively to prevent the growth of marine organisms on the hulls of large ships. It is a problem in the aquatic environment because it is extremely toxic to non-target organisms, is linked to immune suppression and imposex (development of male characteristics in females) in snails and bivalves, whilst also persistent (https://www.sciencedirect.com/topics/earth-and-planetary-sciences/tributyltin).

Acting on the best information available linking collapse of local oyster fisheries to the presence of TBT, France was the first country to introduce legislation prohibiting the application of TBT paints to small (< 25 metre) vessels in 1982, followed by the UK in 1987 (http://marinespecies.org/introduced/wiki/TBT_and_Imposex).

At the same time, in recognition of low-dose effects, the UK Water Research Centre recommended environmental quality standards (EQS) for organotin compounds of only 0.002 µg/l in seawater, based in part upon findings, for example, that sterilisation of female dogwhelks occurs at TBT concentrations as low as 0.003 µg/l (https://www.eea.europa.eu/publications/environmental_issue_report_2001_22/issue-22-part-13.pdf/view).

Figure 2 shows EA Water Quality Archive results for TBT measured from 1999 to 2019 at River Yealm Lower Estuary, at a site off Warren Point, just downstream of what is now the Harbour Office. Clearly, as late as 1999, 12 years after setting the new EQS, levels remained well in excess of 0.002 µg/l. Levels have since fallen well below that EQS of 0.002 µg/l, as suggested by the blue dotted line in Figure 2.

(ii) Suspended solids

Periodically, over many years, the River Yealm has been known to turn "emulsion white", such as occurred on 16 Nov 2021 (https://www.plymouthherald.co.uk/news/plymouth-news/river-yealm-turns-white-contaminated-4728073). This is thought to be suspended solids from quarry operations in the upper catchment, and which is in addition to periodic inputs from other commercial and agricultural sources.

Suspended solids of this type can elicit short- or long-term responses from aquatic plants and animals, depending on the quantity, quality, and duration of suspended exposure (https://link.springer.com/article/10.1007/s10669-015-9557-2). Suspended matter blocks out light, so that photosynthesis may cease, when algae and other plants may die, with less production of oxygen for fish and other aquatic life. Whilst also stopping fish seeing, suspended matter may clog the gills of fish and shellfish, killing them directly.

Figure 3 shows EA Water Quality Archive results for suspended solids measured from 2007 to 2021 at two sites, both illustrated in Figure 1; Hele Cross towards the top of River Yealm and Puslinch Bridge not far above where the river discharges into estuary. All measures of suspended solids and which averaged (± 95% confidence interval) 3.2 ± 0.2 mg/l at the top of system (Hele Cross) were below the EU Freshwater Fish Directive's Guideline Standard, which is an annual mean of 25 mg/l, and which guideline standard is used by the Environment Agency to help set controls on discharges of inorganic material from quarries, open caste coal sites, and mines (https://www.wfduk.org/sites/default/files/Media/Environmental%20standards/Environmental%20standards%20phase%202_Final_110309.pdf).

Higher levels of suspended solids were generally evident at Puslinch Bridge, indicating persistent contamination downstream from Hele Cross (Figure 3). Taking all data for Puslinch Bridge from 2007 to 2021, average (± 95% confidence interval) suspended solids were 23.00 ± 4.00 mg/l, and thus statistically ($p < 0.05$) similar to the EU Freshwater Fish Directive's Guideline Standard described above. Saying that, from 2007 to 2012, levels of up to more than 600 ml/g frequently exceeded that Guideline Standard. Overall, however, levels of suspended solids at Puslinch Bridge appear in general to have improved from 2007 to 2021, as suggested by the fitted dashed line (Figure 3).

(iii) Faecal contamination

Besides the living organisms that form part of the natural cycle in rivers, there are other organisms that are less desirable. Their presence is generally due to human activities, and they are a form of pollution. Many of these organisms are pathogenic bacteria, which can cause disease. Apart from land-runoff, usually during heavy rainfall, the most common source of pathogenic bacteria is human sewage.

Pathogenic bacteria are adapted to body temperatures so they die off relatively quickly in cold river waters. For example, typhoid bacteria die within seven days in river water at the temperatures found in Britain—but a week is long enough to spread infection (https://www.open.edu/openlearn/nature-environment/environmental-studies/understanding-water-quality/content-section-2.2).

Similarly, intestinal enterococci are important members of gut communities in many animals and humans, although some types are environmental in origin, and which are also opportunistic pathogens that cause millions of infections annually.

Non-pathogenic bacteria are also part of the aquatic system. One such bacterium, *Escherichia coli* (*E. coli*), has various strains, most of which are non-pathogenic and exist in human and animal intestines in a symbiotic relationship, making substances needed by humans and animals.

For these reasons, the presence of either intestinal enteroccoci and/or *E. coli* bacteria indicates that human or animal faeces may be present, together with other organisms, such as viruses, also derived from faeces, that can cause illness.

Collectively, their abundance in human and animal faeces, the ease with which they are cultured, and their correlation with human health outcomes in waterbodies, have led to their widespread use as tools for assessing water quality (https://mmbr.asm.org/content/76/4/685).

The Environment Agency takes water samples for intestinal enteroccoci and *E. coli* at each of England's designated bathing waters during the bathing water season between May and September each year. A classification for each bathing water is calculated annually based on samples from the previous four years. These classifications are, from best to worst:

- excellent – the highest cleanest seas
- good – generally good water quality
- sufficient – the water meets minimum standards
- poor – the water has not met the new minimum standards. Work is planned to improve bathing waters not yet reaching Sufficient

The analysis groups bathing waters into classifications based on the probability that most of the time concentrations of intestinal enterococci or *E. coli* will be below classification thresholds, there are no 'pass' or 'fail' standards. All the samples are combined and the classification is based on a statistical measure, known as the percentile which measures the probability of high results occurring (https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html).

Figures 4 and 5 show EA Water Quality Archive results for intestinal enteroccoci and *E. coli*, respectively, measured from 2007 to 2016 or 2021 at three sites, each illustrated in Figure 1; Hele Cross towards the top of River Yealm and Puslinch Gauging Station towards the bottom of River Yealm, plus Kitley Lake outflow from Silverbridge tributary that feeds the estuary further below.

Average values (± 95% confidence interval) for intestinal enteroccoci from 2007 to 2016 at Puslinch Gauging Station (1744 ± 455 cfu/100 ml) and Kitley Lake outflow

(567 ± 162 cfu/100ml) were as much as 40 and 13 times the coincident average recorded at Hele Cross (44 ± 19 cfu/100ml).

Average values (± 95% confidence interval) for *E. coli* from 2007 to 2021 at Puslinch Gauging Station (6543 ± 682 cfu/100 ml) and Kitley Lake outflow (1117 ± 210 cfu/100ml) were as much as 25 and 4 times the coincident average recorded at Hele Cross (263 ± 188 cfu/100ml).

From the above average values, time-averaged concentrations of intestinal enterococci and *E. coli* at Puslinch Gauging Station were 3 and 6 times greater than at Kitley Lake outflow, respectively. Given greater average water flow past Puslinch compared with through Kitley Lake, these findings indicate that the great majority of faecal contamination within catchment as a whole occurred through inputs to the River Yealm.

Given the popular swimming hole at “Pimple Rock”, only a few hundred metres upstream, it is also of note that ALL measures of intestinal enteroccoci from 2007 to 2016 at Puslinch Gauging Station were above the Environment Agency water quality environmental threshold for inland bathing waters of 330 cfu/100ml, as defined by the red horizontal line in Figure 4, above which threshold the associated classification is “Poor”, showing values that are “worse than the sufficient”. Normally, “if water is classified as poor, then the symbol for "Poor" together with a sign showing advice against bathing must be displayed in the following year. A sign displaying a "Poor" classification and advice against bathing does not mean bathing is banned or that a beach is closed, beaches remaining open for people to enjoy (https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html).

Average values for *E. coli* measured from 2007 to 2021 at Puslinch Gauging Station were 6543 (cfu/100 ml) with 90% CL (as required by the EA for this classification) of ± 573 (cfu/100ml), also indicating levels that were consistently and very significantly ($p < 0.05$) above the Environment Agency water quality environmental threshold for inland bathing waters of 900 cfu/100ml, as defined by the red horizontal line in Figure 5, and above which threshold the associated classification is also “Poor”, confirming values that are “worse than the sufficient” (https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html).

Bivalve mollusc (shellfish) harvesting areas are classified by CEFAS (Centre for Environment, Fisheries and Aquaculture Science) according to the extent of microbial (faecal) contamination as shown by monitoring of *E. coli* in shellfish flesh. Treatment processes before shellfish can be marketed are stipulated according to the resulting classification status of the area (https://www.cefas.co.uk/data-and-publications/shellfish-classification-and-microbiological-monitoring/england-and-wales/).

Towards such classification, *E. coli* have been monitored by CEFAS in shellfish on the River Yealm since about 1999. To afford a historical perspective that matches the EA water quality data for *E. coli* from 2006 described above, data were downloaded from the CEFAS data archive (https://www.cefas.co.uk/data-and-publications/shellfish-classification-and-microbiological-monitoring/england-and-wales/shellfish-monitoring-results/) to enable comparison of *E. coli* content in the tissues of Pacific oysters cultured at Fox Cove (Figure 6) over the last 22 years, and which measures are illustrated in Figure 7. These measures show no statistically significant change ($p > 0.05$) over time, consistent with the EA water quality data since 2006 (Figures 4

and 5), and throughout which time the associated range of values for *E. coli* content in Pacific oyster tissues most often resulted in classifications requiring significant treatment processes before shellfish could be marketed.

Collectively, these analyses indicate that there has not been any improvement in concentrations of *E. coli* as a key marker of faecal contamination within the River Yealm over the past two decades.

4. Discussion

Findings reported here show how there has not been any improvement in concentrations of *E. coli* as a key marker of faecal contamination within the River Yealm over the past two decades. Further, those concentrations have consistently remained at levels such that the Environment Agency classification of water quality status for inland bathing waters there is “poor”, showing values that are “worse than the sufficient”. Compared with tributyl tin and suspended solids, high and consistent loads of faecal bacteria within the River Yealm may be of greater potential significance to human and ecological health, including to our local shellfishery.

Addressing the sources from which *E. coli* originate in the River Yealm, CEFAS (p.24 of their Sanitary Survey Report dated 2010) stated that: “Statistically significant positive relationships were detected between rainfall and levels of *E. coli* in bivalves from all current representative monitoring points in the estuary. Therefore, rainfall seems an adequate parameter to predict levels of *E. coli* in bivalves in this estuary. However, the strength of the association varied according to the monitoring point and the time of sampling relative to the rainfall event. Higher coefficients were computed when sampling took place 1–2 days after the rainfall event. No positive associations were found between flows in the River Yealm and levels of *E. coli* in bivalves. Taken together, these results indicate that rainfall-dependent sewage discharges and dairy washings/surface runoff from agricultural land are the most likely significant sources of faecal contamination impacting the quality of bivalves in the Yealm. This is confirmed by microbial source tracking studies undertaken by the Environment Agency across the Yealm catchment, which have indicated mixed dominance of animal/human sources across the catchment”.

Relative contributions to *E. coli* levels from sewage or from agricultural land runoff remain unclear. There are in fact very few useful data helping to resolve human versus agricultural and other sources of bacteria for the River Yealm Catchment in the EA Water Quality Archive. However, on this subject, a recent article within Guardian newspaper (https://www.theguardian.com/environment/2021/mar/31/water-firms-discharged-raw-sewage-into-english-waters-400000-times-last-year?utm_term=e39160e993382f0bdb62e4bc81a6fefc&utm_campaign=GuardianTodayUK&utm_source=esp&utm_medium=Email&CMP=GTUK_email)
described how water companies discharged raw sewage into rivers and coastal waters in England more than 400,000 times during the year 2020, and nearly 300,000 times in 2019. This apparent increase may in part be associated with a coincident increase in the monitoring of storm overflows by water companies. In 2020, monitoring was placed on 12,092 storm overflows, compared with 8,276 in 2019, a 46% increase.

Further to the above, the 2020 Water Quality Report published by Surfers Against Sewage (https://www.sas.org.uk/wp-content/uploads/SAS-Water-Quality-Report-Digital-v1.pdf) states that "Southern Water failed to provide combined sewage overflow (CSO) discharge notifications for popular and important Bathing Waters impacted by their sewer assets, throughout the whole of the 2020 Bathing Season. In comparison to the 690 sewage spill notifications issued by Southern Water in 2019, they only managed to issue 78 alerts this year, stating "notifications should have been sent but frustratingly they weren't".

To help obtain such information, Windrush Against Sewage Pollution (WASP) group (https://www.windrushwasp.org/) can provide guidance on wording for any Environmental Information Request one may wish to send to Southern Water in respect of disclosing historical recorded data that define combined sewage overflows.

Encouragingly, during 2020, the UK Government covened the Storm Overflow Taskforce; including representatives from DEFRA, the Environment Agency and Ofwat, as well as Water Company directors and Blueprint for Water (a group of environmental NGO's), to look for solutions to sewage pollution. In Jan 2021, following the first hearing of Phillip Dunne's Sewage (Inland Waters) Bill, it was announced that:

(i) Water companies have agreed to make real-time data on sewage discharges available at bathing sites all year round;
(ii) Water companies will accelerate work to install monitoring devices to create a complete picture of their activity by 2023; and
(iii) Water companies will publish annual monitoring data on their websites about their use of storm overflows so that progress in reducing their use can be tracked. The Environment Agency will compile this data into an annual report that is easily accessible to the public.

Meanwhile, the general ecological health of UK rivers would not appear to be improving, 14% meeting "good" status in 2020, exactly the same proportion as under the 2016 assessment. At the same time, the chemical health of water bodies appears to have fallen off a cliff, with no water bodies at all making the grade in 2020, compared with 97% hitting the required target in 2016. DEFRA and the Environment Agency suggest this is due to "more sophisticated chemical monitoring" (https://www.endsreport.com/article/1694741/englands-rivers-fail-meet-legal-water-quality-standards).

Despite this backdrop, the number of spot samples taken by the EA has dropped by more than a quarter over the last five years, while the number of sites visited by its officers has fallen by almost a fifth over the same period (https://www.endsreport.com/article/1694741/englands-rivers-fail-meet-legal-water-quality-standards).

Further to which, environmental monitoring measures by the EA are in general undertaken monthly. Such a sampling routine can help identify persistent, low level pollution problems or areas. However, sampling rivers once a month or less can miss intermittent pollution events such as raw sewage spills from storm overflows and runoff from farms in bad weather. ENDS Report (https://www.endsreport.com/article/1673511/ea-insiders-slam-agencys-completely-useless-water-

monitoring-regime) quotes an officer from the Environment Agency stating anonymously how “a failing water body can pass if a spot sample is taken between the hours of 10am and 4pm”…because the worst quality discharge from water treatment works takes place in the morning and evenings when people are preparing to leave for work or returning home. Despite this, most sewage effluent samples are confined to the working day, when it is a “matter of common sense that spot sampling will fail to pick up low quality morning and evening discharges, including run off pollution during wet weather”.

Given the above, to help the EA achieve its 25-Year Environment Plan for at least three quarters of our waters to be close to their natural state, the present report concludes by suggesting 2 outstanding questions:

1.How can we best help everyone improve how they use water and discharge waste to water bodies; engaging accordingly with water companies, planners, farmers and the public?
2. How can we best help ensure appropriate environmental measures to underpin evidence-backed arguments for change, most especially through a capability for immediate sampling in response to evident pollution, with community engagement such as through the Westcountry Rivers Trust “Citizen Science Investigation” (CSI) programme (https://wrt.org.uk/project/become-a-citizen-scientist)?

5. Figures

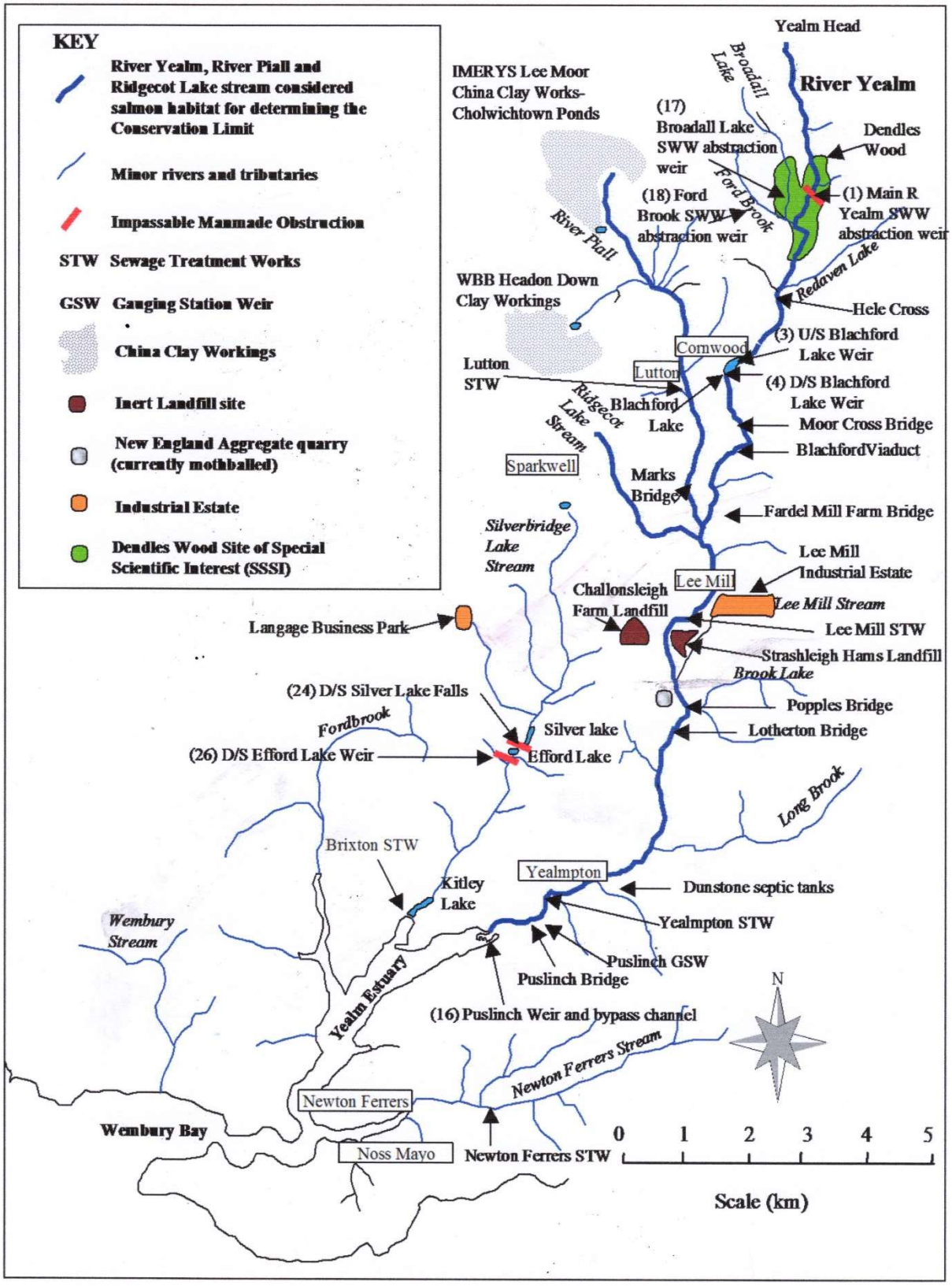

Figure 1. Map of the River Yealm catchment, taken from the Environment Agency's "River Yealm Final Salmon Action Plan" dated 2020 (http://www.environmentdata.org/archive/ealit:1392).

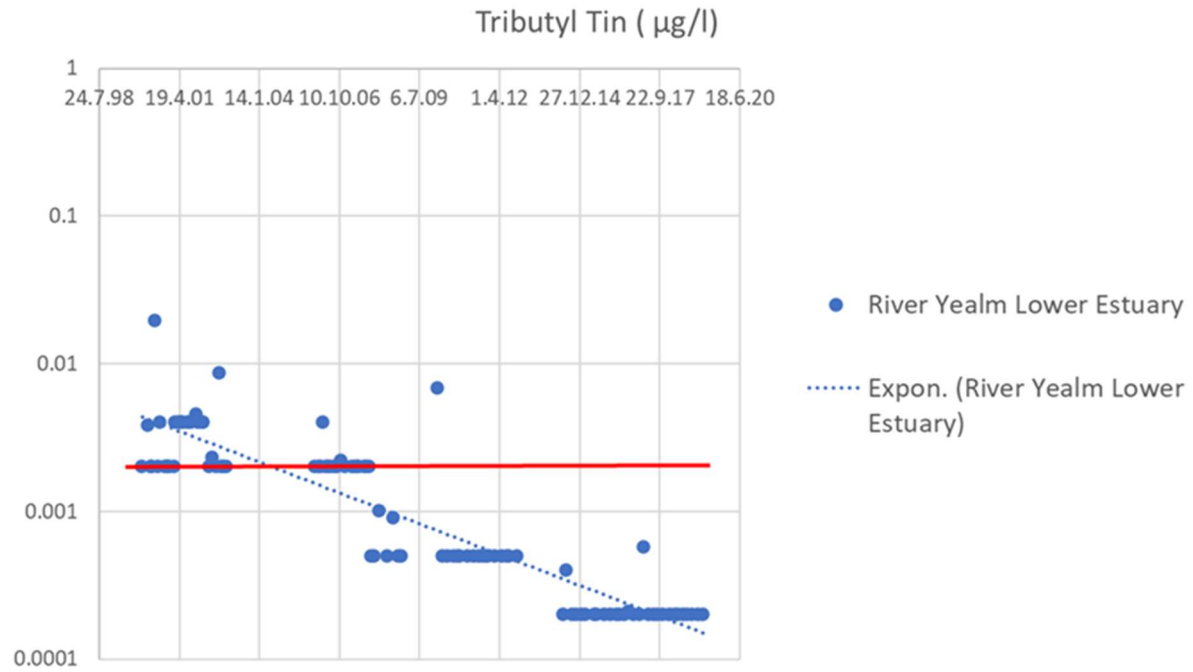

Figure 2. EA Water Quality Archive results downloaded to show tributyl tin measured from 1999 to 2019 at River Yealm Lower Estuary, at a site off Warren Point, just downstream of what is now the Harbour Office. The horizontal red line denotes the UK Water Research Centre's environmental quality standard (EQS) for organotin compounds of 0.002 µg/l. The dotted blue line was fitted by least squares regression.

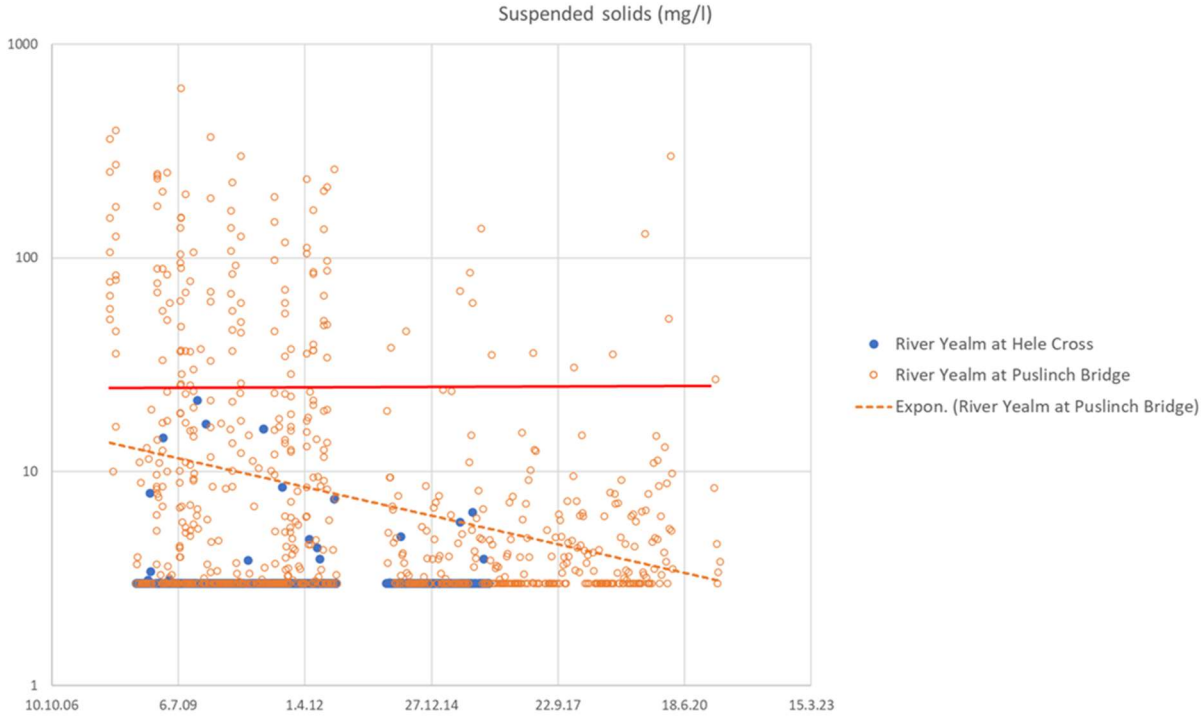

Figure 3. EA Water Quality Archive results downloaded to show suspended solids measured from 2007 to 2021 at two sites: Hele Cross towards the top of River Yealm and Puslinch Bridge not far above where the river discharges into estuary. Most data for Hele Cross are "hidden" behind those for Puslinch Bridge at the lowest recorded levels. The horizontal red line denotes the EU Freshwater Fish

Directive's Guideline Standard, which is an annual mean of 25 mg/l. The dotted orange line was fitted to data for Puslinch Bridge alone by least squares regression.

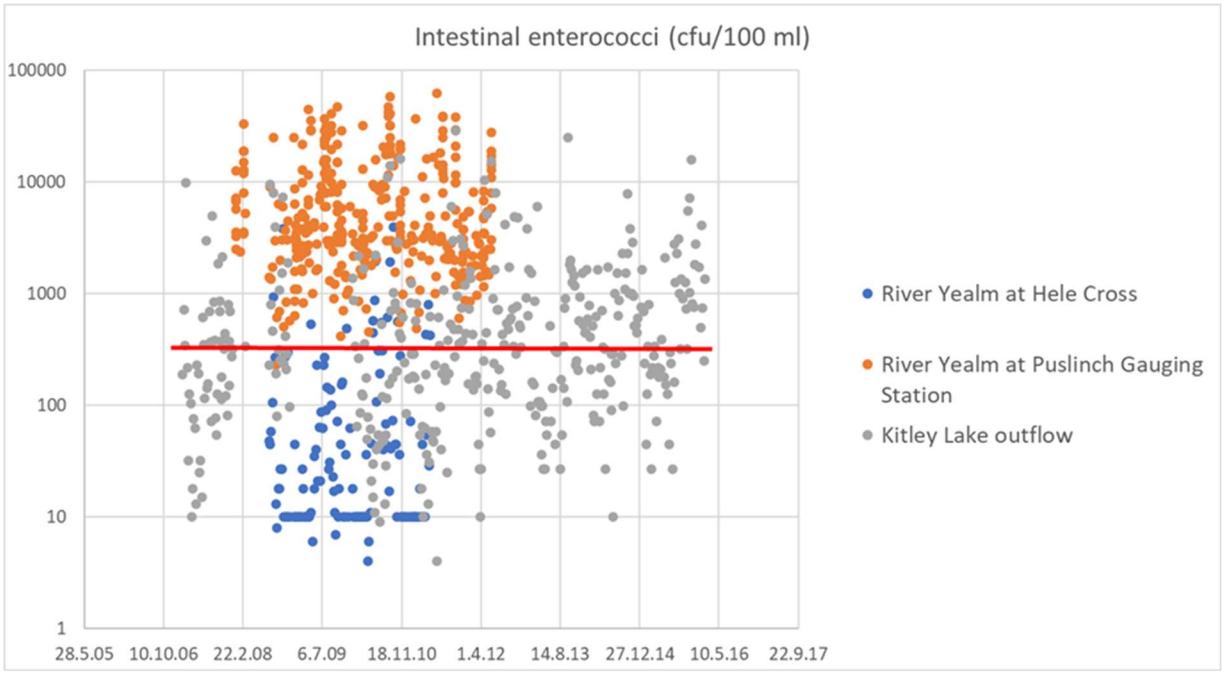

Figure 4. EA Water Quality Archive results downloaded to show intestinal enteroccoci measured from 2007 to 2016 at three sites: Hele Cross towards the top of River Yealm and Puslinch Gauging Station towards the bottom of River Yealm, plus Kitley Lake outflow from Silverbridge tributary that feeds the estuary further below. The horizontal red line denotes the Environment Agency water quality environmental threshold for inland bathing waters of 330 cfu/100ml, above which threshold the associated classification is "Poor".

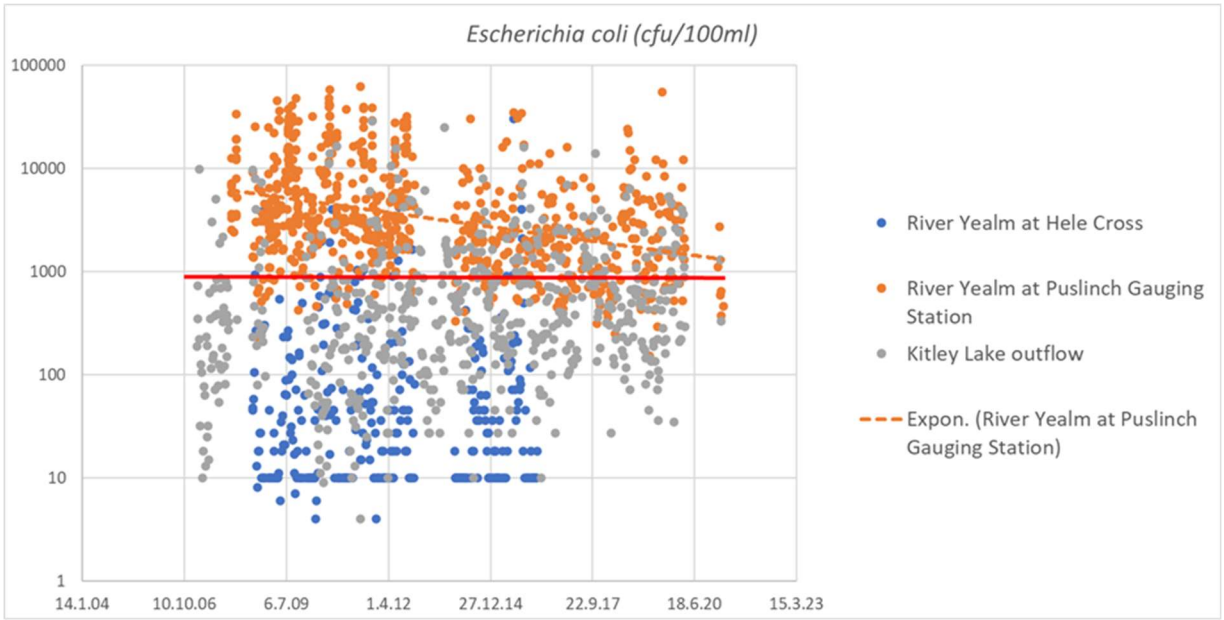

Figure 5. EA Water Quality Archive results downloaded to show *E. coli* measured from 2007 to 2021 at three sites: Hele Cross towards the top of River Yealm and Puslinch Gauging Station towards the bottom of River Yealm, plus Kitley Lake outflow from Silverbridge tributary that feeds the estuary further below. The horizontal red line denotes the Environment Agency water quality environmental

threshold for inland bathing waters of 900 cfu/100ml, above which threshold the associated classification is “Poor”.

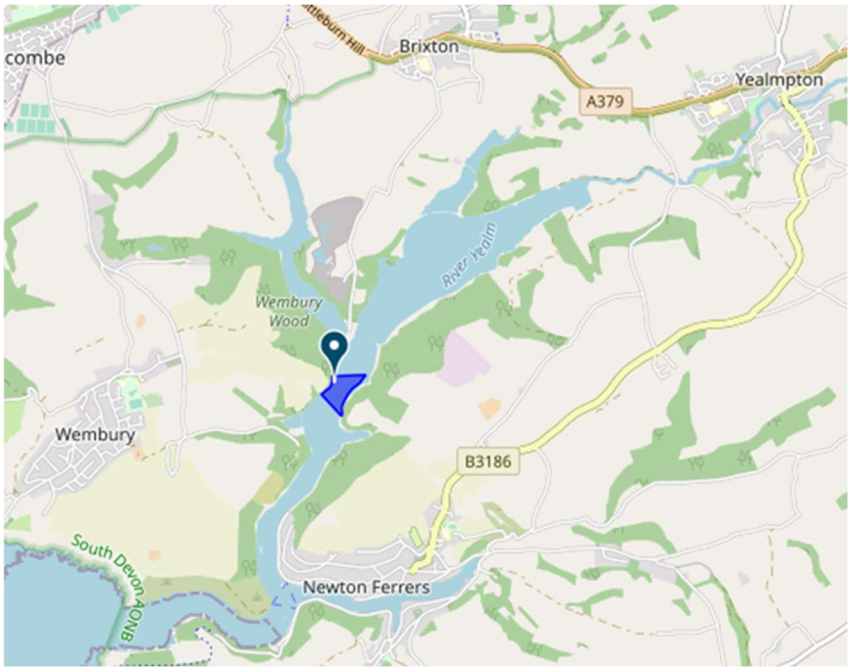

Figure 6. Site of the Fox Cove representative monitoring point from which Pacific oysters have been monitored by CEFAS.

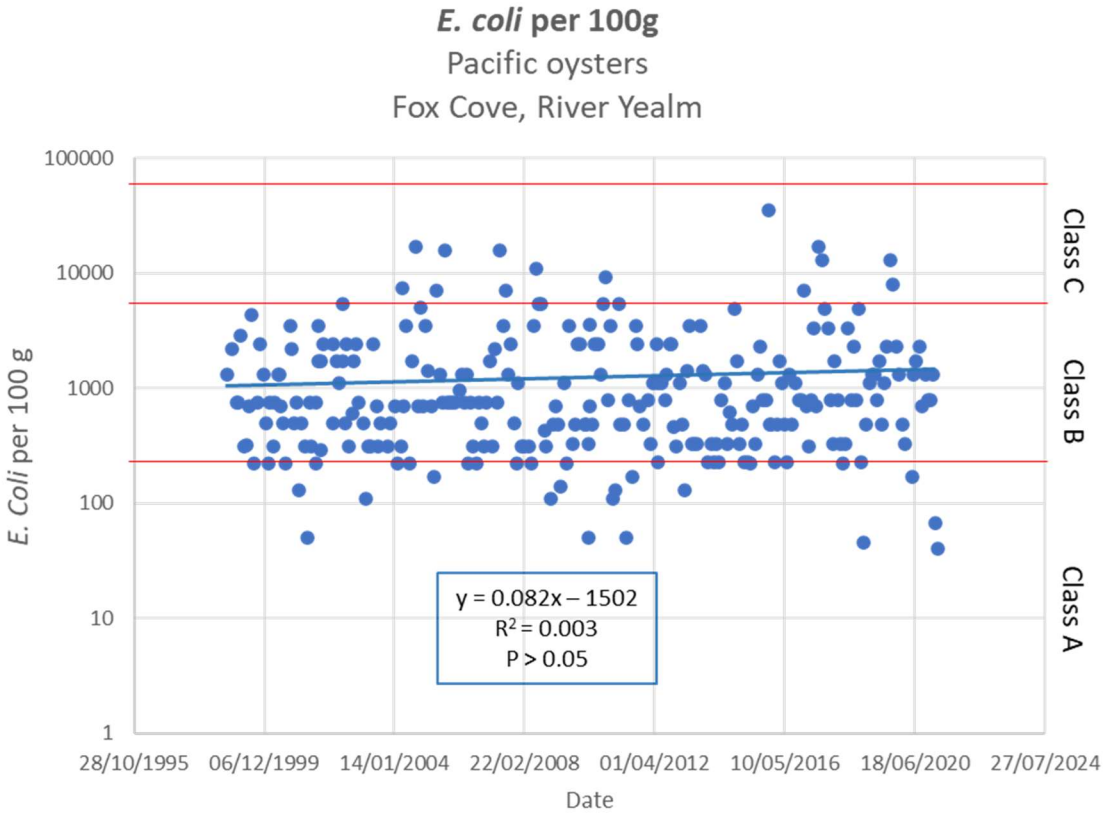

Figure 7. CEFAS data archive results downloaded to show *E. coli* per 100 mg soft tissue in Pacific oysters from Fox Cove over 22 years from 1999 to 2021. Horizontal red lines denote thresholds for associated classification of harvesting areas by CEFAS, with consequences for the treatment processes required before shellfish can be marketed (https://www.cefas.co.uk/data-and-publications/shellfish-classification-and-microbiological-monitoring/england-and-wales/).