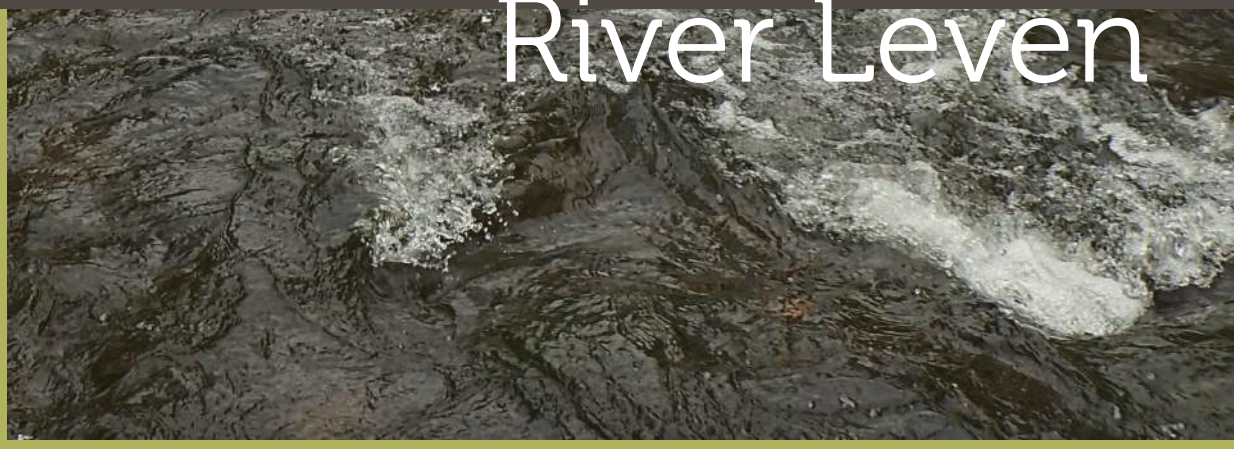
RIVERFLY CENSUS RESULTS

River Leven



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WHAT WE'VE DONE

The Riverfly Census was created to collect much needed high-resolution, scientifically robust data about the state of our rivers and the pressures facing them. We frequently talk about missing flylife and lack of fish compared to the 'good old days', but anecdotal evidence like this has little weight in environmental decision making.

> "Without data you're just another person with an opinion"
>
> W. Edwards Deming

River insects spend the majority of their lives in the water as nymphs, making them brilliant indicators of river health. Their continuous exposure to water makes examining them much more informative than spot chemical samples. Every invertebrate is unique, and each requires a specific set of conditions to thrive.

The Riverfly Census utilises the invertebrate assemblage: presence, absence and abundance of certain invertebrates, to indicate the types of stress our rivers are experiencing. The composition of the invertebrate community in the sample allows a biometric score to be calculated, which provides a surrogate, or direct scale, of physical chemical impact. Below are the biometrics used and the type of stress they indicate.

BIOMETRIC GLOSSARY

PSI

Proportion of Sediment-sensitive Invertebrates

A measure of stress caused by excess fine sediment on the invertebrate community

TRPI

Total Reactive Phosphorus Index

A relatively new metric developed to indicate pressure from phosphorus pollution

SPEAR

SPEcies At Risk

A measure to assess the impact of exposure to pesticides, herbicides and complex chemical toxicants on the invertebrate community

LIFE

Lotic-invertebrate Index for Flow Evaluation

A metric to assess the impact of flow related stress on invertebrate communities which live in flowing water

SI

Saprobic Index

A measure to indicate stress on the invertebrate community caused by organic pollution

WHAT WE'VE DONE
Census Method

The Riverfly Census has spanned three years. It began in 2015, with 12 rivers across England. Multiple sample sites were carefully selected on each river.

SCOPE

Kick-sweep sampling was completed in spring and autumn to EA guidelines, at all sample sites. Sampling and species-level identification were carried out by professional external consultants, Aquascience Consultancy Ltd.

SAMPLE

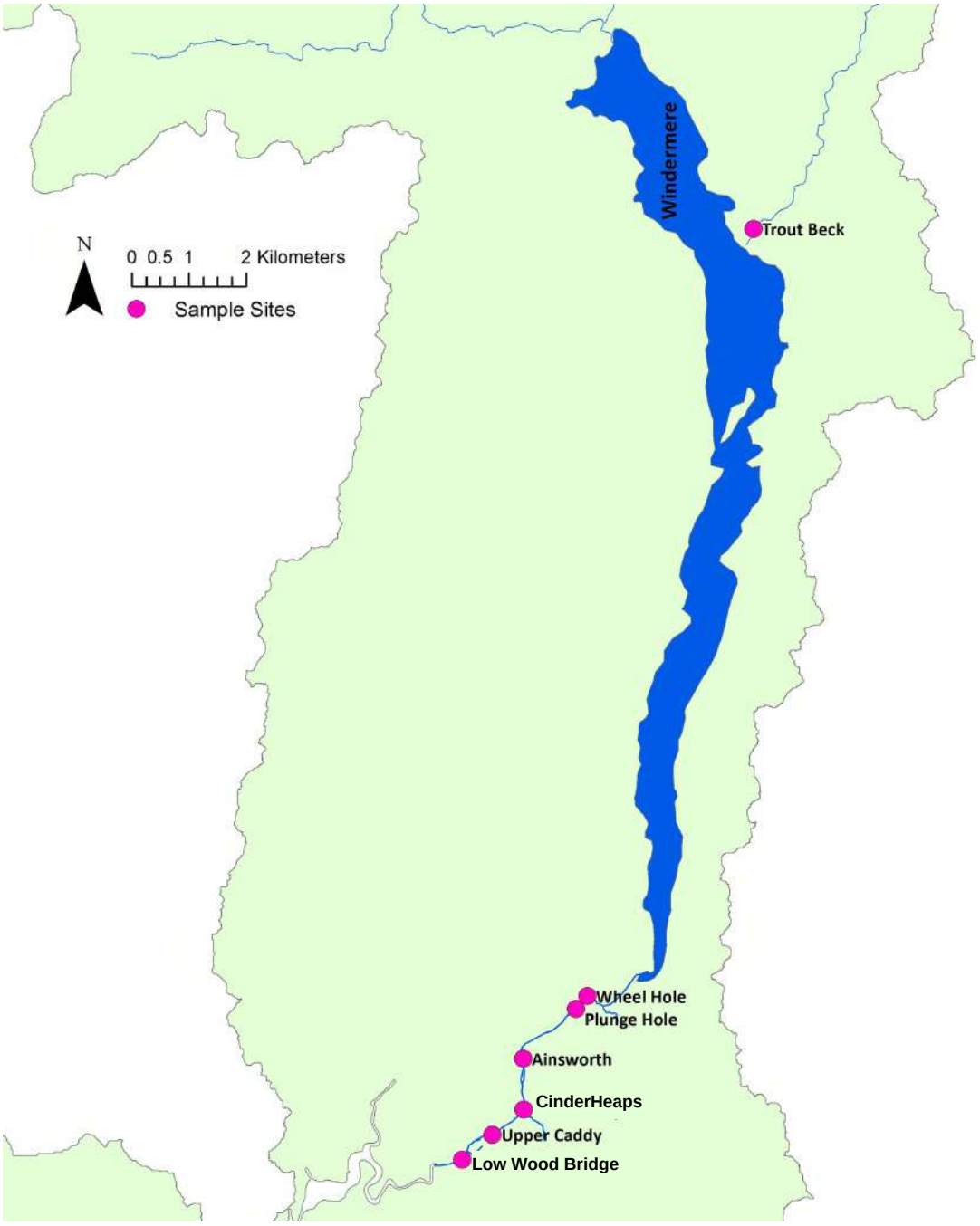
Species presence/absence data was inputted into Aquascience's biometric calculator to obtain scores against key stress types. The data was then evaluated in a whole catchment context to pinpoint likely suspects contributing to river deterioration.

STUDY

The data was compiled, and is being reported to stakeholders and policy makers, to improve management and conservation of our rivers.

MAKE A STAND

Results



Riverfly Census sampling on the Leven began in spring 2017 and continued for three years on six sites: Wheel Hole, Plunge Hole, Ainsworth, Cinderheaps, Upper Caddy and Low Wood Bridge. A seventh site, Trout Beck, was also sampled for comparative purposes.

The locations of our sample sites are shown on the map, represented by pink circles.

1 WHAT WE'VE FOUND
Wheel Hole

The invertebrate community at Wheel Hole exhibited minimal stress from excess fine sediment in spring, but moderate impact was indicated in autumn in 2018 and 2019.

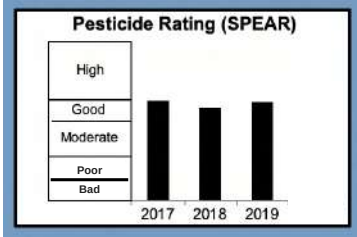
Nutrient stress was prominent and persistent, with all sample events yielding TRPI scores of either impacted or heavily impacted.

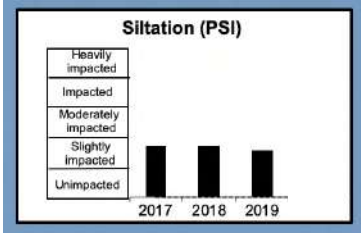
Broad brush water quality ASPT values were consistently below what would be expected for intermediate rivers, or indeed any of 685 river reference clean conditions from data in the Environment Agency RIVPACS/RICT predictive databanks throughout the 2017-2019 study period (see Appendix 1).

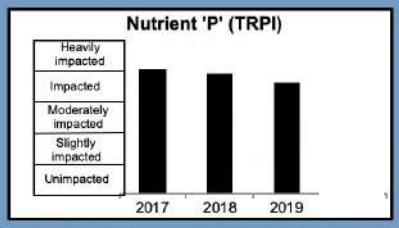
No failures against the proposed WFD SPEAR standard (Beketov *et al.* 2009) for chemicals occurred at this site.

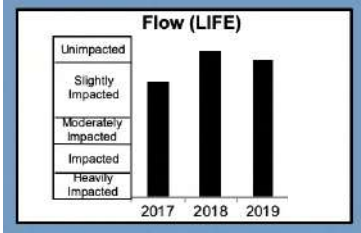
SPRING BIOMETRICS

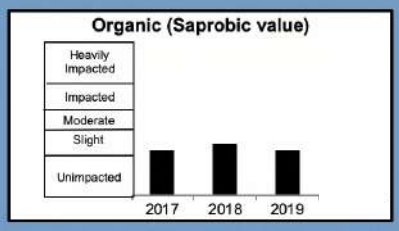
	2017	2018	2019
BMWP	140	136	124
ASPT	5.60	5.67	6.20
Annual Mayfly Sp Richness	3	3	4
Total Abundance	999	NA	NA
EPT	18	14	16
CCI	9.82	10.45	16.24
LIFE	7.66	8.21	8.04
PSI	66.18	65.57	68.52
SPEAR	43.77	40.37	43.48
TRPI	19.23	22.22	27.78
Saprobic	1.89	2.02	1.89





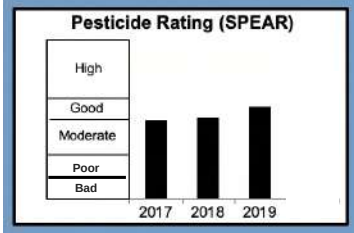


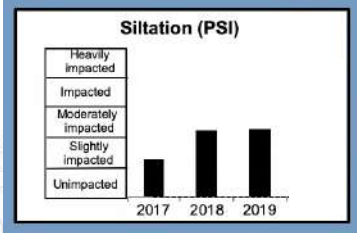


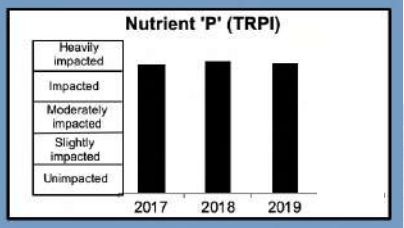


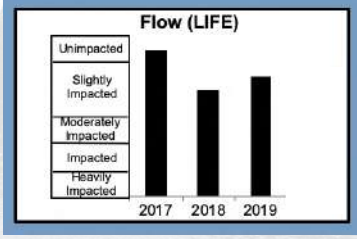
AUTUMN BIOMETRICS

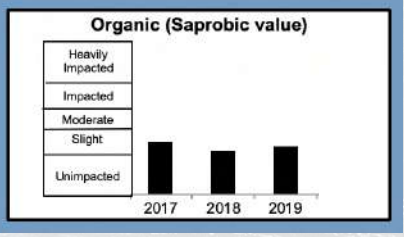
	2017	2018	2019
BMWP	104	115	152
ASPT	5.80	5.48	5.85
Annual Mayfly Sp Richness	3	3	4
Total Abundance	NA	NA	NA
EPT	12	11	19
CCI	10.00	8.00	15.50
LIFE	8.20	7.48	7.72
PSI	75.00	55.56	54.79
SPEAR	34.68	36.11	40.75
TRPI	16.67	14.29	15.38
Saprobic	2.05	1.87	1.97











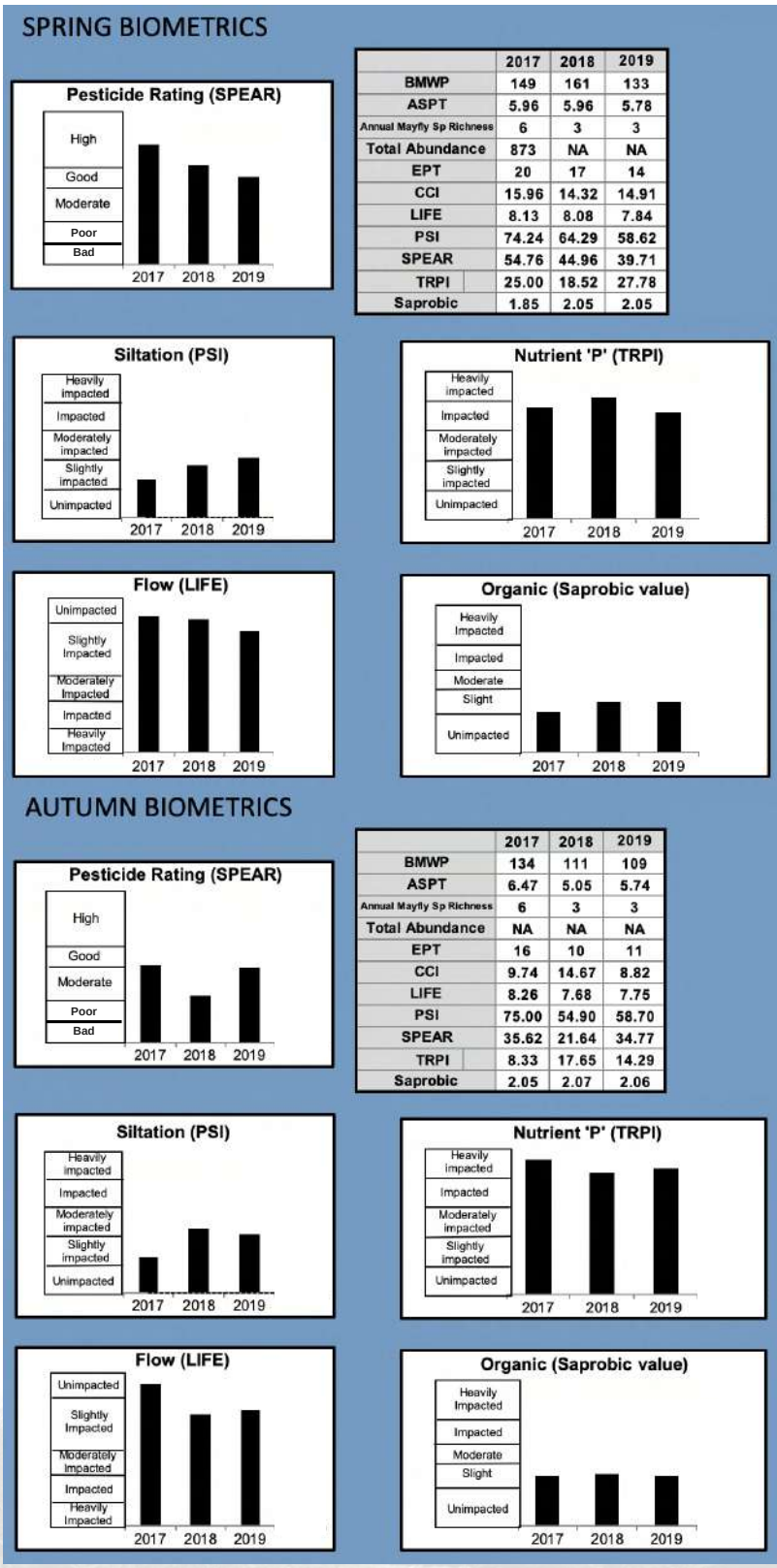
2 WHAT WE'VE FOUND
Plunge Hole

Stress from excess fine sediment was exhibited by the invertebrate community in autumn 2018, spring 2019 and autumn 2019

Plunge Hole showed biological stress from excess nutrients throughout the survey, with all TRPI scores ranking as impacted or heavily impacted.

After examining data in the Environment Agency RIVPACS/ RICT predictive databanks from 2017-2019 (see Appendix 1), broad brush water quality ASPT values at this site were frequently below what would be expected for intermediate rivers, or indeed any of the 685 river reference clean conditions.

One failure of the proposed WFD SPEAR standard for chemicals occurred in autumn 2018.



	2017	2018	2019
BMWP	149	161	133
ASPT	5.96	5.96	5.78
Annual Mayfly Sp Richness	6	3	3
Total Abundance	873	NA	NA
EPT	20	17	14
CCI	15.96	14.32	14.91
LIFE	8.13	8.08	7.84
PSI	74.24	64.29	58.62
SPEAR	54.76	44.96	39.71
TRPI	25.00	18.52	27.78
Saprobic	1.85	2.05	2.05

	2017	2018	2019
BMWP	134	111	109
ASPT	6.47	5.05	5.74
Annual Mayfly Sp Richness	6	3	3
Total Abundance	NA	NA	NA
EPT	16	10	11
CCI	9.74	14.67	8.82
LIFE	8.26	7.68	7.75
PSI	75.00	54.90	58.70
SPEAR	35.62	21.64	34.77
TRPI	8.33	17.65	14.29
Saprobic	2.05	2.07	2.06

3 WHAT WE'VE FOUND
Ainsworth

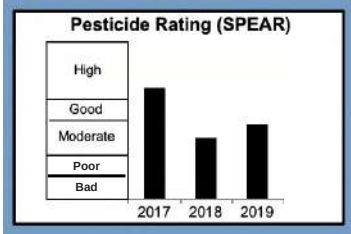
Sediment stress was not pronounced at Ainsworth.

Nutrient stress was considerable throughout the survey, apart from spring 2018 which exhibited some recovery.

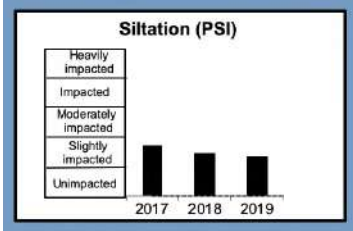
Broad brush water quality ASPT values here were consistently below what would be expected for intermediate rivers (see Appendix 1). They were also below any of the 685 river reference clean conditions shown in the Environment Agency RIVPACS/RICT predictive databanks throughout the 2017-2019 study period.

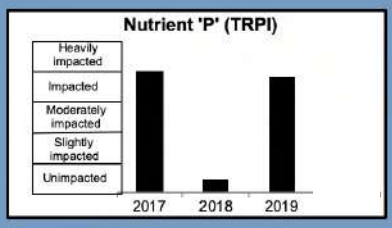
Chemical stress was indicated, with failure of the proposed WFD SPEAR standard in autumn 2017, spring 2018, autumn 2018 and spring 2019.

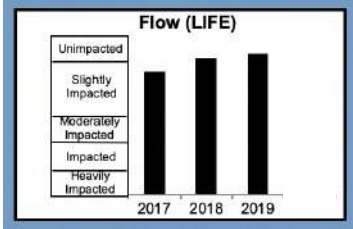
SPRING BIOMETRICS

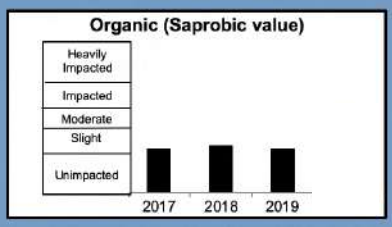


	2017	2018	2019
BMWP	151	100	117
ASPT	6.29	5.56	5.85
Annual Mayfly Sp Richness	4	3	3
Total Abundance	1137	NA	NA
EPT	22	11	12
CCI	15.81	16.19	10.56
LIFE	7.81	8.06	8.15
PSI	66.18	70.59	72.50
SPEAR	49.17	27.31	32.96
TRPI	20.83	91.30	23.81
Saprobic	1.91	1.97	1.90

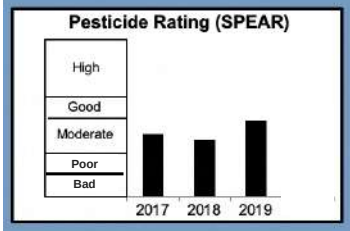




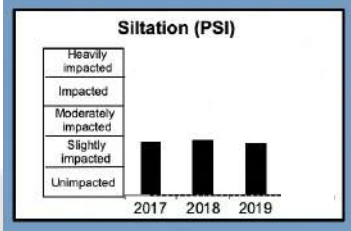


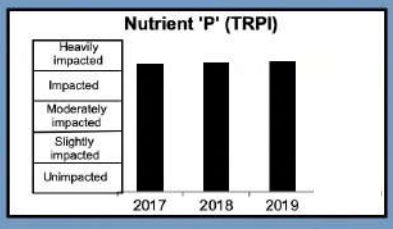


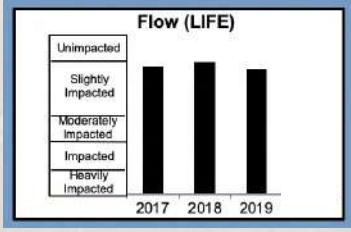
AUTUMN BIOMETRICS

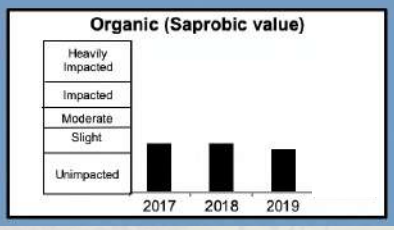


	2017	2018	2019
BMWP	115	101	147
ASPT	5.78	5.65	5.88
Annual Mayfly Sp Richness	4	3	3
Total Abundance	NA	NA	NA
EPT	12	10	18
CCI	8.68	15.94	10.58
LIFE	7.91	8.00	7.84
PSI	64.29	63.04	64.71
SPEAR	27.73	25.30	33.97
TRPI	16.67	15.38	14.29
Saprobic	1.98	1.99	1.87









4 WHAT WE'VE FOUND
Cinder Heaps

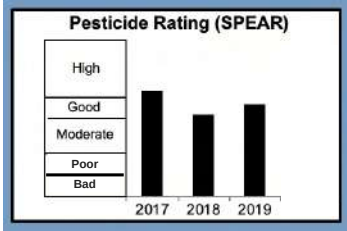
The invertebrate community at Cinder Heaps indicated minimal stress from excess fine sediment.

Nutrient stress was prominent at this site, with all TRPI scores at impacted or heavily impacted.

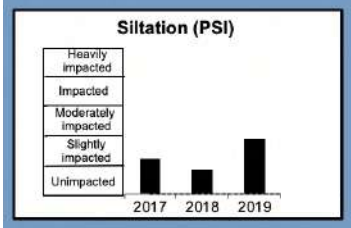
Looking at data from Environment Agency RIVPACS/RICT predictive databanks (2017-2019), water quality ASPT values at Cinder Heaps were frequently below what would be expected (see Appendix 1).

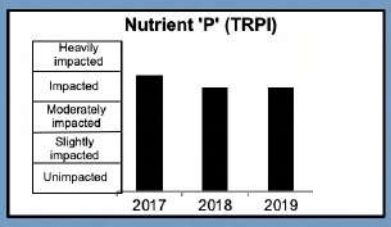
The proposed WFD SPEAR standard for chemicals was failed in autumn 2018.

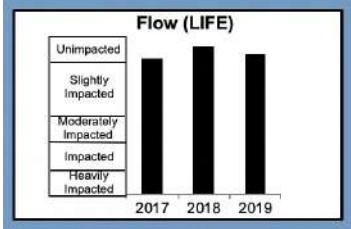
SPRING BIOMETRICS

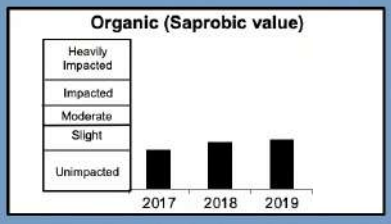


	2017	2018	2019
BMWP	132	90	113
ASPT	6.00	6.00	5.95
Annual Mayfly Sp Richness	2	4	3
Total Abundance	853	NA	NA
EPT	17	9	12
CCI	10.00	15.50	10.29
LIFE	8.08	8.29	8.16
PSI	75.86	82.76	63.04
SPEAR	47.07	36.40	40.93
TRPI	23.08	31.25	31.58
Saprobic	1.81	1.97	2.01

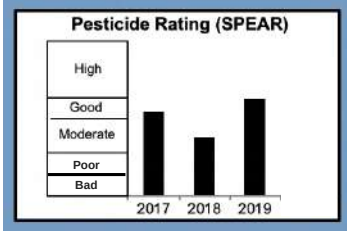




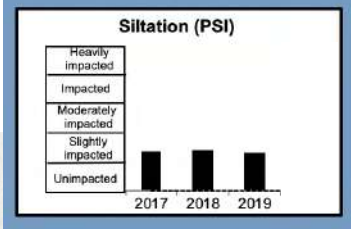


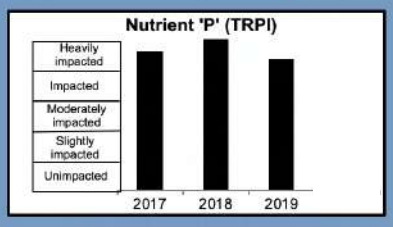


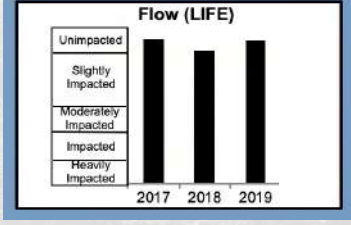
AUTUMN BIOMETRICS

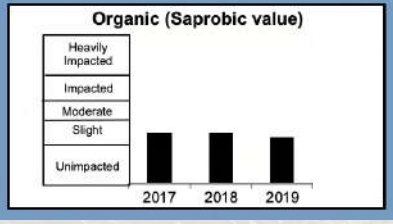


	2017	2018	2019
BMWP	97	104	118
ASPT	6.98	5.78	6.21
Annual Mayfly Sp Richness	2	4	3
Total Abundance	NA	NA	NA
EPT	10	13	14
CCI	14.00	9.75	15.75
LIFE	8.28	8.05	8.25
PSI	72.92	72.34	73.91
SPEAR	37.68	26.43	44.14
TRPI	7.69	0.00	12.50
Saprobic	2.04	2.05	1.97









5 WHAT WE'VE FOUND
Upper Caddy

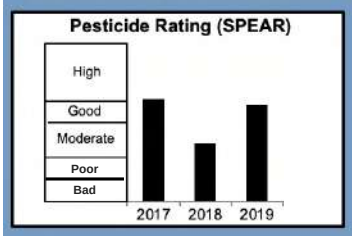
Moderate stress from excess fine sediment was indicated in autumn 2018.

Upper Caddy yielded a combination of impacted and heavily impacted nutrient biosignatures in the survey.

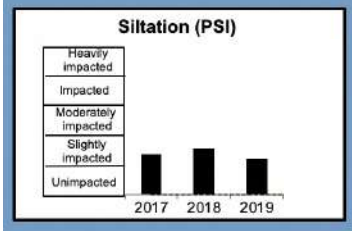
Across the board, water quality ASPT values here were consistently below what would be expected for intermediate rivers, or indeed any of 685 river reference clean conditions from data in the Environment Agency RIVPACS/RICT predictive databanks (2017-2019)(see Appendix 1).

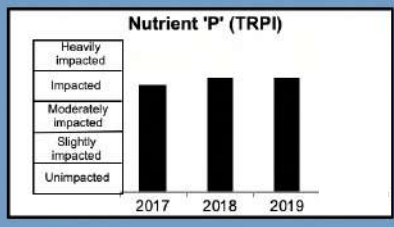
Chemical stress was indicated, with failures against the proposed WFD standard for SPEAR in spring 2018 and all of autumn.

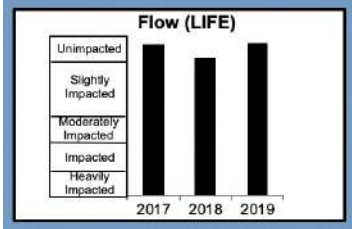
SPRING BIOMETRICS

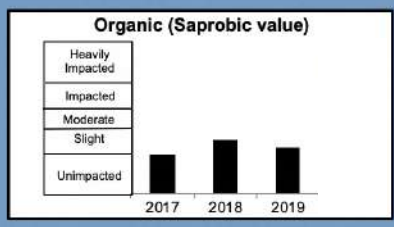


	2017	2018	2019
BMWP	138	101	133
ASPT	6.00	5.94	6.05
Annual Mayfly Sp Richness	5	4	5
Total Abundance	1025	NA	NA
EPT	15	11	17
CCI	16.43	9.38	10.45
LIFE	8.32	8.06	8.36
PSI	72.88	68.42	76.36
SPEAR	45.44	25.67	42.28
TRPI	30.00	25.00	25.00
Saprobic	1.77	2.09	1.94

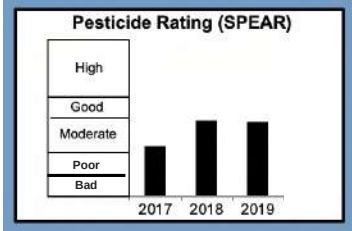




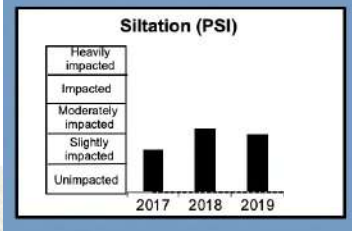


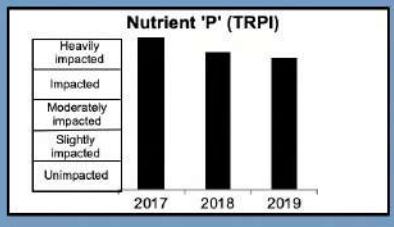


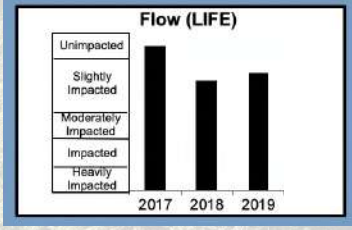
AUTUMN BIOMETRICS

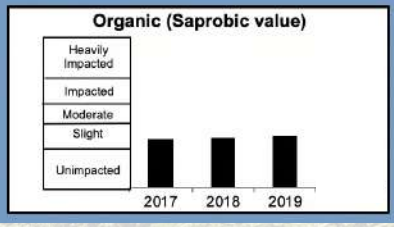


	2017	2018	2019
BMWP	78	128	116
ASPT	5.45	5.82	5.80
Annual Mayfly Sp Richness	5	4	5
Total Abundance	NA	NA	NA
EPT	9	12	11
CCI	5.00	9.00	9.72
LIFE	8.25	7.59	7.73
PSI	70.73	56.52	61.11
SPEAR	22.40	33.94	33.18
TRPI	0.00	10.00	13.33
Saprobic	2.00	2.02	2.04









6 WHAT WE'VE FOUND
Low Wood Bridge

Moderate sediment stress was indicated by the invertebrate community in autumn 2019. Throughout the survey, Low Wood Bridge exhibited nutrient stress, with TRPI scores of impacted or heavily impacted.

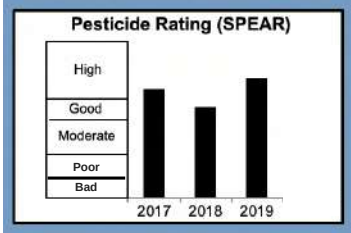
After examining data in the Environment Agency RIVPACS/ RICT predictive databanks from 2017-2019 (see Appendix 1), broad brush water quality ASPT values at this site were frequently below what would be expected for intermediate rivers, or indeed any of the 685 river reference clean conditions

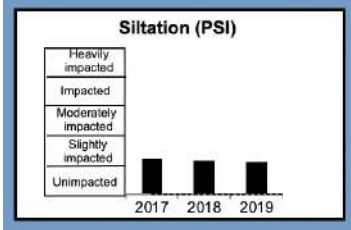
Despite regular discharge from a CSO upstream of this sample site, no signs of marked organic pollution were present. However, it remained nutrient and fine sediment impacted, which may be being fuelled by these incursions lower down the watercourse.

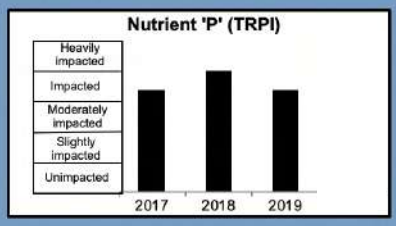
Seasonal chemical stress was present, with the proposed WFD standard for SPEAR consistently failing in autumn.

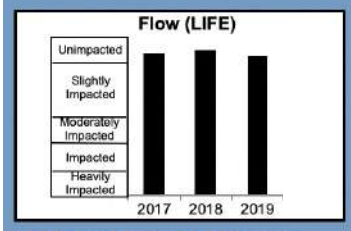
SPRING BIOMETRICS

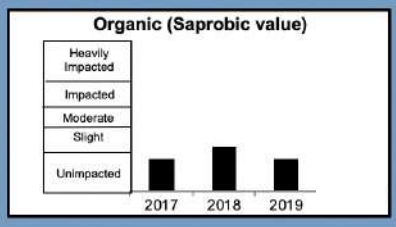
	2017	2018	2019
BMWP	137	148	150
ASPT	6.23	5.92	6.52
Annual Mayfly Sp Richness	4	5	3
Total Abundance	614	NA	NA
EPT	19	19	17
CCI	14.91	10.83	10.00
LIFE	8.19	8.24	8.12
PSI	75.81	76.92	78.00
SPEAR	48.47	40.32	53.36
TRPI	33.33	20.69	33.33
Saprobic	1.65	1.91	1.67





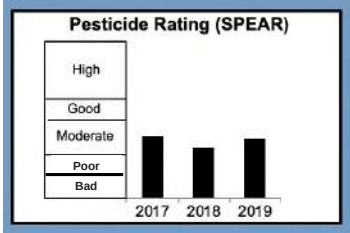


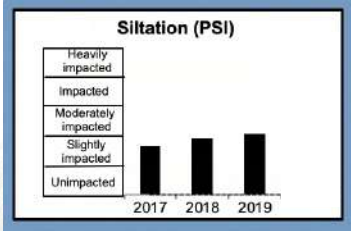


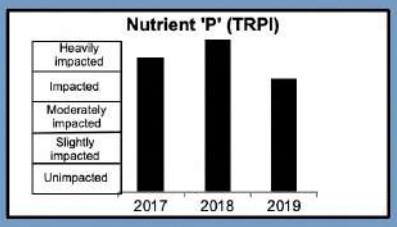


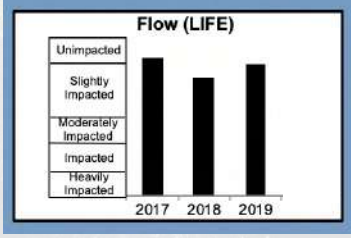
AUTUMN BIOMETRICS

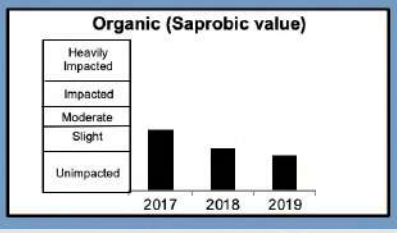
	2017	2018	2019
BMWP	101	96	85
ASPT	5.83	5.65	5.31
Annual Mayfly Sp Richness	4	5	3
Total Abundance	NA	NA	NA
EPT	9	11	9
CCI	8.46	9.69	5.25
LIFE	8.11	7.72	8.00
PSI	66.67	62.16	58.54
SPEAR	27.73	22.14	26.50
TRPI	11.11	0.00	25.00
Saprobic	2.24	1.86	1.73











7 WHAT WE'VE FOUND
Trout Beck

Due to unsuitable conditions, sampling could not take place in autumn 2018.

Trout Beck is not a river like the Leven, but within the natural moulding of its hydro-geomorphological conditions it did show consistently good broad brush water quality ASPT values.

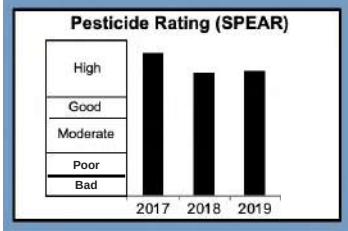
The ASPT values were above what would be expected for upland northern stream reference clean conditions (based on data from Environment Agency RIVPACS/RICT predictive databanks) unlike the River Leven against its reference conditions below Windermere (see Appendix 1 and 2).

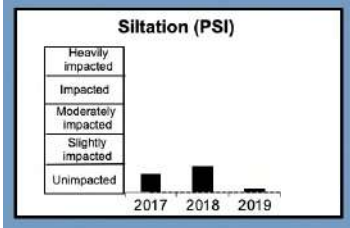
Some nutrient stress was indicated in autumn 2017 and spring 2019, but overall was less pronounced than the Leven sites.

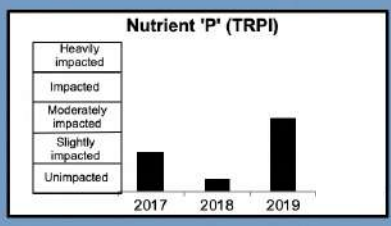
Trout Beck exhibited healthy bio-signatures for sediment and chemicals.

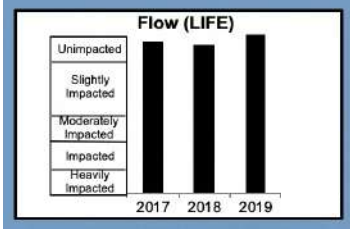
SPRING BIOMETRICS

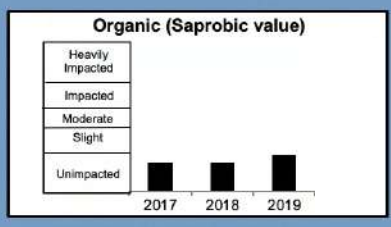
	2017	2018	2019
BMWP	160	182	124
ASPT	6.67	6.28	6.89
Annual Mayfly Sp Richness	5	5	5
Total Abundance	413	NA	NA
EPT	21	24	15
CCI	29.14	14.47	9.33
LIFE	8.39	8.32	8.95
PSI	87.27	82.43	97.62
SPEAR	64.02	55.24	56.21
TRPI	73.33	91.30	51.18
Saprobic	1.60	1.61	1.74





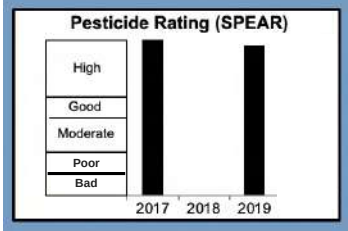


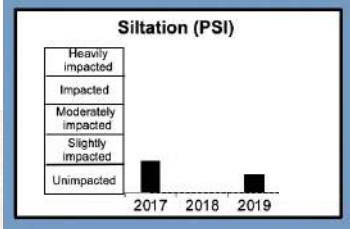


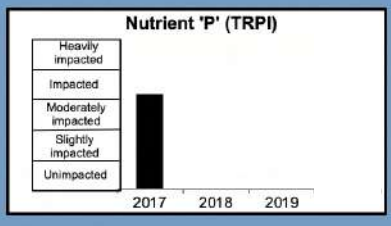


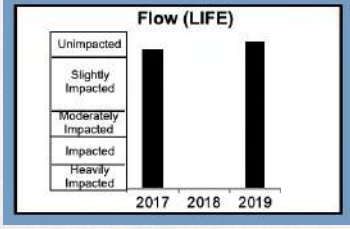
AUTUMN BIOMETRICS

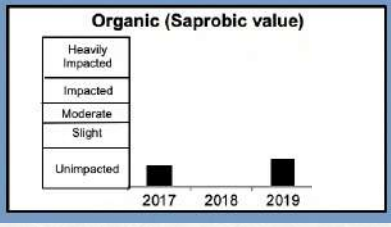
	2017	2018	2019
BMWP	151	NA	109
ASPT	7.66	NA	6.41
Annual Mayfly Sp Richness	5	NA	5
Total Abundance	NA	NA	NA
EPT	22	NA	18
CCI	13.30	NA	11.32
LIFE	8.15	NA	8.29
PSI	78.43	NA	86.96
SPEAR	71.90	NA	67.36
TRPI	37.50	NA	100.00
Saprobic	1.46	NA	1.58











OUR THOUGHTS: Discussion

The Salmon & Trout Conservation (S&TC) Riverfly Census on the River Leven has revealed that ecologically the river is performing below healthy status and associated reference site standards it should be achieving. It is currently not meeting Good Ecological Status (GES), as required under the Water Framework Directive (WFD). The overall classification in the most recent WFD cycle (2016) was moderate and the reason for GES failure was fish (Environment Agency, Catchment Data Explorer). There are 25 water bodies that fall within the Leven operational catchment, these all lie largely within the Lake District National Park, including Lake Windermere.

A number of key trait specific signatures of environmental impact were indicated by the invertebrate communities during the Riverfly Census survey (2017-2019) on the River Leven. One of the key water quality stressors present down the entire river was the nutrient phosphorus, as measured by the Total Reactive Phosphorus Index (TRPI) (Everall *et al*, 2019a). Faunal signatures have been found to associate with other river eutrophic indicators like benthic algal growth (Everall *et al*, 2019b). This was true of the River Leven and demonstrated in riverbed photographs of benthic algal growth at various sites taken during the survey in autumn (Fig. 1).

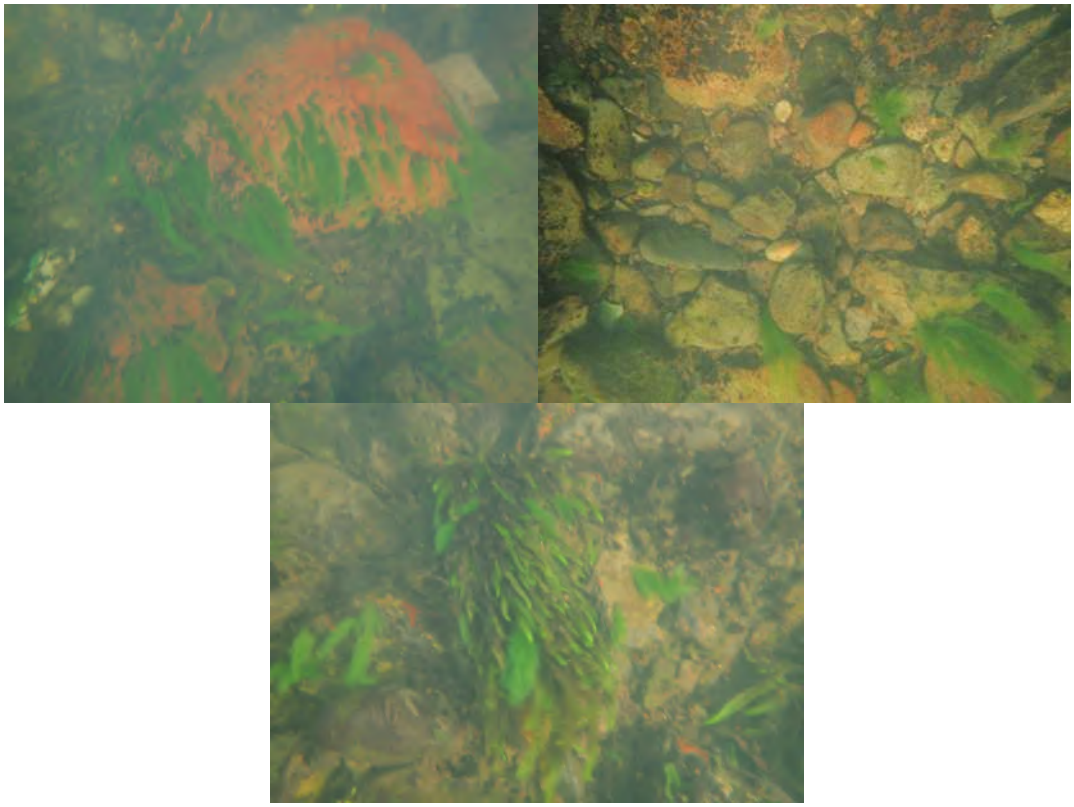


Fig. 1 - Benthic algal growth on riverbed at Cinder Heaps (top left), Plunge Hole (top right) and Wheel Hole (bottom).

River eutrophication encourages entrapment and deposition of fine sediments. Excess fine sediments block spaces in the bed gravels. This can limit insect life at the base of the food chain, is of direct toxicity to aquatic life (Everall *et al*, 2017) and can impair potential salmonid spawning habitat (Greig *et al*, 2007). Fine sediment stress was reflected by the faunal communities from the sedimentation index (PSI) at a number of the Riverfly Census sites.

Eutrophication of the River Leven is, in part, a knock-on effect of the eutrophication of Lake Windermere over time. Increased algal productivity, a key indicator of eutrophication, has been documented since the 1800's from cultural eutrophication. This is where excess nutrients from human activity speed up natural eutrophication processes (Elliot, 2012 and McGowan *et al,* 2012). Windermere South Basin algal biomass data, which discharges into the River Leven, has consistently exhibited a eutrophic status over the last 10 years as shown in the Organisation for Economic Co-operation and Development's (OECD's) mean annual and lake chlorophyll a trophic status plot shown below (OECD, 1982)(Fig. 2).

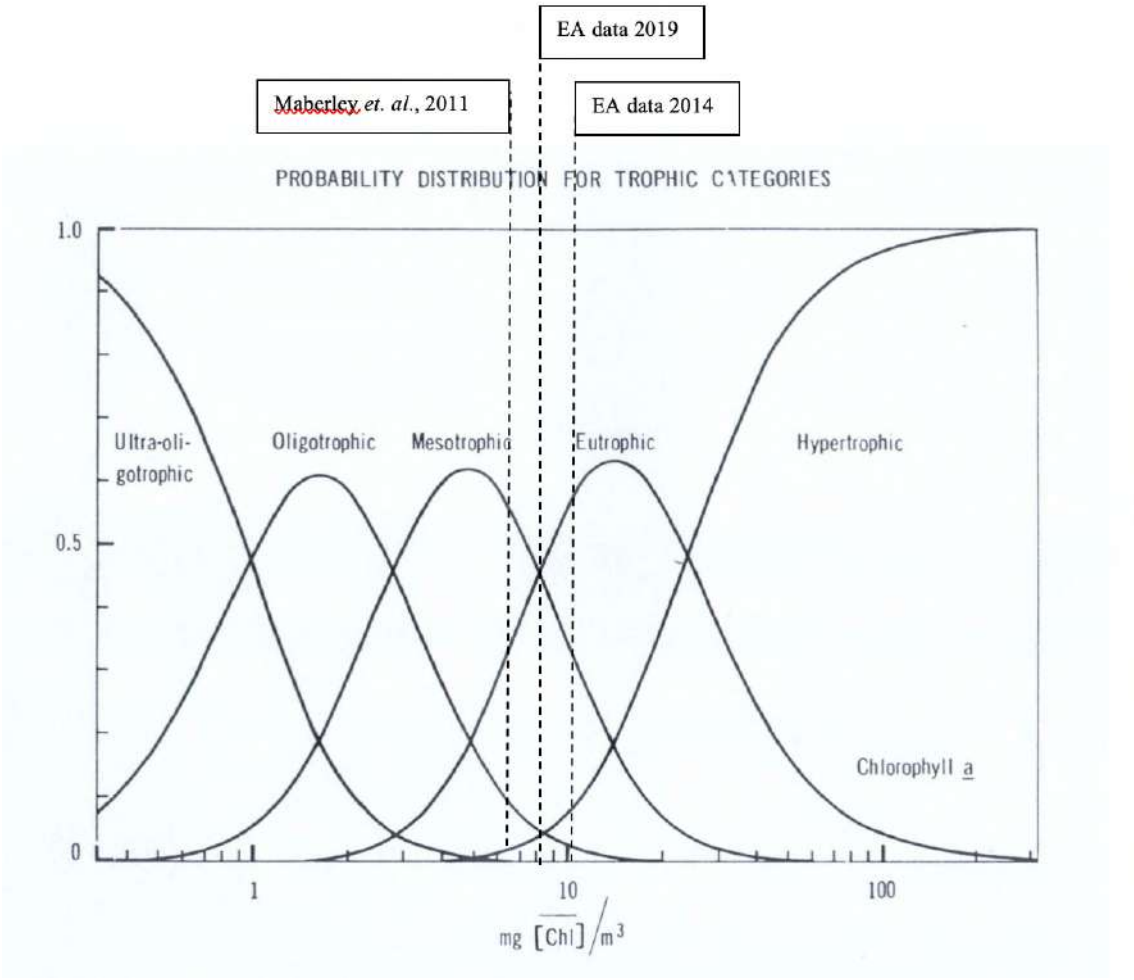


Fig. 2 - OECD (1982) mean annual and lake chlorophyll a trophic status plot, overlayed with data from Maberly et al. (2011) and Environment Agency archives (2014, 2019).

Past studies on the Windermere catchment lakes link to point source nutrient sources and their role in in enhanced phosphorus delivery as the key nutrient driver for eutrophication (Dong *et al*, 2012 and Moorhouse *et al*, 2018). Proportional sources of phosphorus in the Windermere catchment are shown below (Fig. 3).

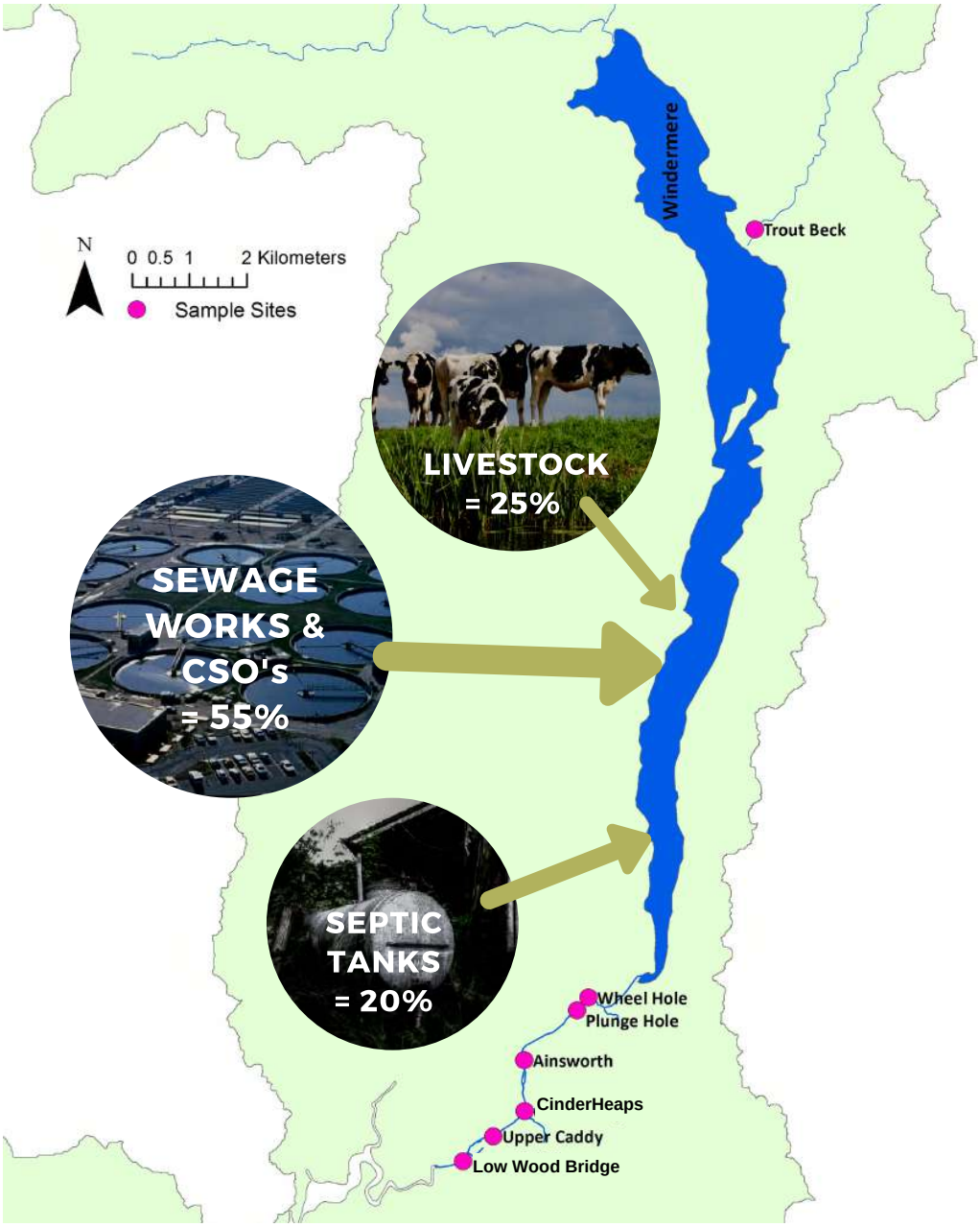


Fig. 3 - Proportional sources of phosphorous in the Windermere catchment. Percentages from a presentation by Heath & Smith, 2015.

To remediate eutrophication in the Windermere catchment, investments by United Utilities in tertiary treatment and phosphate stripping were made in April 1992 at Ambleside and Windermere Tower Wood sewage works (Maberly, 2008). Despite these and other efforts to tackle phosphorus loading from wastewater, reasons for not achieving GES in the Leven operational catchment were mostly attributed to the water industry sector.

The most recent measures, required for compliance with WFD, include further tightening of final effluent phosphorus permits at Windermere wastewater treatment works (WWTW) (from 1 mg/l to 0.25mg/l) and Ambleside WWTW (from 1 mg/l to 0.5 mg/l). Expected completion of these actions is 2020. Tightening of phosphorus at Grasmere WWTW (from 0.6mg/l to 0.4 mg/l) has also been proposed, as well as monitoring of spills from storm tanks (South Cumbria Rivers Trust, Windermere and Leven: Action Table). It would be beneficial to continue invertebrate monitoring to assess how the river responds biologically to the tightening of these permits.

Another factor likely to be contributing to eutrophication of Lake Windermere and the receiving River Leven is private sewerage. It is difficult to quantify the true impact septic tanks and cesspits are having without a full inventory of their whereabouts and condition. It is unclear whether such work has been undertaken, if not, compiling this inventory should be a priority. It is essential that management of the deleterious enrichment of both Windermere and the receiving River Leven should focus on mitigating the negative impacts of all point sources of phosphorus in this catchment through regulatory WWTW, CSO, farming and private septic tank incursions.

Aside to the direct nutrient presence driving algal blooms and thus reaching the Leven, the ‘carry over’ and eventual decomposition in the riverbed of algae from the lake will also add to the phosphate enrichment and eutrophication of this receiving river. When the bed ecology of a salmonid river is showing marked evidence of eutrophication, as it is now in the River Leven, then it is time to implement effective action to prevent the further demise of this watercourse and to re-instate it to a clean condition.

Fine sediment and nutrient stress are impact enough for any river but the Leven also showed intermittent signs of chemical stress. Many chemicals, such as pesticides and herbicides used in arable agriculture, bind to soil and are delivered to watercourses via sediment run-off and sewage works-sewer overflow discharges. Chemical stress was indicated concomitantly in space and time at a number of the River Leven study sites. These were Plunge Hole (autumn 2018), Upper Caddy (autumn 2018) and Low Wood Bridge (autumn 2019). There is a CSO overflow discharge from Low Wood Pumping Station just upstream of the Low Wood Bridge biomonitoring site. All these chemical signatures may be more marked in the Autumn following low summer river flows and a lack of dilution of chemicals released from or entering with sediments.

Contrastingly, Ainsworth had marked chemical signatures alone in autumn 2017, spring 2018, autumn 2018 and spring 2019 which kicks this trend. This could be explained by a localised sediment legacy impact of chemicals used at the now redundant 'Dolly Blue' works. A range of toxic chemicals, such as arsenic, were previously used in the manufacturing process here and discharged into this reach of the river (pers. comm, 2020).

Lake algal blooms and associated carry over into rivers is well documented to raise the pH of receiving waters. There was evidence of this in the Windermere/River Leven scenario in recent years. The true water quality regime of a lake or river is only likely to be evaluated by continuous monitoring (Alabaster & Lloyd, 1980). A study of pH in the River Leven was undertaken in the Spring of 2019 in collaboration with the Environment Agency. The results are shown below (Fig. 4).

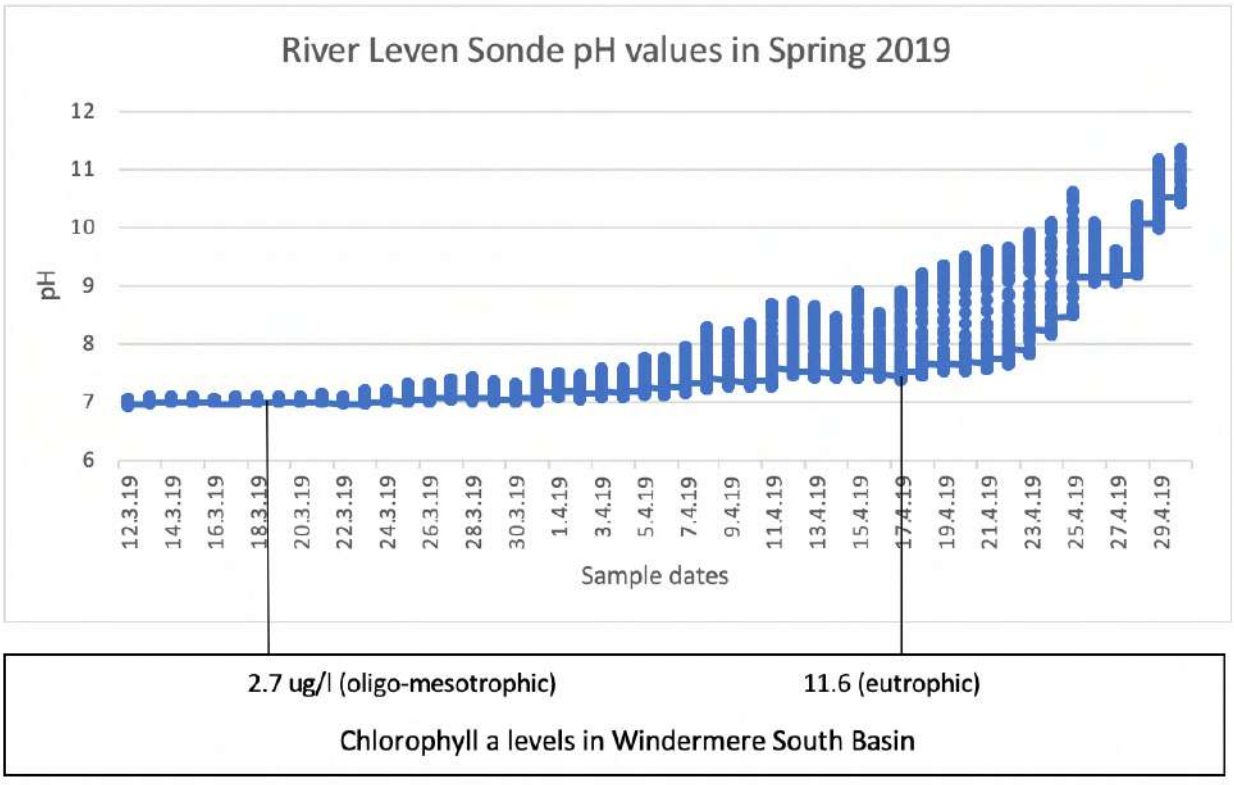


Fig. 4 - Spring 2019 pH values from Environment Agency sonde monitoring. Real time data accessed from open database on Meteor Data Cloud.

A caveat with the sonde data was that hand-held pH probe measurements taken at the same time were lower, with a maximum of 8.9 being recorded (pers. comm, 2019). Questions over the reliability of Environment Agency Sonde pH measurements were an ongoing cause of frustration in trying to understand the true pH regime at times of algal blooms in South Windermere and carry over into the River Leven. Despite these

technical issues, it was clear that at times of high algal productivity, there appeared to be associated elevation of pH in the receiving River Leven.

Both fish (Alabaster & Lloyd, 1980) and invertebrates like the freshwater shrimp *Gammarus pulex* (Costa, 1967) show avoidance to varying degrees at pH greater than 9. *Gammarus* were not found at any of the sample sites, except the reference site (Trout Beck), in spring 2019 (Fig. 5). According to the sonde data, the pH was elevated at this time (Fig. 4).

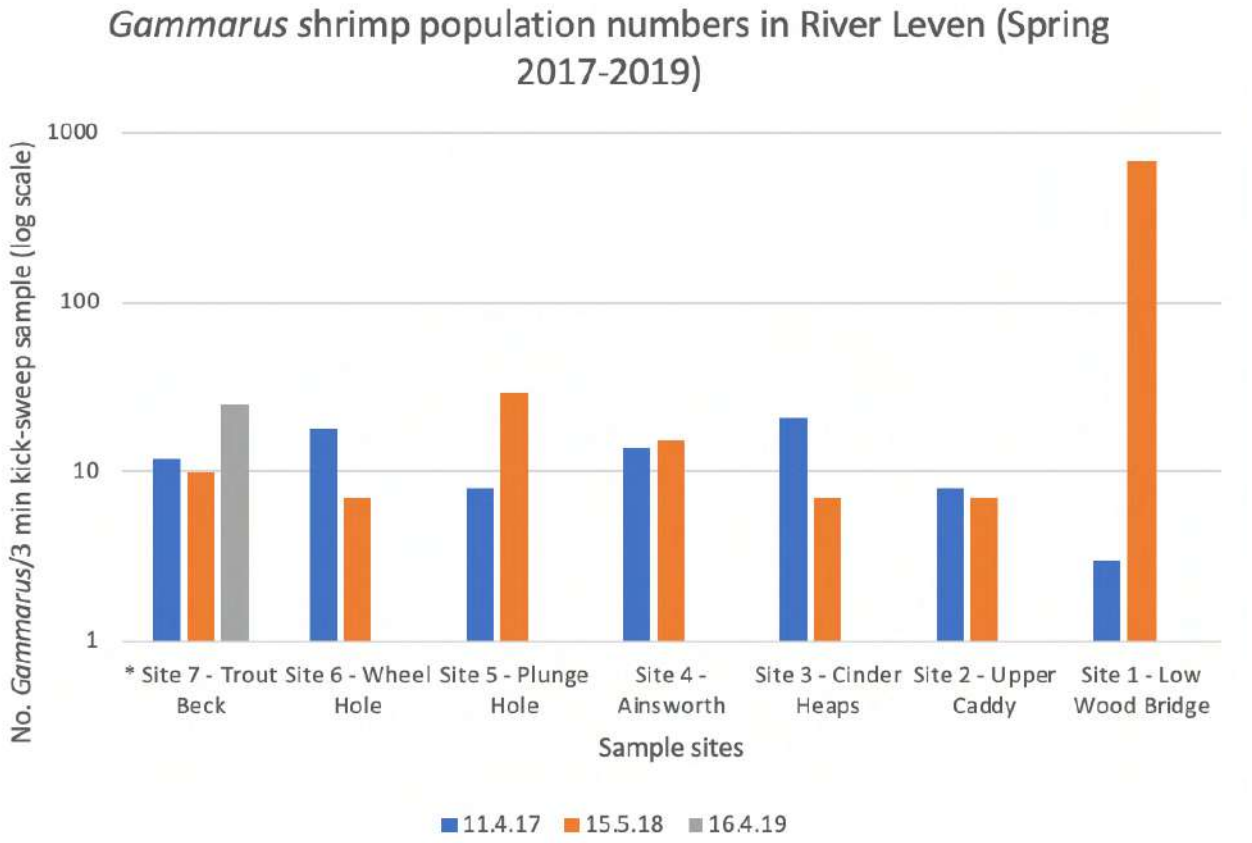


Fig. 5 - Spring Gammarus abundances in 2017, 2018 and 2019 from Riverfly Census survey.

This is one of the many River Leven stresses that requires further monitoring, evaluation and remediation. The River Leven was found to be impacted from multiple stresses upon the ecological and fishery status which requires urgent multi-agency and stakeholder group action to remedy. Failure to do so would result in further decline in the condition of the aquatic ecology and salmonid fisheries. Indeed, much catchment level work will be required not just to stop further decline, but to return the river and lake Windermere to a healthy condition.

RECOMMENDATIONS

It is clear from our results that biologically the River Leven is under intense stress from excess phosphorus, which is largely attributed to wastewater discharges. It would be useful to continue species-level invertebrate monitoring to measure the biological response following phosphorus permit tightening at Ambleside and Windermere wastewater treatment works, which is due to be completed in 2020.

Considerable effort has and is being made in improving infrastructure at the various sewage treatment works in the area, but nutrient stress is still marked. Creation of a more easily accessible inventory on the whereabouts and state of septic tanks and cesspits in the Leven operational catchment (including Windermere) is essential to understand the role they are playing in nutrient enrichment.

Changes in river pH associated with algal blooms are extremely detrimental to fish and invertebrates. Further monitoring and evaluation of the true pH regime at times of algal blooms in South Windermere and the impact on the Leven through carry over is necessary.

FINAL WORD

Many of our rivers lack historical reference points, making it difficult to know exactly what optimal conditions in our rivers should look like. It is only with a reliable 'benchmark' of health that we can properly quantify deterioration or recovery, and only with robust long term monitoring can we truly understand the changes occurring in our freshwater systems.

Our Riverfly Census data has highlighted the subtle but lethal pressures facing UK rivers, but we need help to extend species level invertebrate analysis to many more. Our new project, SmartRivers, will enable volunteers to monitor the water quality in their rivers to a near-professional standard. SmartRivers compliments existing Riverfly Partnership monitoring but provides more information. The high-resolution nature of the data also means that S&TC is able to work with the Environment Agency and others to address the causes of poor water quality and drive forward positive change.

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APPENDIX 1

River Leven (intermediate rivers) reference clean conditions from data in the Environment Agency RIVPACS/RICT predictive databanks throughout the 2017-2019 study period (SNIFFER, 2008).

Group	No. sites	Mean TAXA	Mean ASPT	Dominant characteristics
1-7	64	23	6.27	All in Scotland mainly islands
8-16	148	25.2	6.79	Upland streams, mainly in Scotland and N England
17-26	169	31.7	6.42	Intermediate rivers, SE Scotland, Wales, N & SW England
27-30	48	27.1	6.25	Small steeper streams, within 13km of source, discharge 1/2
31-36	115	34.8	5.84	Intermediate size lowland streams, incl. chalk, SE
37-40	84	32.7	5.58	Small lowland streams, including chalk, SE Britain
41-43	57	32.7	5.14	Lowland streams, SE England, larger, fine sediments

APPENDIX 2

Trout Beck (upland northern stream) reference clean conditions from data in the Environment Agency RIVPACS/RICT predictive databanks throughout the 2017-2019 study period (SNIFFER, 2008).

Group	No. sites	Mean TAXA	Mean ASPT	Dominant characteristics
1-7	64	23	6.27	All in Scotland mainly islands
8-16	148	25.2	6.79	Upland streams, mainly in Scotland and N England
17-26	169	31.7	6.42	Intermediate rivers, SE Scotland, Wales, N & SW England
27-30	48	27.1	6.25	Small steeper streams, within 13km of source, discharge 1/2
31-36	115	34.8	5.84	Intermediate size lowland streams, incl. chalk, SE
37-40	84	32.7	5.58	Small lowland streams, including chalk, SE Britain
41-43	57	32.7	5.14	Lowland streams, SE England, larger, fine sediments

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