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Cunsey Beck Data Report

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Macroinvertebrate communities and their associated scores calculated from Environment Agency and SmartRivers monitoring data between 2006 and 2024.

1. Summary:

- Classification of the invertebrate community in Cunsey Beck using the WHPT metric in RICT clearly shows a decline since the last full EA survey in 2014. Using SmartRivers data from 2023 three sites were classified as 'bad' with one site as 'poor'.
- Trends in traditional water quality scores based on family-level taxonomic data suggest a clear pattern of decline since the surveys conducted by the Environment Agency (EA) in 2006. Additionally, mixed-level taxonomic assessment of fine sediment and organic pressure indicates that conditions are worse than in 2006, with multiple seasons' scores below a 'healthy' level.
- Trends in the invertebrate community show a general decline in the ecological health of the beck with biodiversity taxonomic richness and abundance appearing worse than in 2006. Additionally, species of importance, such as the protected white-clawed crayfish, has not been recorded in a survey since 2008.
- SmartRivers surveys show consistent signs of anthropogenic impact (e.g., sediment, organic, phosphorus and EPT diversity and abundance declines). Particularly, at the site downstream of the WwTW.
- Overall, the evidence indicates a deterioration in the water quality and ecological health of Cunsey Beck since the last RBMP. Given that SmartRivers spatial data highlights that the worst impacts are detected downstream of the Near Sawrey WwTW, this suggests that sewage is contributing to the deterioration of Cunsey Beck and urgent action is needed to address these concerns.

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2. Background:

Collaboration between WildFish and Save Windermere on the SmartRivers macroinvertebrate monitoring programme has indicated that all is not well beneath the surface on Cunsey Beck. Our surveys suggest phosphorus, organic and fine sediment pressure at the monitoring site below the Near Sawey wastewater treatment works (WwTW). Overall, our data indicates that water quality and biodiversity on this river has declined in recent years.

The EA has not conducted a macroinvertebrate survey on Cunsey Beck since 2014. There was a survey in 2022 on Black Beck, which is upstream of Esthwaite Water and all United Utility assets. The 280-acre lake is likely to act as a barrier to the movement of some lentic macroinvertebrate species between the two becks. This site is therefore not representative of the water quality further downstream in Cunsey Beck.

To assess if there has been a decline in the invertebrate community (a biological indicator of water quality) in Cunsey Beck, using both EA and SmartRivers data, we; I) calculated classifications of the water body using the WHPT metric in RICT, II) assessed trends in water quality using commonly implemented biometrics, and III) assessed trends in taxonomic richness and abundance of the invertebrate communities. Additionally, we present SmartRivers data highlighted where on the river that declines are most apparent.

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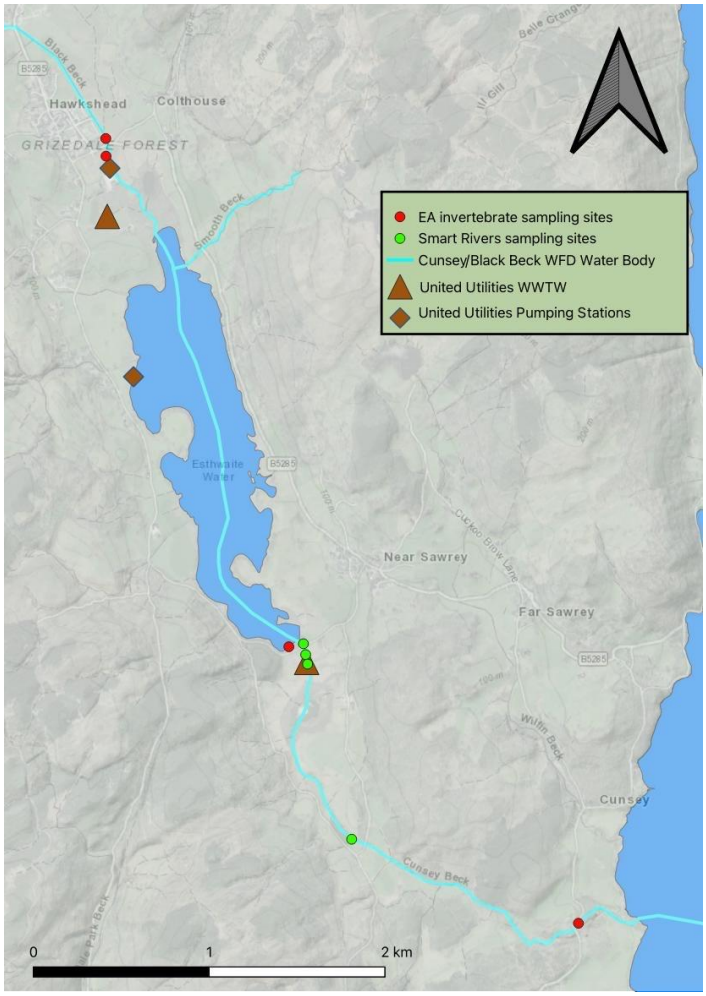

Figure 1: Map showing the SmartRivers sites on Cunsey Beck in relation to the EA site and United Utilities infrastructure.

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3. Methods and Data Handling

Invertebrate surveying for both the EA and SmartRivers datasets follows the standard three-minute kick sweep sample and one minute hand search, allowing us to make direct comparisons between the datasets. SmartRivers invertebrate sampling and subsequent identification were conducted by a professional entomologist/ecotoxicologist: Dr Nick Everall, FIFM C ENV UK expert witness, Aquascience Consultancy Ltd.

Historical data for the EA site on Cunsey Beck (SD 38125 93607) were downloaded from the EA 'Ecology and Fish Data Explorer' (river invertebrate dataset) on 07/06/2024. We were interested in the condition of Cunsey Beck since 2007 as this is when the Environmental Liability Directive came into effect. As there were no benthic invertebrate surveys conducted by the EA in 2007, we have plotted data from 2006 and 2008, where both a spring and autumn surveys were conducted. EA sampling has been irregular, and therefore the final dataset included spring/autumn samples for 2006, 2008, 2013 and 2014. When downloading data for these analyses we followed the Freshwater Biology and Ecology Handbook (Murray Bligh and Griffiths, 2022) seasonal guidance with spring samples being taken in March-May and autumn samples being taken in September to November.

SmartRivers sampling on Cunsey Beck started in 2023. We have used data from spring and autumn surveys in 2023 and 2024 to assess the current condition of Cunsey Beck. SmartRivers' surveying sites were designed to monitor the impact of the Near Sawrey wastewater treatment works (WwTW) on Cunsey Beck, and as such has two paired up/downstream sites of the works monitoring riffle (sites 2 and 4) and glide (sites 1 and 3). In relation to the comparisons discussed in sections 3.2 and 3.3 below these sites do not directly overlap with the historical EA site and so we took an average from the four SmartRivers sites each season, each year, to generate a value as to the 'general' state of Cunsey Beck. These average values are displayed with standard deviation error bars to show the variability of data in a given sample. We acknowledge that this is not a direct site comparison, however, given the paucity of EA sampling in recent years we were forced to make what assessment we could with the data available. All SmartRivers samples were taken within the above Freshwater Biology and Ecology Handbook seasonal window.

3.1 UKTAG River Assessment Method – Benthic Invertebrate Fauna

An assessment of the general degradation of the invertebrate community of Cunsey Beck was calculated using the Whalley, Hawkes, Paisley, and Trigg (WHPT) metric (see definition in 3.2 below) in River Invertebrate Classification Tool (RICT). This method assesses the degradation of the invertebrate community in a waterway according to the requirements of the Water Framework Directive (WFD).

These calculations were completed using RICT v3.1.8 (https://rictapplications.shinyapps.io/rictapp/) with guidance from the UKTAG Guide to WHPT in RICT (WFD-UKTAG, 2021) and the Freshwater Biology and Ecology Handbook (Murray Bligh and Griffiths, 2022).

RICT (Davy-Bowker *et al*, 2007) is used to contextualise WHPT data in relation to the River Invertebrate Prediction and Classification System (RIVPACS) (Wright, 1997). This ultimately results in a WFD classification and an associated confidence probability, but also Ecological Quality Ratios (EQR) for both WHPT NTAXA and WHPT ASPT (see definitions in 3.2 below).

For the EA data, environmental predictor variables were taken from the 'SITE' spreadsheet and these data, along with both spring and autumn values for WHPT NTAXA/ASPT, were inputted to the 'model 1 template GB' for each year a spring and autumn survey had been conducted. This was the uploaded to RICT. A standard EA NTAXA bias value of '1.68' was used.

For the SmartRivers data, environmental predictor variables were generated using the 'RICT – Location Checker for Model 44 Input Variables' online database (Environment Agency, 2024). For the alkalinity we used the same value from the EA site data as this is not collected during SmartRivers and unlikely to vary greatly in this water course. Data for both spring and autumn 2023 samples at all sites was inputted to the 'model 44 temple GB' before uploading to RICT. The location checker generated a negative slope value (-9) for sites 1 and 2 which were changed to '0' in order to run the model. As all SmartRivers invertebrates for Cunsey Beck were identified by Aquascience Consultancy Ltd we used a NTAXA bias value of '0' based on independent analytical quality controls (based on 13 spring and 6 autumn samples). We also ran the same data in RICT with an NTAXA EA bias of '1.68' and found no difference in the final classification.

For both data sets all rows of data generated a suitability code of 1, meaning that classifications are reliable.

3.2 Water Quality Trends

Biometrics were chosen that were already calculated by both the EA and SmartRivers' online databases to allow for easy comparisons between the two datasets to assess the change in river health since 2006. Additionally, values for the saprobic index were manually calculated for EA data using SmartRivers data processing pathways.

The 2013 EA surveys were only identified to family level and subsequently mixed-level taxonomic scores (PSI) and the number of taxonomic observations were not calculated for these surveys.

Definitions:

- WHPT (Whalley, Hawkes, Paisley, and Trigg metric): A further measure of water quality using family-level macroinvertebrate taxonomic data that superseded the BMWP system in 2014. This metric makes some consideration of invertebrate abundance (log scale).
- WHPT (NTAXA): The number of scoring families contributing to the BMWP score.
- WHPT (ASPT): The average score per taxa. I.e., WHPT/NTAXA.
- PSI (the Proportion of Sediment-sensitive Invertebrates index): A biomonitoring tool that uses mixed-level macroinvertebrate taxonomic data to identify the degree of sedimentation in river (Extence, 2010). As well as being one of the metrics calculated

by both the EA and SmartRivers programme this metric was chosen as SmartRivers surveys have highlighted it as a key issue on this water, particularly downstream of the WwTW.

- Organic (Saprobic Index): A water quality measure estimating organic pollution (e.g. ammonia and BOD) using mixed-level macroinvertebrate taxonomic data. Although not actively calculated by the EA it has been widely used since the 1950's, particularly in Europe, as the key biological quality assessment of rivers until a shift to the WHPT system for conformity of practices across the sector. As metric based mixed-taxonomic data (i.e. including species level data) the saprobic index can give a far clearer picture than generic estimates of taxonomic family responses. Saprobic values were manually calculated for EA data using SmartRivers data processing pathways.

3.3 Invertebrate Biodiversity Trends

Macroinvertebrate diversity and abundance values were automatically calculated from SmartRivers data. For the EA data these values were manually extracted from the 'TAXA' spreadsheet. Measures of biodiversity were taken at two levels. 'Total' is a measure of the entire invertebrate community and 'EPT' which refers to the EPT riverflies (Ephemeroptera, Plecoptera, and Trichoptera) which are orders of insects traditionally considered as sensitive to pollution. These data were each considered in terms of diversity (taxonomic observations) and abundance.

- Taxonomic observations: The number of distinct taxonomic observations in a survey as an assessment of diversity. This measure was chosen over species richness due to the mixed-level taxonomic data. To avoid artificial inflation of richness when two associated observations of different taxonomic levels were recorded in a survey (e.g., genus *Ecdyonurus* and species *Ecdyonurus dispar*) this was counted as a single observation.
- Abundance: The number of invertebrates found in a survey.

For EA taxonomic observations species counts were reduced by 1 in spring 2006/2014 and 2 in autumn 2006 due to taxonomic replication. All these observations related to mayflies.

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4. Results

4.1 UKTAG River Assessment Method – Benthic Invertebrate Fauna

Site	Year	Spring Sample	Autumn Sample	EQR ASPT	Class (Probability)	EQR NTAXA	Class (Probability)	MINTA Overall Class
66050	2006	28-Apr	12-Sep	0.92	Good (86.05)	1.51	High (100)	Good
66050	2008	09-May	05-Nov	0.91	Good (84.99)	1.32	High (100)	Good
66050	2013	29-Apr	25-Sep	0.87	Good (64.14)	1.15	High (99.96)	Good
66050	2014	11-Mar	25-Sep	0.95	Good (71.13)	0.89	High (81.37)	Good

Figure 2: The condition of the invertebrate community according to the WHPT metric in RICT using EA data on Cunsey Beck at the historical EA site, between 2006 and 2014 for years when both spring and autumn sample had been taken. All rows of data had a suitability code of 1.

Site	Year	Spring Sample	Autumn Sample	EQR ASPT	Class (Probability)	EQR NTAXA	Class (Probability)	MINTA Overall Class
1	2023	03-May	07-Sep	0.88	Good (68.09)	0.35	Bad (98.94)	Bad
2	2023	03-May	07-Sep	0.91	Good (79.23)	0.38	Bad (94.85)	Bad
3	2023	03-May	07-Sep	0.68	Poor (79.84)	0.37	Bad (97.47)	Bad
4	2023	03-May	07-Sep	0.83	Moderate (75.03)	0.51	Poor (49.20)	Poor

Figure 3: The condition of the invertebrate community according to the WHPT metric in RICT using SmartRivers data on Cunsey Beck at the four SmartRivers sites in 2023. All rows of data had a suitability code of 1.

While we acknowledge that our SmartRivers sites do not directly overlap with the historical EA site for comparison, the above data paints a stark picture of deteriorating water quality on Cunsey Beck since last assessed in 2014. Three of the SmartRivers sites scored an overall class of 'bad' condition in 2023 with one site being 'poor', compared to the 'good' condition seen at the EA site in 2014. Interestingly this change appears to primarily be linked to declines in the values for EQR NTAXA, i.e. family-level diversity contributing to the WHPT scores. According to the Freshwater Biology and Ecology Handbook (Murray Bligh and Griffiths, 2022, pg176), when ASPT class is higher than that of NTAXA this may point to toxic pollution or habitat degradation. Additionally, when ASPRT score is lower than 'good', as with site 3 (below the WwTW), this can be a signal of organic pollution. These kinds of pollution signals are often associated with sewage inputs.

Overall, given than there hasn't been a full invertebrate survey taken on Cunsey Beck since 2014, the current WFD classification of 'good' seems likely to not be reflective of the actual

condition of Cunsey Beck in the present day. Our evidence points to a clear decline in the last decade.

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4.2 Water Quality Trends

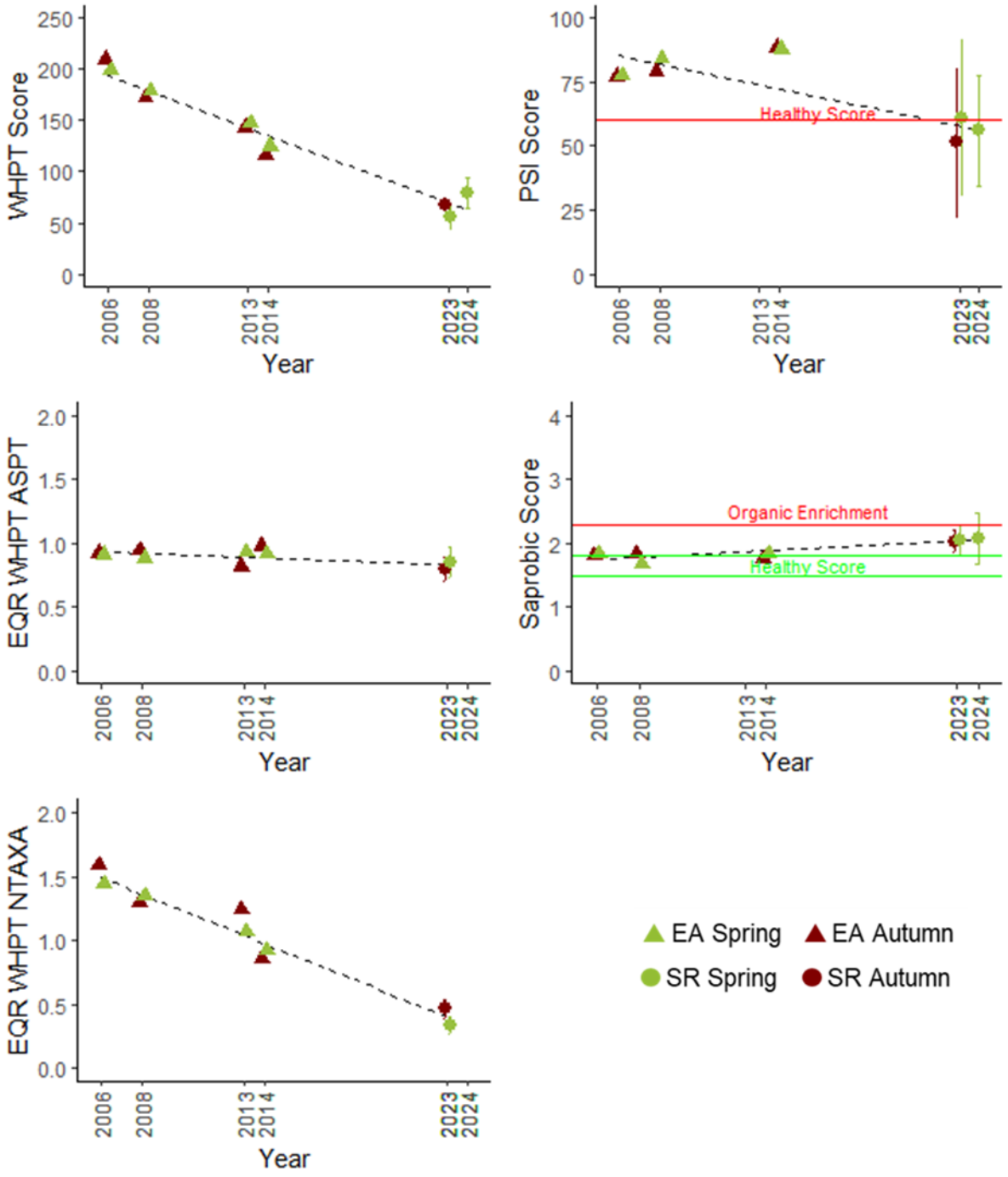

Figure 4: WHPT, EQR WHPT NTAXA, EQR WHPT ASPT, PSI, and Saprobic scores calculated from spring and autumn macroinvertebrate surveys conducted on Cunsey Beck between 2006 and 2024. SmartRivers data points shown the average score (±SD) from the four sites surveyed in a given season/year to give a general comparison to the historic EA monitoring site. Datapoints within a year are slightly spaced along the X-axis to increase legibility.

The above trends show a general decline in the ecological condition of Cunsey Beck since EA surveys were conducted in 2006. This pattern is consistent in the family-level WHPT

score, despite the large gaps in the data set where no full surveys were conducted for several years. While the change for the EQR ASPT values is fairly minor, the gradient for EQR NTAXA (i.e., diversity) shows a steep decline The fine sediment (PSI) trends are also concerning and suggest increasing impact. The average condition in autumn 2023 and spring 2024 was below what is considered a ‘healthy’ score. These error bars on the graphs highlight how the condition of the sites below the WwTW has scored as heavily impacted by fine sediment (see figures 6 and 7 for more detail). Saprobic scores appear to reflect increasing levels of organic pollution since 2006. While the average condition of the beck is below what would be considered organic enrichment some sites, i.e. those downstream of the WwTW, have surpassed this threshold (see figures 6 and 7 for more detail). These scores indicate that rather than the expected oligotrophic (low nutrient) unpolluted condition, sites register as beta-alphamesosaprobic (moderately polluted water course).

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4.3 Invertebrate Biodiversity Trends

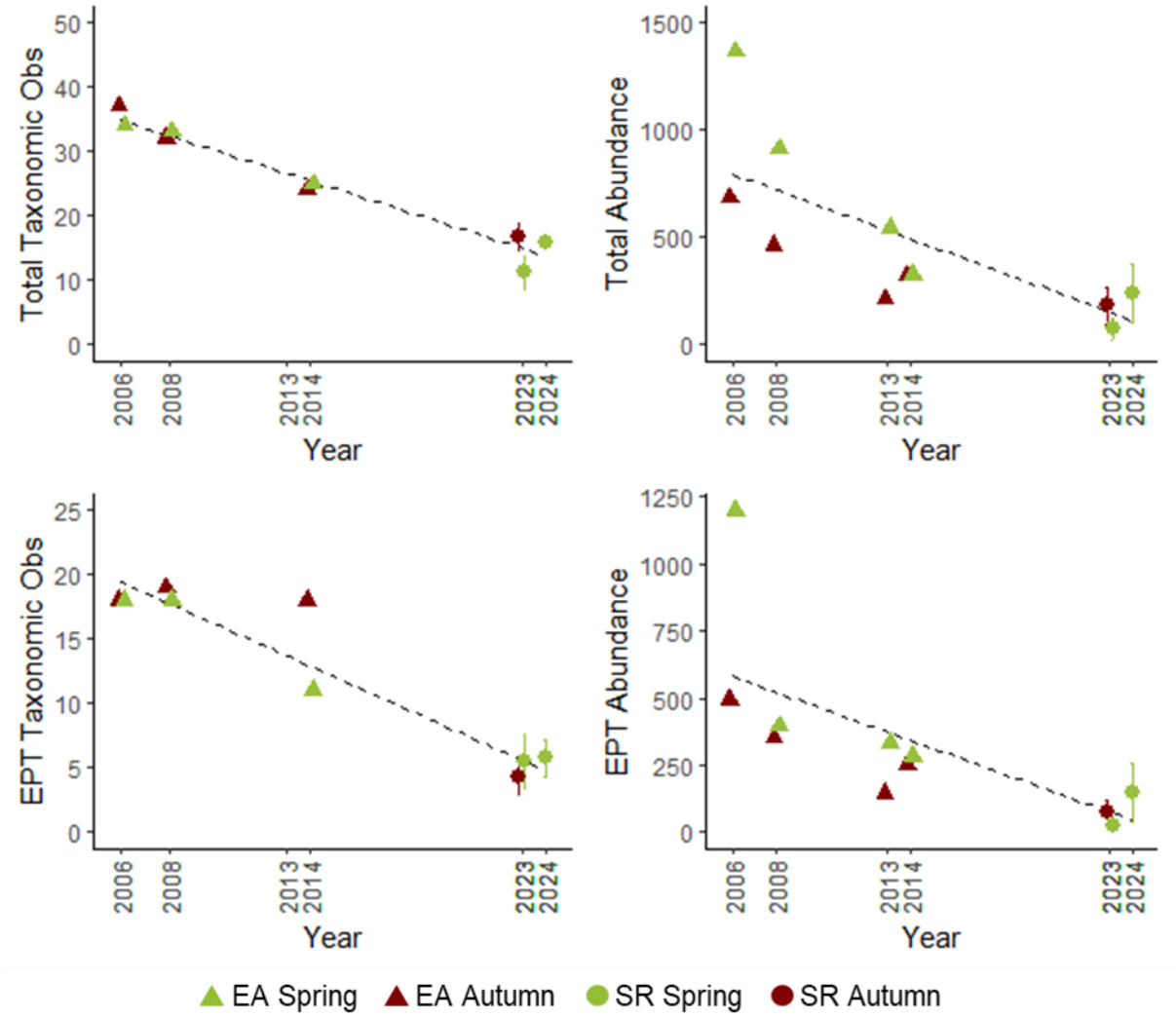

Figure 5: The number of taxonomic observations and the recorded abundances of both the total invertebrate community and EPT riverfly populations on Cunsey Beck between 2006 and 2024. No richness values displayed in 2013 as data was left at family-level. SmartRivers data points shown the average score (±SD) from the four sites surveyed in a given season/year to give a general comparison to the historic EA monitoring site. Datapoints within a year are slightly spaced along the X-axis to increase legibility

The invertebrate biodiversity trends, both in terms of taxonomic richness and abundance, also indicate declines in Cunsey Beck since EA surveys in 2006. Native white-clawed crayfish (*Austropotambius pallipes*), a species protected under schedule V of the Wildlife and Countryside Act 1981 and is included in Annex II and V of the EC Water Habitats Directive, was present in all surveys in 2006 and 2008, but has not been recorded in subsequent visits. Additionally, as well as general reductions in the diversity and abundance of EPT riverflies there are specific examples at the species level that suggest a decline in the water quality. For example, for the mayfly genus *Beatis* in 2006 and 2008 spring surveys both the iron blue (*B. muticus*) and large dark olive (*B. rhodani*) were recorded but subsequent monitoring has only recorded large dark olives. The iron blue is considered more

sensitive to pollution than the large dark olive and so it's absence in latter surveys (particularly for 2023/24 as some EA data left at family/genus level in 2013/14) is concerning. Additionally, some groups such as caddisfly have been routinely left at family level in EA surveys. As latter SmartRivers surveys speciate this group it is possible that the loss of species is higher than indicated in this data report.

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5. SmartRivers Data - All Sites

The above invertebrate community classification (4.1) combined with water quality (4.2) and invertebrate community (4.3) data trends clearly demonstrates that the general condition of Cunsey Beck has deteriorated since 2006. The SmartRivers programme monitors four sites each season and this allows us greater spatial resolution of data which we can use to highlight where anthropogenic inputs are impacting the ecological health of the beck. As mentioned above the sites are paired, with one riffle and one glide habitat both up and downstream of the WwTW. Therefore, the key comparison to focus on in the below figures is between site one (upstream glide) and site 3 (downstream glide), the latter is below the WwTW.

SmartRivers monitoring on Cunsey Beck is currently in its second year, but already is showing repeat patterns of impact. Namely, in terms of biometrics where there are consistent strong signals of phosphorus (TRPI), organic (Saprobic) and fine sediment (PSI) stress at the site downstream of the WwTW. This is supported by the classifications in 4.1 (fig. 3) with a ‘poor’ EQR ASPT at site 3 in 2023 (as signal of organic pollution) and lower class values for EQR NTAXA, suggesting possible toxic pollution/habitat degradation. Additionally, the biodiversity of EPT riverfly communities (orders of pollution sensitive insects) is notably worse downstream of the works.

Furthermore, traditional family-level measures of water quality (BMWP and WHPT) show lower scores downstream of the works, particularly in the spring surveys.

All of this evidence taken together indicates that the WwTW is having a negative impact on the invertebrate community and water quality in Cunsey Beck.

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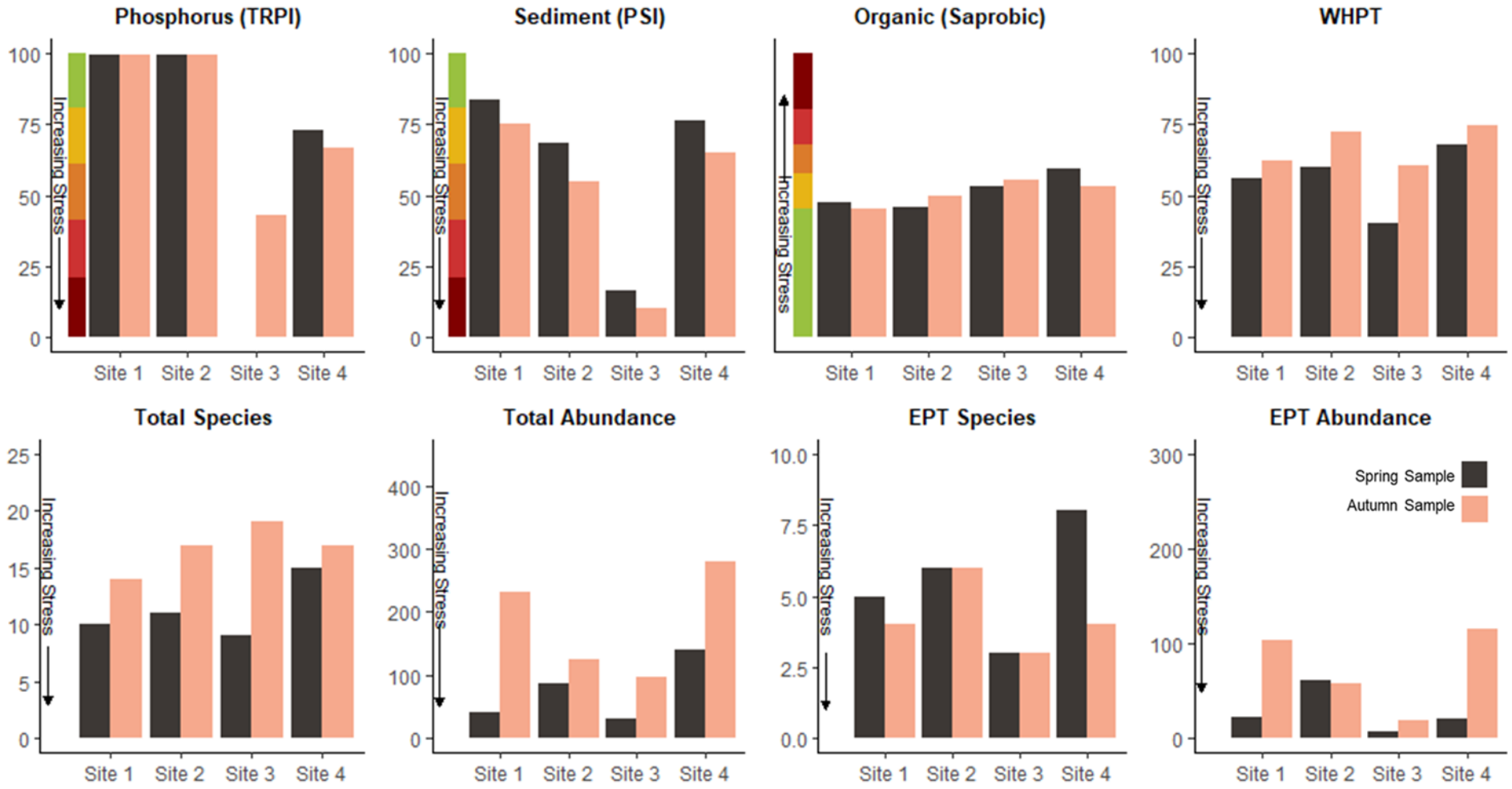

Figure 6: A subset of water quality and invertebrate biodiversity measures calculated from SmartRivers surveys along Cunsey Beck in spring and autumn 2023. Near Sawrey WwTW sits between sites 2 and 3.

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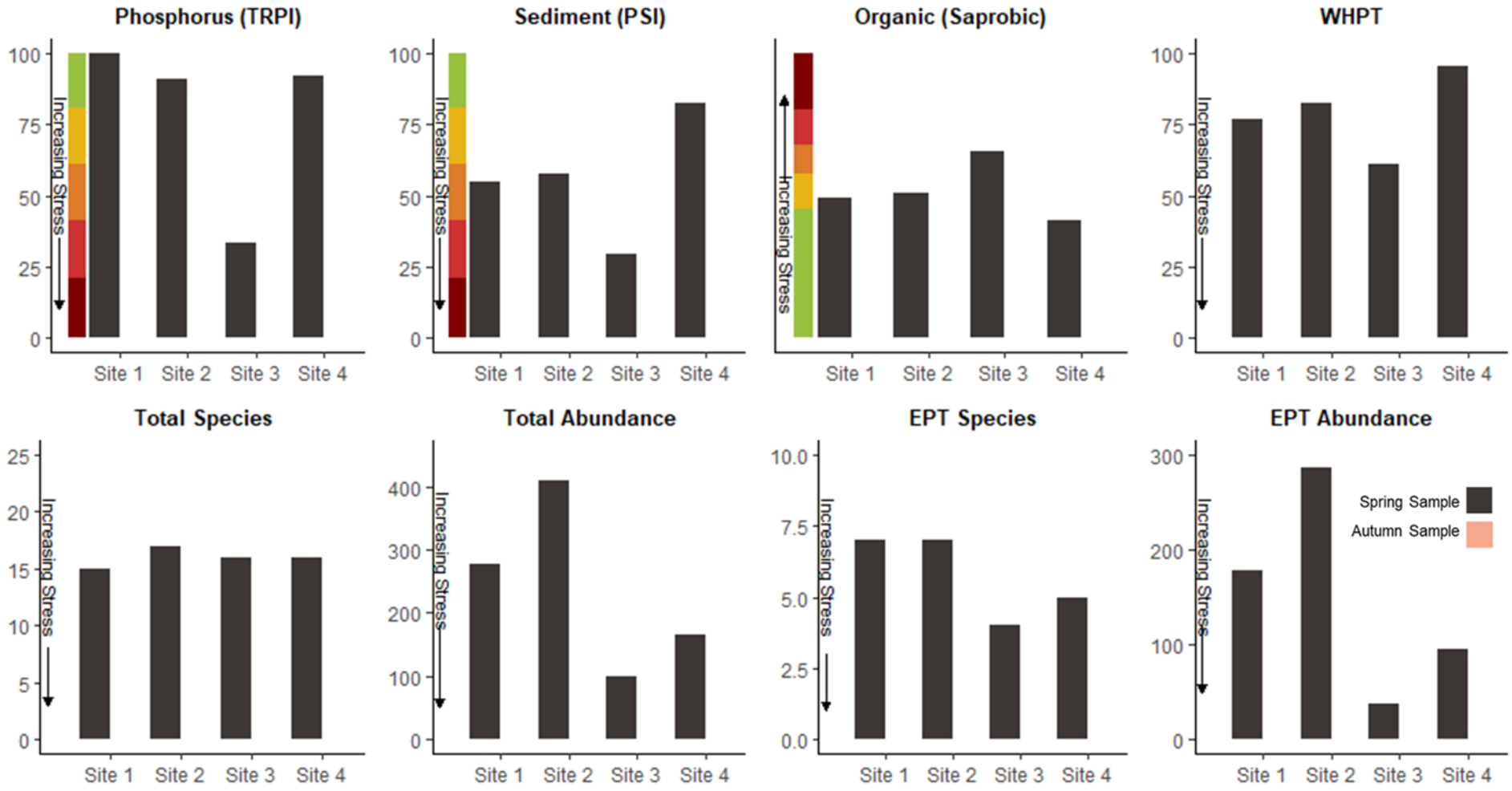

Figure 7: A subset of water quality and invertebrate biodiversity measures calculated from SmartRivers surveys along Cunsey Beck in spring 2024. Near Sawrey WwTW sits between sites 2 and 3.

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