

# **Diatom and macroinvertebrate surveys of the River Wye SAC (Wales) in 2022- 23**

Report No: 783

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Report series: NRW Evidence Report  
Report number: 783  
Publication date: May 2026  
Contract number: SEWTAPS-2022.00438  
Contractor: Stantec Ltd.  
Contract manager: Hatton-Ellis TW.  
Title: Diatom and macroinvertebrate surveys of the River Wye SAC (Wales) in 2022-23  
Author(s): Jones, C.  
Technical editor: Hatton-Ellis TW.  
Quality assurance: Tier 3  
Peer reviewer(s): Oakley R, Hearn S, Tanner J, Byrne S, Owen J, Sanchez F.  
Approved by: R. Thomas and R. Cardwell  
Restrictions: None

## Distribution list

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## Recommended citation for this volume:

Jones, C. 2026. Diatom and macroinvertebrate surveys of the River Wye SAC (Wales) in 2022-23. NRW Evidence Report No: 783, 60pp, Natural Resources Wales, Cardiff.

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# Crynodeb gweithredol

## Cefndir

Afon fawr sy'n croesi'r ffin rhwng Cymru a Lloegr yw afon Gwy. Mae'n Ardal Cadwraeth Arbennig (ACA) ac yn Safle o Ddiddordeb Gwyddonol Arbennig (SoDdGA), gan adlewyrchu ei gwerth uchel o ran cadwraeth natur. Mae amrywiaeth o gynefinoedd a rhywogaethau allweddol yn y dalgylch, gan gynnwys afonydd sy'n cynnwys rhywogaethau crafanc y dŵr, eogiaid a gwangod.

Yn ystod y blynyddoedd diwethaf, mae arferion ffermio wedi newid yn rhannau uchaf afon Gwy, gyda chynnydd mawr yn nifer yr unedau dofednod dwys. Yn ogystal, mae rhannau sylweddol o'r dalgylch yn methu â chyrraedd targedau ffosforws ar gyfer Ardaloedd Cadwraeth Arbennig. Nodwyd gordyfiant ffytoplancion difrifol yn rhan isaf afon Gwy ger Rhosan-ar-Wy yng ngwanwyn 2020. Mae hyn wedi arwain at bryder sylweddol ymhlith y cyhoedd.

Gall pwysau maethynnau effeithio'n negyddol ar gymunedau biolegol a thrwy hynny leihau statws ecolegol cyrff dŵr. Yn unol â hynny, mae Cyfoeth Naturiol Cymru (CNC) wedi comisiynu rhaglen samplu helaeth o ddwy elfen ansawdd fiolegol allweddol, sef diatomau ac anifeiliaid di-asgwrn-cefn dyfrol (macroinfertebratau), gan ddefnyddio offer safonol Rheoliadau'r Gyfarwyddeb Fframwaith Dŵr.

## Sail resymegol a dulliau

Mae monitro biolegol yn offeryn defnyddiol wrth ganfod pwysau amgylcheddol ac asesu cyflwr ecolegol. Mae tacsonau diatomau (algâu microsgopig) a macroinfertebratau yn sensitif i amodau amgylcheddol newidiol ac mae eu casgliadau perthnasol (cyfansoddiad y rhywogaethau o fewn cymuned neu sampl) yn alinio i adlewyrchu eu hamgylchedd. Gellir cyfrifo mynegeion biotig o gyfansoddiad rhywogaethau samplau ym mhob safle a'u defnyddio i gasglu pwysau maethynnau ac amodau ecolegol. Bwriad y Mynegai Diatomau Troffig yw mesur ymateb diatomau i grynodiadau ffosforws. Mae macroinfertebratau yn infertebratau dyfrol ac maent yn sensitif i grynodiadau ocsigen tawdd isel a all ddeillio o lygredd organig (fel arfer o dail neu o ordyfiant algâu), yn ogystal â phwysau cysylltiedig fel siltio ac amonia. Felly, dylai'r offer hyn roi darlun da o effeithiau biolegol unrhyw lygredd.

Mae'r adroddiad hwn yn cyflwyno canlyniadau prosiect monitro graddfa dalgylch diweddar a gynhaliwyd rhwng gwanwyn 2022 a hydref 2023. Casglwyd samplau diatomau o 101 o safleoedd a macroinfertebratau o 43 o safleoedd. Roedd y rhain yn gymysgedd o bwyntiau samplu presennol CNC a lleoliadau newydd. Canolbwyntiwyd yr ymdrechion samplu ar ran ACA Afon Gwy sydd yng Nghymru, yn enwedig ardaloedd lle mae unedau dofednod yn bresennol mewn niferoedd mawr ac felly yr amheuir eu bod wedi cael llwyth ffosforws cynyddol (yn enwedig afon leithon a'i hisafonydd), ond samplwyd lleoliadau eraill hefyd. Deilliwyd mynegeion ansawdd amgylcheddol perthnasol o gyfansoddiad y rhywogaethau ym mhob digwyddiad samplu.

Mae tail o bob math o dda byw fferm, gan gynnwys unedau dofednod, yn cael ei wasgaru ar dir at ddibenion amaethyddol naill ai ar y fferm neu oddi arni, neu'n cael ei gludo i rywle

arall i'w brosesu (e.e. i weithfeydd treulio anaerobig). Mae diffyg data ar faint ac amseru gwasgaru tail, ac felly nid oedd modd asesu effaith arferion gwasgaru tail.

Y targed ar gyfer yr offer macroinfertebrat a'r offer diatom ar draws ACA Afon Gwy yw statws uchel, sy'n adlewyrchu'r angen am yr amodau ecolegol gorau posibl mewn safleoedd gwarchoddedig.

## Canlyniadau

Dylid ystyried y canlyniadau hyn yn ddangosol oherwydd na chasglwyd pob sampl gwanwyn/hydref o fewn yr un flwyddyn galendr gan ddilyn y dull a amlinellir yn UKTAG (2014). Roedd y mwyaf o'r samplau diatomau ac anifeiliaid di-asgwrn-cefn yn cyfateb i statws da neu statws uchel o dan Reoliadau'r Gyfarwyddeb Fframwaith Dŵr (Tabl ES1). Cyrhaeddodd tua 47% o samplau diatomau darged statws uchel yr ACA, o'i gymharu â dim ond 7% o safleoedd infertebratau. Ar gyfer safleoedd na chyflawnodd statws uchel, fe ddosbarthwyd y mwyafrif fel 'da', sy'n dangos y byddai gwelliannau ecolegol cymharol gymedrol yn debygol o fod yn ddigonol i gyrraedd y trothwy statws uchel.

Oherwydd bod y samplau tymhorol yn cael eu cyfuno i lunio dosbarthiad cyffredinol, ac, ar gyfer anifeiliaid di-asgwrn-cefn, bod dau fetrig yn cael eu hintegreiddio, dyfarnwyd statws da i'r mwyaf o'r safleoedd yn y pen draw. Safleoedd sy'n methu â chyflawni statws da yn gyffredinol wedi'u halinio â rhannau o afonydd a nodwyd yn flaenorol fel rhai nad ydynt yn cyrraedd targedau ffosfforws ar gyfer ACA Afon Gwy (yng Nghymru).

Y ddau fetrig sy'n cael eu cyfrifo ar gyfer infertebratau yw fel a ganlyn:

- NTAXA, sef cyfanswm y gwahanol dacsas macroinfertebrat a geir mewn sampl. Mae NTAXA uwch yn gyffredinol yn dynodi cynefin dŵr croyw mwy amrywiol ac iachach. I'r gwrthwyneb, gall NTAXA isel awgrymu llygredd, dirywiad cynefinoedd neu ansawdd dŵr gwael.
- ASPT, sef y sgôr goddefgarwch llygredd gyfartalog ar gyfer yr holl dacsas sy'n bresennol yn y sampl. Mae ASPT uchel yn golygu bod y casgliad yn cael ei ddominyddu gan dacsas sy'n sensitif i lygredd, tra bod ASPT isel yn awgrymu bod tacsas yn gallu goddef llygredd, sy'n dynodi straen neu ddiraddio.

Dangosodd y ddau fetrig anifeiliaid di-asgwrn-cefn ganlyniadau cyferbyniol: cyflawnodd y metrig NTAXA 'statws uchel' mewn 81% o safleoedd, tra bod y metrig ASPT wedi cyflawni 'statws uchel' mewn dim ond 9% o safleoedd, ac mae'r rhan fwyaf (84%) wedi'u dosbarthu fel 'da' (Tabl ES1). Roedd y patrymau hyn yn gyson ar draws yr ystod lawn o safleoedd, gan gynnwys y rhai lle mae pwysau amaethyddol uchel yn debygol a'r rhai lle'r oedd disgwyl i bwysau o'r fath fod yn isel.

| Metrig             | Statws uchel (targed) | Statws da | Statws cymedrol | Statws gwael | Statws drwg |
|--------------------|-----------------------|-----------|-----------------|--------------|-------------|
| Diatomau (samplau) | 95 (47%)              | 92 (46%)  | 12 (6%)         | 3 (1%)       | 0           |

| Metrig   | Statws uchel (targed) | Statws da | Statws cymedrol | Statws gwael | Statws drwg |
|--|-----------------------|-----------|-----------------|--------------|-------------|
| Anifeiliaid di-asgwrn-cefn – NTAXA                               | 35 (81%)              | 5 (13%)   | 2 (5%)          | 1 (3%)       | 0           |
| Anifeiliaid di-asgwrn-cefn – ASPT                                | 4 (9%)                | 36 (84%)  | 3 (7%)          | 0            | 0           |
| Anifeiliaid di-asgwrn-cefn – dosbarth statws cyffredinol y safle | 3 (7%)                | 34 (79%)  | 5 (12%)         | 1 (2%)       | 0           |

Tabl ES1. Nifer y samplau a'r safleoedd sy'n cyrraedd gwahanol lefelau o ansawdd amgylcheddol.

Mae targed 'statws uchel' yr ACA wedi'i gyflawni mewn llawer o leoliadau samplu yn y blynyddoedd blaenorol, ond mae angen dadansoddiad cymharol pellach i ddehongli'r patrymau cyffredol yng nghyd-destun pwysau lleol, amodau hinsoddol, a diweddariadau i offer dosbarthu.

Ni chyflawnodd chwe safle ddosbarthiad dros statws cymedrol yn seiliedig ar fetrigau anifeiliaid di-asgwrn-cefn. Roedd y rhain yn cynnwys dau ar afon Gwy ac un yr un ar Nant Hindwell, afon Irfon, Nant Bachawy, a Nant Camnant.

Lleolwyd safleoedd a fethodd â chyrraedd 'statws da' yn seiliedig ar fetrigau diatom ar afon Llynfi, Nant Camnant, Nant Gwenlas, afon Arwy, afon Ieithon, Nantmel Dulas, Nant Bach Howey, Nant Camddwr, Nant Gladestry a Nant Gwenlas.

Roedd metrigau diatom mewn rhai safleoedd yn dangos dylanwadau posibl pwysau nad ydynt yn faethynnau a allai effeithio ar ddosbarthiad waeth beth fo'r amodau maethynnau. Yn aml, roedd casgliadau'n cael eu dominyddu gan "fath" *Achnantheidium minutissimum*, yn gyson ag ymchwiliadau blaenorol yn y rhanbarth. Er y gall y tacson hwn fod yn gysylltiedig ag effeithiau anthropogenig neu fetelau, gall ei oruchafiaeth hefyd adlewyrchu amrywioldeb hydrolegol. Er mwyn cryfhau dehongliad o fetrigau biotig ac egluro'r ffactorau sy'n gyrru patrymau ymhlith casgliadau, argymhellir dadansoddi ymhellach berthnasoedd gofod-amserol ac amrywioldeb ffisegemegol.

Roedd dosbarthiadau ecolegol sy'n deillio o fynegeion anifeiliaid di-asgwrn-cefn yn gyffredinol yn cyd-fynd â dosbarthiadau sy'n seiliedig ar ddiatomau, ac eithrio un lleoliad ar Nant Hindwell, a dderbyniodd ddosbarth statws gwael.

## Casgliadau

Mae tystiolaeth o fethiant eang i gyrraedd targed statws uchel yr ACA ar draws afon Gwy (Cymru) ar gyfer dangosyddion diatomau ac anifeiliaid di-asgwrn-cefn. Mae'r canlyniadau hyn yn awgrymu straen maethynnau bach: er na chyflawnwyd statws uchel yn y mwyaf o'r safleoedd, fe arhosodd y mwyafrif llethol ar 'statws da' yn hytrach na 'chymedrol' neu 'wael', a fyddai i'w ddisgwyl o dan effeithiau maethynnau mwy difrifol.

Roedd yr amrywioldeb gofodol yn y canlyniadau yn isel, sy'n dangos bod pwysau'n debygol o weithredu ar raddfa dalgylch yn hytrach na chael eu gyrru gan arfer gwael ynysig. Mae pwysau posibl ar draws y dalgylch yn cynnwys mwy o ddefnydd o dail oherwydd mwy o argaeledd neu gost is. Fodd bynnag, mae dehongli'n gymhleth oherwydd llifau anarferol o isel yn sgil gwanwyn a haf cynnar sych iawn yn 2022, ac yna gwanwyn a haf sych arall yn 2023. Gall llifau isel efelychu neu waethygu effeithiau ecolegol sy'n gysylltiedig â chrynodeiadau maethynnau uchel. Mae diffyg cysgod torlannol mewn llawer o rannau uchaf afon Gwy hefyd, gan gynyddu'r bygythiad o dymereddau uchel a gormodedd algâu o dan amodau llif isel.

Er bod y samplu wedi'i anelu at ddilyn dulliau sy'n cydymffurfio â'r Gyfarwyddeb Fframwaith Dŵr (UKTAG, 2014), nid yw'r canlyniadau a gyflwynir yma yn gyfystyr â dosbarthiadau'r Gyfarwyddeb Fframwaith Dŵr nac asesiadau ffurfiol o gyflwr ACA. Bydd CNC yn integreiddio'r data hyn â ffynonellau tystiolaeth eraill wrth adrodd ar ddosbarthiad y Gyfarwyddeb Fframwaith Dŵr a chyflwr safleoedd gwarchoddedig, ac wrth asesu tueddiadau dros amser.

# Executive summary

## Background

The Wye is a large river crossing the border between Wales and England. It is a Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI), reflecting its high nature conservation value, with a variety of key habitats and species including rivers with water crowfoots, Atlantic salmon and twaite shad.

Recent years have seen changes to farming practices in the Upper Wye, with a large increase in the number of Intensive Poultry Units (IPUs). Additionally, significant portions of the catchment are failing to meet SAC phosphorus targets. A severe phytoplankton bloom was noted in the lower Wye near Ross-on-Wye in spring 2020. This has led to significant public concern.

Nutrient pressures can negatively impact biological communities and thereby reduce the Status of waterbodies. Accordingly, NRW has commissioned an extensive sampling programme of two key biological quality elements, diatoms and aquatic invertebrates (macroinvertebrates) using standard Water Framework Directive (WFD) Regulations tools.

## Rationale and methods

Biological monitoring is a useful tool in detecting environmental pressures and assessing ecological condition. Diatom (microscopic algae) and macroinvertebrate taxa are sensitive to changing environmental conditions and their respective assemblages (composition of species within a community or sample) align to reflect their environment. Biotic indices can be calculated from the species composition of samples at each site and used to infer nutrient pressures and ecological conditions. The Trophic Diatom Index is intended to measure diatom response to phosphorus concentrations. Macroinvertebrates are aquatic invertebrates and are sensitive to low dissolved oxygen concentrations that can result from organic pollution (typically from manures or from algal blooms), as well as related pressures such as siltation and ammonia. These tools should therefore provide a good picture of the biological impacts of any pollution.

This report presents the results of a recent catchment scale monitoring project conducted between Spring 2022 and Autumn 2023. Diatom samples were collected from 101 sites and macroinvertebrates from 43 sites. These were a mixture of existing NRW sampling points and new locations. Sampling was focussed on the Welsh part of the River Wye SAC, especially areas where poultry units are frequent and hence that were suspected to have received increased phosphorus loading (notably the Ithon and its tributaries), but other locations were also sampled. Relevant environmental quality indices were derived from the species composition at each sampling event.

Manures from all types of livestock farm, including poultry units, are spread to land for agricultural purposes either on or off the farm, or else transported elsewhere for processing (e.g. to anaerobic digester plants). Data on the amount and timing of manure spreading are lacking and therefore no assessment of the impact of manure spreading practice was possible.

The target for both the macroinvertebrate and the diatom tools across the River Wye SAC is High Status, reflecting the need for the best possible ecological conditions in protected sites.

## Results

These results should be considered indicative as not all spring / autumn samples were collected within the same calendar year following the method set out in UKTAG (2014). Most diatom and invertebrate samples corresponded to Good or High Status under the WFD Regulations (Table ES1). Approximately 47% of diatom samples met the SAC target of High Status, compared with only 7% of invertebrate sites. For sites that did not achieve High Status, the majority were classified as Good, indicating that relatively modest ecological improvements would likely be sufficient to reach the High Status threshold.

As the seasonal samples are combined to derive an overall classification, and, for invertebrates, two metrics are integrated, the majority of sites were ultimately assigned Good Status. Sites failing to achieve Good Status generally aligned with river reaches previously identified as not meeting phosphorus targets for the River Wye SAC (in Wales).

The two metrics that are calculated for invertebrates are:

- NTAXA, the total number of different macroinvertebrate taxa found in a sample. A higher NTAXA generally indicates a more diverse and healthier freshwater habitat. Conversely a low NTAXA may suggest pollution, habitat degradation or poor water quality; and
- ASPT, Average Score Per Taxon, the average pollution-tolerance score of all taxa present in the sample. A high ASPT means the assemblage is dominated by pollution-sensitive taxa, whilst a low ASPT suggests taxa are pollution-tolerant, indicating stress or degradation.

The two invertebrate metrics showed contrasting results: the NTAXA metric achieved High Status at 81% of sites, while the ASPT metric achieved High Status at only 9% of sites, with most (84%) classified as Good (Table ES1). These patterns were consistent across the full range of sites, including both those with likely high agricultural pressures and those where such pressures were expected to be low.

| Metric                | High status (target) | Good status | Moderate status | Poor status | Bad status |
|-----------------------|----------------------|-------------|-----------------|-------------|------------|
| Diatoms (samples)     | 95 (47%)             | 92 (46%)    | 12 (6%)         | 3 (1%)      | 0          |
| Invertebrates – NTAXA | 35 (81%)             | 5 (13%)     | 2 (5%)          | 1 (3%)      | 0          |
| Invertebrates – ASPT  | 4 (9%)               | 36 (84%)    | 3 (7%)          | 0           | 0          |

| Metric                                    | High status (target) | Good status | Moderate status | Poor status | Bad status |
|---|----------------------|-------------|-----------------|-------------|------------|
| Invertebrates – site overall status class | 3 (7%)               | 34 (79%)    | 5 (12%)         | 1 (2%)      | 0          |

Table ES1. Number of samples and sites reaching different levels of environmental quality.

The SAC target of High Status has been achieved at many sampling locations in previous years, but further comparative analysis is needed to interpret the current patterns in the context of local pressures, climatic conditions, and updates to classification tools.

Six sites did not achieve a classification above Moderate Status based on invertebrate metrics. These included two on the River Wye and one each on the Hindwell Brook, Irfon, Bachawy Brook, and Camnant Brook.

Sites failing to reach Good Status based on diatom metrics were located on the Afon Llynfi, Camnant Brook, Gwenlas Brook, the Arrow, Ithon, Nantmel Dulas, Bach Howey Brook, Camddwr Brook, Gladestry Brook and Gwenlas Brook.

Diatom metrics at some sites indicated potential influences of non-nutrient pressures that may affect classification regardless of nutrient conditions. Assemblages were frequently dominated by *Achnanthes minutissimum* “type”, consistent with previous investigations in the region. Although this taxon can be associated with anthropogenic or metal-related impacts, its dominance may also reflect hydrological variability. To strengthen interpretation of biotic metrics and clarify the drivers of assemblage patterns, further analysis of spatio-temporal relationships and physico-chemical variability is recommended.

Ecological classifications derived from invertebrate indices generally aligned with diatom-based classifications, except for a single location on the Hindwell Brook, which received a Poor status class.

## Conclusions

There is evidence of widespread failure to meet the SAC target of High Status across the River Wye (Wales) for both diatom and invertebrate indicators. These results suggest slight nutrient stress: although High Status was not achieved at most sites, the overwhelming majority remained at Good Status rather than Moderate, Poor, or Bad, which would be expected under more severe nutrient impacts.

Spatial variability in results was low, indicating that pressures are likely acting at a catchment scale rather than being driven by isolated poor practice. However, interpretation is complicated by unusually low flows resulting from the extremely dry spring and early summer of 2022, followed by another dry spring and summer in 2023. Low flows can mimic or exacerbate ecological effects associated with high nutrient concentrations. Many upper Wye reaches also lack riparian shade, increasing vulnerability to elevated temperatures and algal proliferation under low-flow conditions.

Although sampling aimed to follow WFD Regulations-compliant methods (UKTAG, 2014), the results presented here do not constitute WFD Regulations classifications or formal SAC condition assessments. NRW will integrate these data with other evidence sources when reporting WFD Regulations classification, protected site condition and assessing trends over time.

# Introduction

## Context

The River Wye is the largest Welsh Special Area of Conservation (SAC) river. Concerns around eutrophication of the River Wye have been raised, particularly in regard to phytoplankton blooms in spring 2020 and 2021, as well as some qualitative evidence of poor river conditions in the middle / upper river, especially in the Ithon tributary (Hatton-Ellis and Jones 2021). Widespread failures to achieve phosphorus targets for the SAC were reported in 2021: Rivers Irfon, Ithon, and Llynfi, with the greatest failures at the River Wye near Newbridge, the Cammarch, Clettwr Brook, Mithil Brook, lower Irfon, and Garth Dulas (Hatton-Ellis and Jones 2021).

The latest phosphorus compliance assessment in 2024 showed that 19 out of 45 water bodies in the River Wye SAC met the targets. This included six water bodies that improved from 2021 from fail to pass (Duhonw; Irfon - conf Cledan to conf R Wye; Wye - conf Walford Bk to Bigsweir Br; Wye - conf R Irfon to Scithwen Bk; Afon Cammarch; Afon Garth Dulas), 12 that passed previously, and one not previously assessed. Out of the 26 water bodies that failed to meet targets, one of these was carried forward from the previous assessment due to a lack of data in 2024 (Afon Gwesyn). 23 also failed previously, but two are newly failing after having passed in the last assessment (Clywedog Brook and the River Ithon), and one water body was assessed for the first time in 2024 and failed. (Natural Resources Wales, 2024).

## Purpose

As elevated phosphorus concentrations has been identified in the River Wye and its tributaries, it is important to understand the resulting ecological impacts. To address this gap in evidence, an extensive ecological surveillance program has been commissioned. This monitoring provides a snapshot in time of the ecological condition at various points along the River Wye and its tributaries in Wales and highlight areas most at risk of ecological degradation.

## Rationale

Biotic communities respond to changes in the environment and are useful in providing information on average environmental conditions (this may depend on the duration of their lifecycle) or indicating alterations to ecological quality or ecosystem function. Diatoms are microscopic algae, ubiquitous in freshwaters, that are used as indicators of nutrient status (Kelly *et al.* 2007).

Macroinvertebrates are the aquatic invertebrates that can be easily seen with the naked eye: they are primarily used as indicators of organic enrichment (i.e. pollution from manures and sewage) (Davy-Bowker *et al.* 2008) but data from invertebrates can also be used to detect a wide range of pressures including acidification (Davy-Bowker *et al.* 2005; Ormerod *et al.* 2006) and pesticides (Liess and Von der Ohe 2005).

Here, samples of phytobenthic (diatom) and macroinvertebrate communities were obtained from habitats within the river channel. Indices derived from these biotic communities can inform our understanding of general water quality conditions, identify nutrient pressures (risk of eutrophication), and thus the ecological condition of the Upper Wye catchment. The SAC target for both diatoms and invertebrates is High Status, reflecting Common Standards Monitoring guidance (JNCC 2016).

## Methods

### Survey area

Biological monitoring was carried out between spring 2022 and autumn 2023 across the Upper Wye catchment in Wales (Figure 1). Diatom and macroinvertebrate sampling was conducted in line with Natural Resources Wales’ operational instructions 27\_07 and 018\_08 respectively. In total, 202 diatom samples (biofilms forming on the surface of cobbles) were collected at 101 sites, and 86 macroinvertebrate samples (three-minute kick sample and one minute manual search) were collected at 43 sites. Data on reference variables (flow, shading, distance from source, gradient, substrate etc) were also collected in the field or using relevant map-based data in accordance with NRW operational instructions (Natural Resources Wales 2020a).

The programme of sampling was designed to cover a wide range of ecological conditions, including those thought to be either unimpacted or impacted based on existing water quality data (Hatton-Ellis and Jones 2021; Foster *et al.* 2023). There was a particular focus on the Ithon sub-catchment, reflecting the large number of Poultry Units and more intensive land use there (Table 1; Figs 1 and 2). Samples have also been collected from tributaries elsewhere in the catchment that are expected to be largely unimpacted.

| Catchment            | No of sample sites |
|----------------------|--------------------|
| Arrow Lugg and Frome | 8                  |
| Irfon                | 14                 |
| Ithon                | 45                 |
| Wye - Ithon to Hay   | 23                 |
| Wye Source to Ithon  | 11                 |

Table 1. Sampling effort per operational catchments.

Surveys were conducted by the Wye and Usk Foundation, supported by Stantec staff on the following dates:

- Spring 2022 – 14 to 31 May
- Autumn 2022 – 21 October to 8 November
- Spring 2023 – 11 to 25 May
- Autumn 2023 – 5 to 26 September

Survey sites are presented in terms of their operational catchment. A breakdown of sampling effort and river membership to catchments is given in Appendix A.

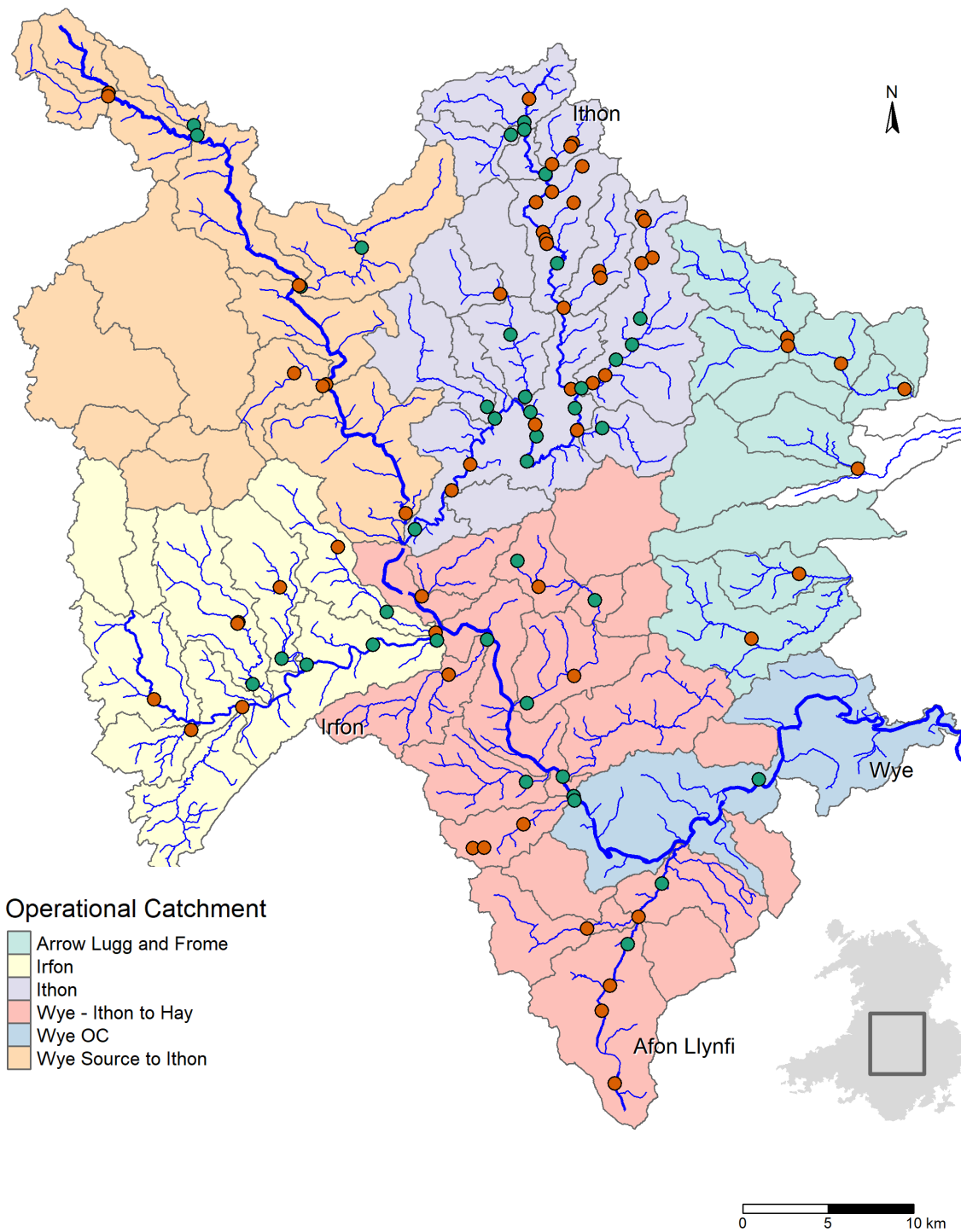


Figure 1. Survey locations in the Wye catchment, mid Wales. All sites represent a diatom sample, green points represent sites where macroinvertebrates were also monitored. Map data were sourced from National Resources Wales ([datamap.gov.wales](http://datamap.gov.wales)) and Ordnance Survey ([ordnancesurvey.co.uk/products/os-open-rivers](http://ordnancesurvey.co.uk/products/os-open-rivers)).

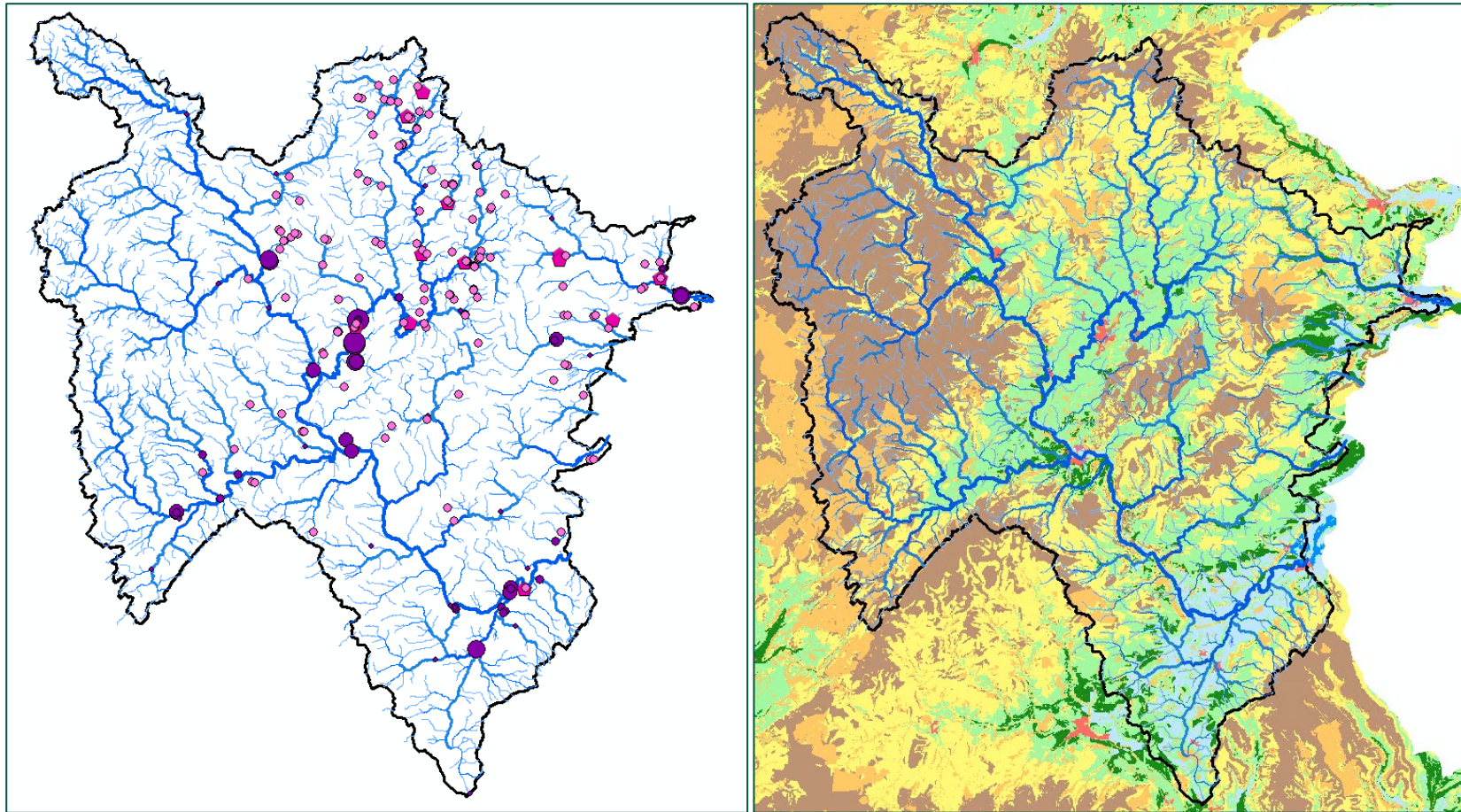


Figure 2. Nutrient sources and Land Use in the study area. Left Panel: Nutrient Sources. Purple circles: Welsh Water sewage discharges, the size of the circle proportional to volume discharged. Pink circles, Poultry Units < 40K birds; pink pentagons, Poultry Units > 40K birds. Right Panel: Land Use from [Welsh Government Predictive Agricultural Land Class Map](#). Brown: Agricultural Land Grade 5; Yellow: Grade 4; Light Green: Grade 3b; Dark Green: Grade 3a; Light Blue: Grade 2; Dark Blue: Grade 1; Orange: Non agricultural; Red: Urban.

## Diatom processing and analysis

Sample preparation and analysis for freshwater benthic diatom samples were undertaken by APEM Ltd following standard methods compliant with BS EN 13946:2014 (Natural Resources Wales 2020a). For calculation of Trophic Diatom Index (TDI) (count of at least 300 diatoms on a slide with identification to species level), compliant with BS EN 14407:2014 (Natural Resources Wales 2020b). The current version of TDI used for WFD Regulations and SAC classification is TDI5 (further references to TDI are all TDI5).

Enumeration of diatom samples was conducted on high power compound microscopes using a 1000X oil immersion lens and phase contrast illumination. Taxonomy was aligned with the check list of DARLEQ3 taxa and only undamaged valves were enumerated. Wherever possible valves are identified to species and variety, and all taxa that contribute  $\geq 2\%$  of the total count were identified to species or variety using external experts so that no more than 5% of the total count would be composed of taxa identified to less than species or variety.

The Trophic Diatom Index (TDI) is a measure of the eutrophication potential at a site. The metric was derived from species responses to nutrient gradients, particularly phosphorus, and is used to define Status by comparing observed scores to those expected at a site. TDI scores were calculated using the [DARLEQ3 \(Diatom Assessment of River and Lake Ecological Quality\) tool](#).

Waters of different alkalinities naturally have different diatom assemblages, with higher alkalinities having naturally higher TDI scores. DARLEQ requires alkalinity values for each sample point to convert TDI scores to environmental quality ratios (EQRs) and hence assign a WFD Regulations status (Table 2). Alkalinity values were assigned using existing NRW water quality data from the nearest available sample point. For the Wye SAC, the target for TDI is High Status (NRW 2023).

| EQR value boundaries | Ecological status classification |
|----------------------|----------------------------------|
| $\geq 0.80$          | High                             |
| $\geq 0.60$          | Good                             |
| $\geq 0.40$          | Moderate                         |
| $\geq 0.20$          | Poor                             |
| $< 0.20$             | Bad                              |

Table 2. Trophic diatom index (TDI) EQR status class boundaries

## Invertebrate processing and analysis

Macroinvertebrate sample analysis was carried out by APEM Ltd following standard NRW procedures including a stringent Analytical Quality Control (AQC) system covering both sample sorting and identification of freshwater macroinvertebrates to family and species level (Natural Resources Wales 2020c, d). Biotic indices were derived from assemblage data using RICT (River Invertebrate Classification Tool) (WFD UKTAG, 2014) and EQRs

derived by comparison with predicted reference conditions provided by RIVPACS (River Invertebrate Prediction and Classification System) model (FBA, 2000)

The Whalley, Hawkes, Paisley and Trigg (WHPT) metric (UKTAG, 2014) is based on the tolerance of different macroinvertebrates to organic pollution. Each macroinvertebrate family is assigned a score from -1.6 to 13, depending on their tolerance to pollution and abundance category (on a continuous scale, -1.6 is for highly abundant pollution-tolerant taxa, 13 is for highly abundant pollution-intolerant taxa) and an overall score is produced from the total. The WHPT index is commonly used to establish the ecological water quality of running waters and specifically the detection of organic pollution. As such, any extrapolation of other water quality pressures should be undertaken with caution (Paisley *et al.*, 2014).

WHPT can be expressed as a standalone score (the sum of values for each taxon in a sample), as the number of scoring taxa (NTAXA) and as an average score per taxon (ASPT). This metric is more easily comparable with other sites and permits an assessment of biological water quality that is less influenced by the presence of a greater proportion of low scoring taxa or sampling effort than the overall WHPT score. Higher NTAXA and ASPT scores indicate better ecological quality.

The River Invertebrate Classification Tool v.2 (RICT2) (WFD UKTAG, 2014; Davy-Bowker *et al.*, 2007) was used to determine the ecological condition of each sample site based on a comparison between the WHPT index scores for the aquatic macroinvertebrate communities observed at each study site with those of aquatic macroinvertebrate communities observed at reference sites. Reference sites are deemed to be as close as possible to pristine conditions and not impacted by environmental stressors such as pollution or habitat modification. Suitable reference sites are determined by the tool using the environmental descriptors.

The observed aquatic macroinvertebrate community score at each study site was divided by the expected community score. Reference and bias adjustments are then applied to obtain the Ecological Quality Ratio (EQR) which can be compared against WFD Regulations-related quality class boundaries (Table 3).

| <b>EQR value boundaries<br/>WHPT NTAXA</b> | <b>EQR value boundaries<br/>WHPT ASPT</b> | <b>Classification</b> |
|--|---|-----------------------|
| > 0.80                                     | > 0.97                                    | <b>High</b>           |
| ≥ 0.68                                     | ≥ 0.86                                    | <b>Good</b>           |
| ≥ 0.56                                     | ≥ 0.72                                    | <b>Moderate</b>       |
| ≥ 0.47                                     | ≥ 0.53                                    | <b>Poor</b>           |
| < 0.47                                     | < 0.53                                    | <b>Bad</b>            |

Table 3. Whalley Hawks, Paisley and Trigg (WHPT) Environmental Quality Ratio (EQR) value classification boundaries.

## Limitations

Monitoring was initially intended to consist of samples collected in consecutive seasons within the same calendar year. However, land access and weather restrictions resulted in 2 of the 101 diatom sites being sampled in autumn 2022 and spring 2023. The remaining diatom sites were collected in consecutive seasons within the same calendar year, 60 sites were sampled in 2022 and 39 in 2023.

Similarly, a total of 86 macroinvertebrate samples were collected at 43 sites. Of these, 4 locations were sampled in consecutive seasons in 2022, and 12 in 2023, meeting the criteria of consecutive seasons within the same calendar year. While 27 were sampled in autumn 2022 and spring 2023.

Sites, where the spring and autumn samples were not taken in the same calendar year, will not be used for WFD Regulations classification.

## Results

A full list of biotic metrics is provided in Appendix B.

Across all invertebrate monitoring locations, most sites were classified as Good (34 samples). Fewer sites fell into the High (3 sites), Moderate (5 sites), or Poor (1 site) classes.

The single Poor status reach was recorded on the Hindwell Brook, outside the SAC boundary. At this site, diatom metrics indicated High and Good Status in spring and autumn, respectively. The low invertebrate classification appears to be driven by a low number of scoring taxa (NTAXA). Despite this, the Average Score Per Taxon (ASPT) was relatively high, indicating that although few taxa were present, those that were recorded tended to be pollution-sensitive and therefore “high scoring.”

The number of sites where the calculated EQR for invertebrates and diatoms fell below the Good status boundary is shown in Figure 2. Invertebrate classifications fell below Good at two sites on the River Wye, and at one site each on the Hindwell Brook, Irfon, Bach Howey Brook, and Camnant Brook.

Diatom indices are presented seasonally. Only three samples were classified as Poor, all collected in autumn. The number of samples classed as Moderate (13), Good (95), and High (91) was broadly similar between seasons. Of the samples assigned Moderate or Poor Status, six were from the Afon Llynfi, and two samples each were from Camnant Brook and Gwenlas Brook. The remaining samples below Good Status were distributed across the Arrow, Ithon, Nantmel Dulas, Bach Howey Brook, Camddwr Brook, Gladestry Brook, and Gwenlas Brook (Figure 3).

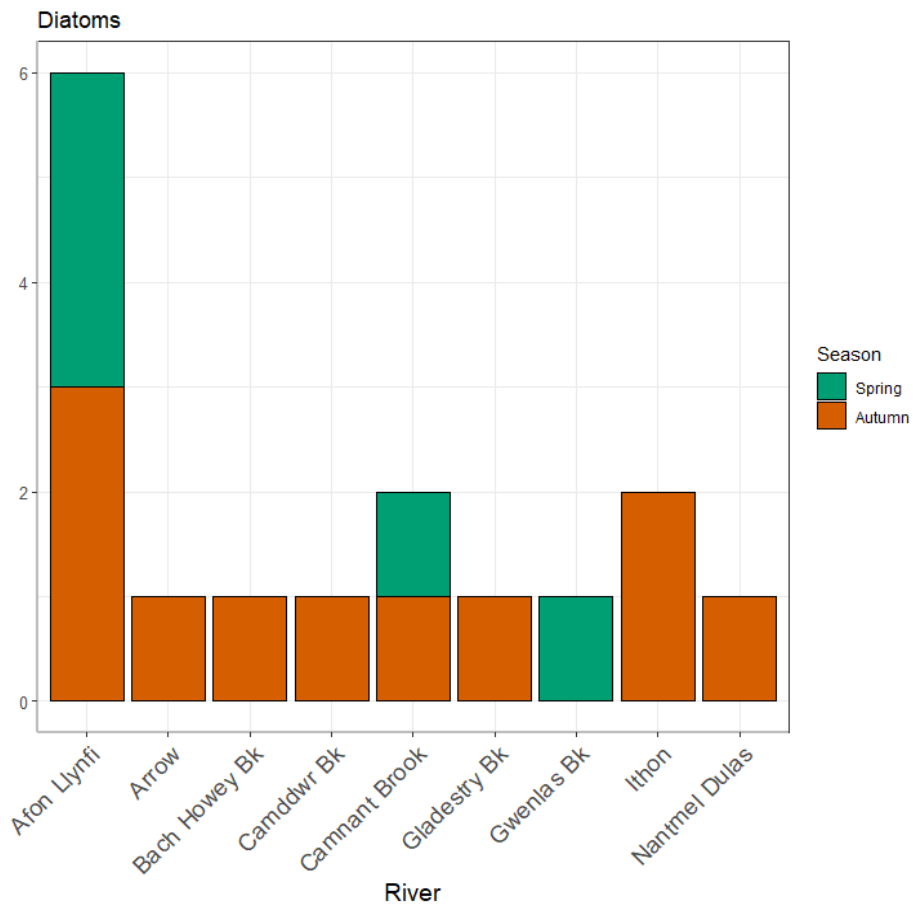
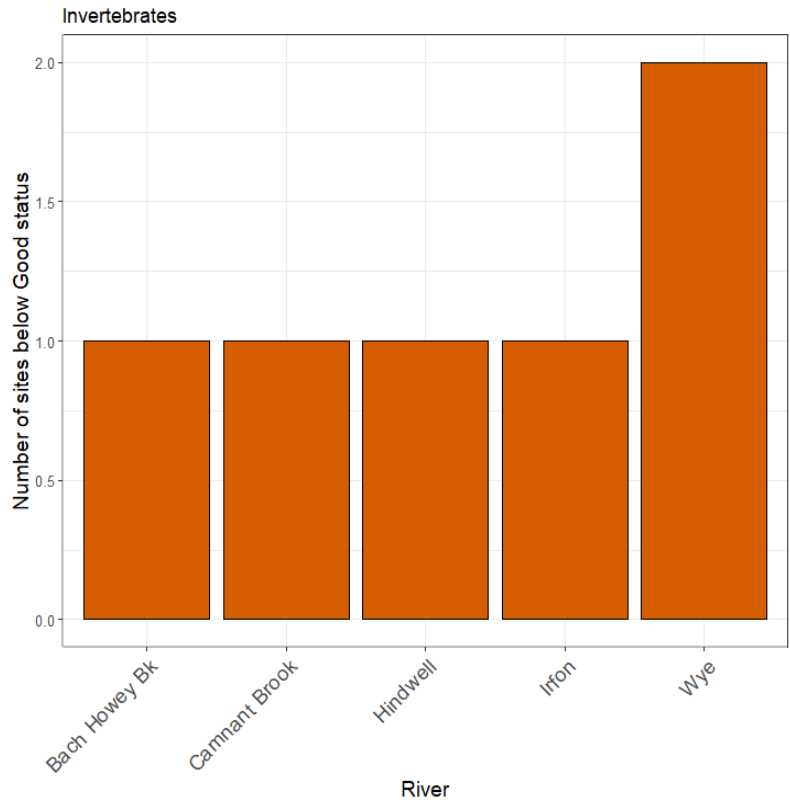


Figure 3. Counts of monitoring locations with EQRs classed as worse than “Good” status for Invertebrate (multi-season) classifications (top) and Diatom classifications (bottom).

## Diatom index results

The distribution of Trophic Diatom Index (TDI) ecological quality ratios (EQRs) and percentage of motile taxa is presented for samples by Operational Catchment and season in Figure 4. The proportion of motile taxa is useful in the interpretation of TDI scores, as motile taxa have a competitive advantage in the presence of non-nutrient pressures such as sedimentation. The variability in scores is illustrated by the height of the box plot for that reach; a large variation in scores, or potential outliers as denoted by points, may indicate nutrient (top panel) or non-nutrient (bottom panel) pressures within that reach.

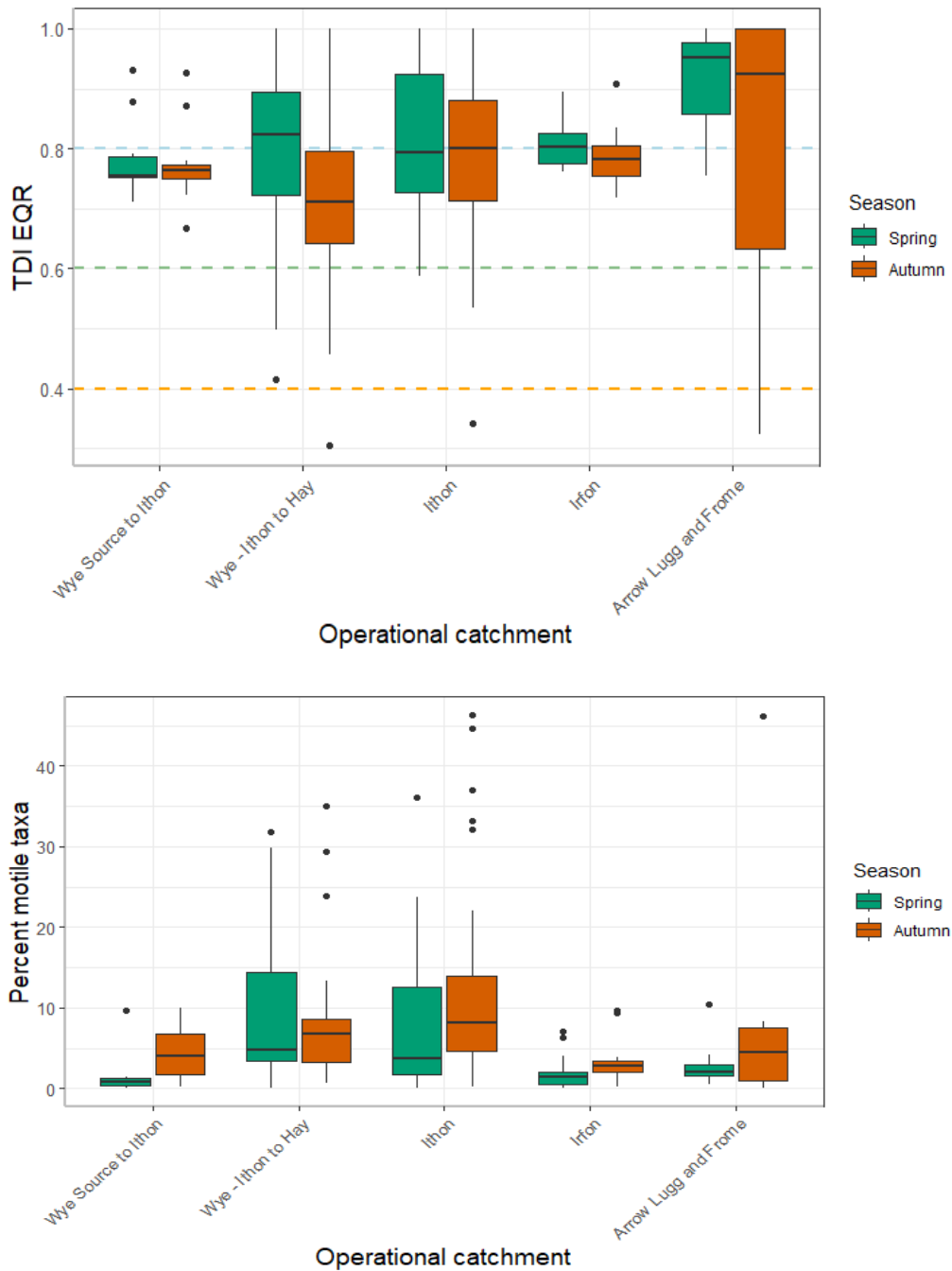


Figure 4. Seasonal and spatial distribution of Trophic Diatom Index (top) and the proportion of motile taxa (bottom). Boxplots are useful for visualising the range of values within groups; the

interquartile range (coloured boxes), the median (horizontal a line), and potential outliers (points beyond the vertical lines, or whiskers).

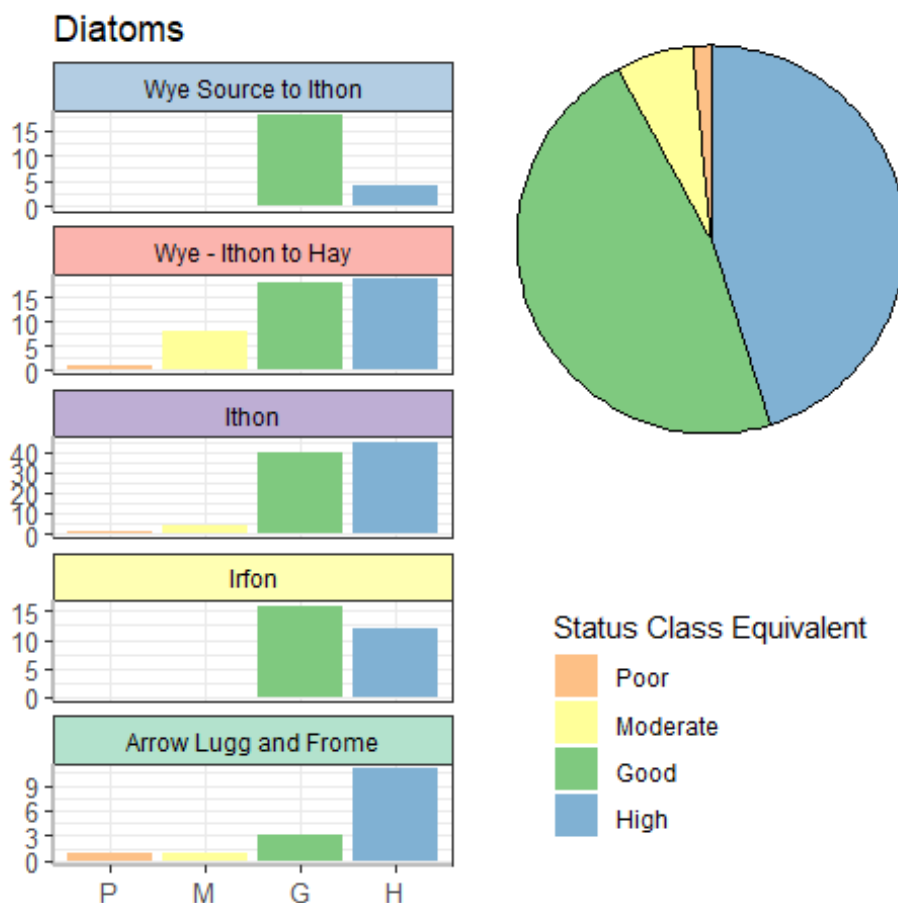


Figure 5. Number of samples within each status class for each operational catchment and summary of equivalent status class records across the survey area.

TDI EQRs fall below the status boundary for Good classification in the “Wye - Ithon to Hay”, “Ithon”, and “Arrow Lugg and Frome” operational catchments. These operational catchments exhibit a large variability in TDI EQRs; low scoring samples are outliers. The median TDI EQR is at, or just below, the High status class boundary for all operational catchments except for “Arrow Lugg and Frome” where most samples are consistently above this status class boundary. Scores are lower in autumn than in spring across all operational catchments. The proportion of motile taxa is higher in samples collected from the Ithon and Wye (Ithon to Hay) operational catchments.

The distribution of diatom samples and their equivalent status classification is illustrated the Spring sampling season in Figure 6, and for the Autumn sampling season in Figure 7.

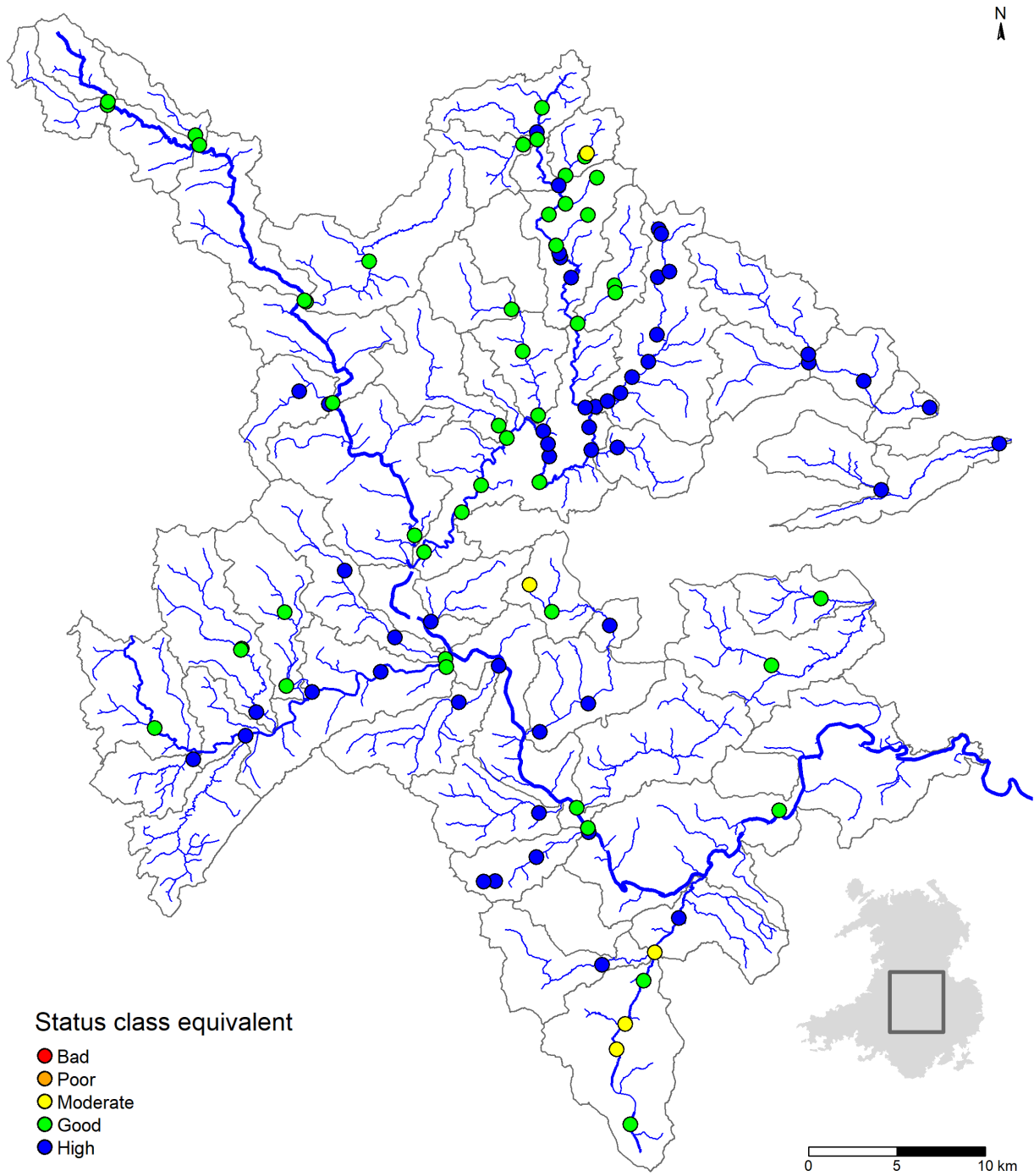


Figure 6. Spring Diatom equivalent status classes.

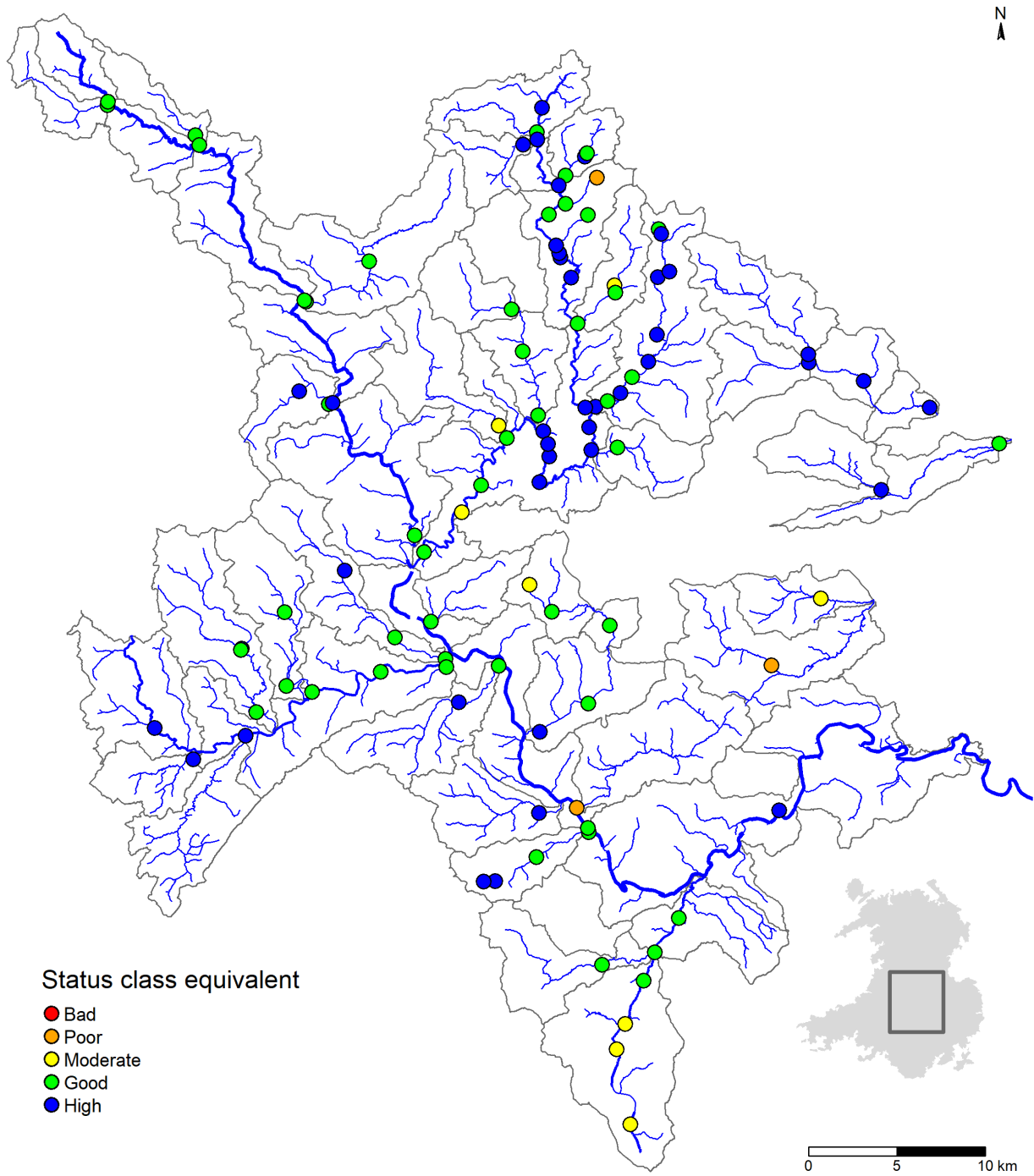


Figure 7. Autumn Diatom sites coloured by status class.

## Interpretation of the Trophic Diatom Index

When interpreting the Trophic Diatom Index, the proportion of motile and or organic tolerant taxa should be considered, as these metrics capture assemblage characteristics that can also be driven by non-nutrient pressures. We can be more confident in asserting that sites with a lower proportion of motile taxa, or are not vastly different from nearby sites, are indicative of a nutrient pressure (Figure 8).

It must be noted that the proportion of motile or organic tolerant species are not metrics for specific pressures (though are often used to broadly highlight the potential for sedimentation and organic pollution pressures); Instead, these measures highlight uncertainty in interpretation of TDI scores (Kelly *et al.* 2001)

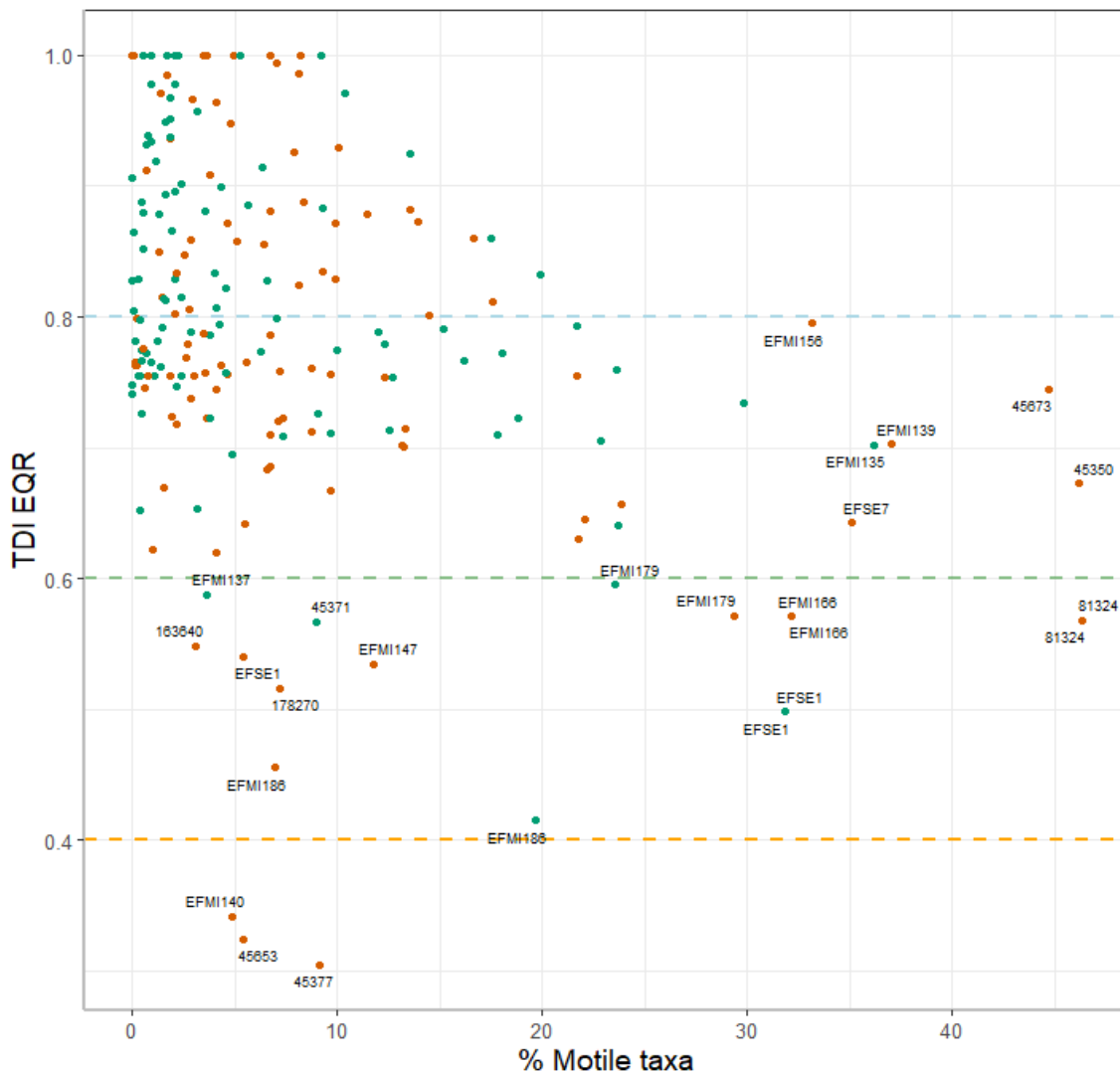


Figure 8. Spring (green) and autumn (orange) Trophic Diatom Index (TDI) Ecological Quality Ratios (EQRs) in relation to the proportion of motile taxa. Labeled sites are those that fall below Good status class or contain a proportion of motile taxa greater than 30% (this is typically below 10% for most samples; 20% deviation from nearby sites is considered meaningful.)

This interpretation requires consideration of the spatial relationship between sites (proximity, watercourse, additional inputs). In this section samples located along the main river of the operational catchment will be presented (upstream to downstream) with TDI, dominant taxa and the proportion of motile taxa to identify points of interest. The percentage of organic tolerant taxa values were not discussed in detail in this report.

## River Wye (main stem)

The River Wye reflects a High Status class between the Afon Marteg and the Afon Elan, and at Hay on Wye in autumn. All other sites along the course of the River Wye are indicative of a Good Status classification (Figure 6 and Figure 7) though are close to the High status class boundary (Figure 9). The dominant diatom taxon throughout is *Achnanthis minutissimum*, which represents more than 70% of the species composition above the Afon Bidno and regularly more than 50% of spring assemblages throughout the river Wye. In Autumn this dominance is reduced as *Fragilaria capucina*, *Cocconeis placentula* and *Tabellaria flocculosa* become more important at various points along the Wye in autumn.

The Lowest TDI score was located upstream of the Marteg Confluence in autumn where the relative abundance of *Diadesmis perpusilla* increases (Figure 9). Motile taxa are only elevated at Llanstephan Court Bridge to The Warren, and Hay-on-Wye in spring (Table 4). When comparing spring and autumn EQRs, the increase in the proportion of motile taxa does not impact the status class equivalent at Llanstephan Court Bridge to The Warren, while the increase in motile taxa at Hay-on-Wye in spring corresponds with a fall in EQR to that reflecting Good status rather than High which was recorded in autumn.

The Edw, a tributary of the Wye below the Ithon to Hay, is worthy of note as Moderate Status class equivalent is recorded in the headwaters (upper Camnant Brook). This does not impact the spring diatom assemblage within the Edw, which reflect High Status, however High Status is not observed in autumn samples until near the Wye confluence.

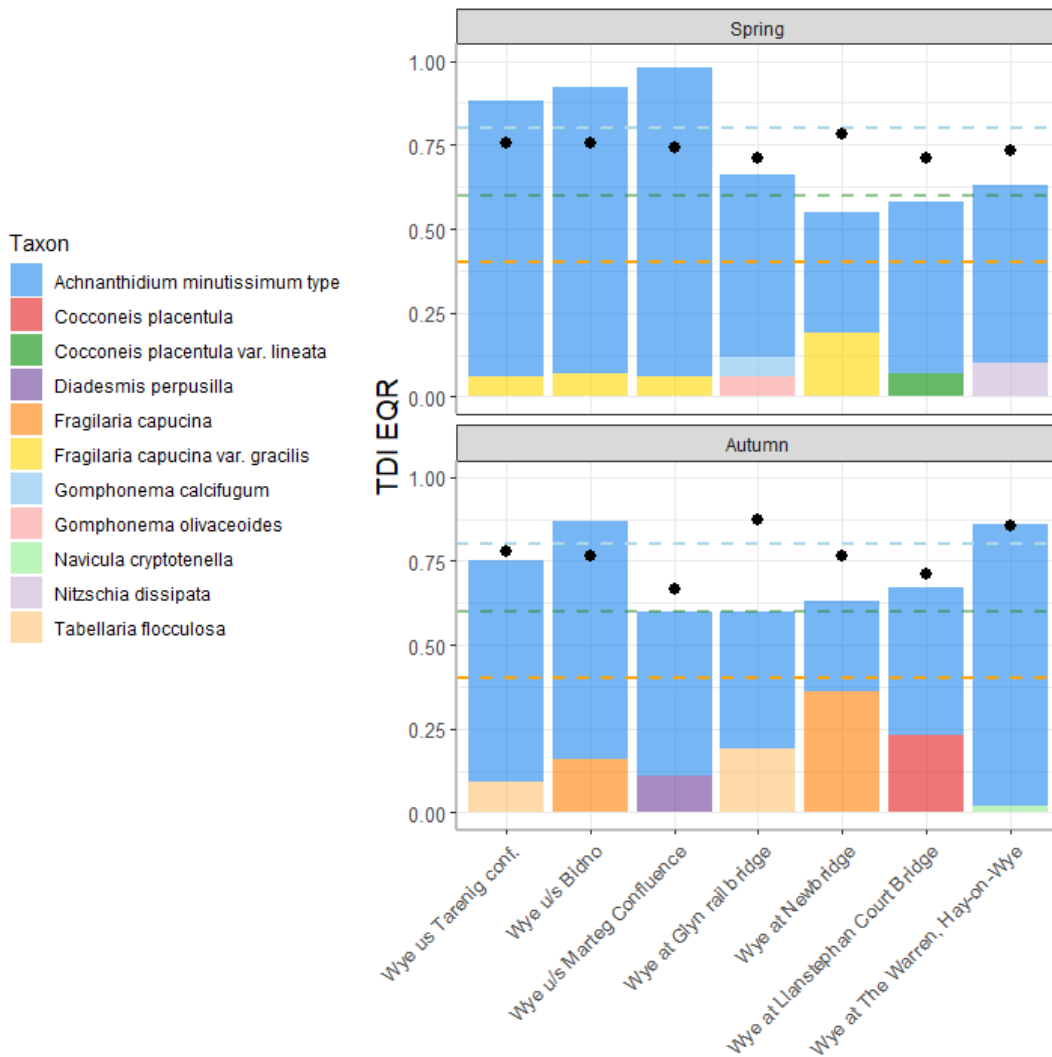


Figure 9. Downstream progression of Trophic Diatom Index scores and dominant taxa at sites on the River Wye.

| Site ID   | 45264                 | 170543        | 45263                     | 45636                   | 45261            | 45259                           | EFMI132                       |
|-----------|-----------------------|---------------|---------------------------|-------------------------|------------------|---------------------------------|-------------------------------|
| Site name | Wye u/s Tarenig conf. | Wye u/s Bidno | Wye u/s Marteg Confluence | Wye at Glyn rail bridge | Wye at Newbridge | Wye at Llanstephan Court Bridge | Wye at The Warren, Hay-on-Wye |
| Spring    | 1.08                  | 0.38          | 0.00                      | 9.66                    | 1.22             | 17.80                           | 29.85                         |
| Autumn    | 2.73                  | 0.15          | 9.67                      | 9.94                    | 4.36             | 6.74                            | 6.42                          |

Table 4. Downstream progression of %motile taxa at sites on the River Wye.

## Irfon

Diatom assemblages in the Irfon reflect Good and High Status with EQRs nearing the High Status class boundary in both spring and autumn (Figure 10), though many of the tributaries indicate Good Status (Figure 6 and Figure 7). In Autumn, this appears to influence the status class equivalent of the Irfon downstream with only a slight reduction in Trophic Diatom Index EQR values.

The diatom assemblages in the Irfon are again dominated by *Achnanthydium minutissimum* throughout. A feature of the headwaters is the high proportion of *Fragilaria capucina* (and vars); further downstream, these are replaced by *Reimeria sinuata*, *Encyonema minutum* and *Cocconeis placentula* (spring and autumn respectively; Figure 10). The proportion of motile taxa is low throughout this reach (Table 5).

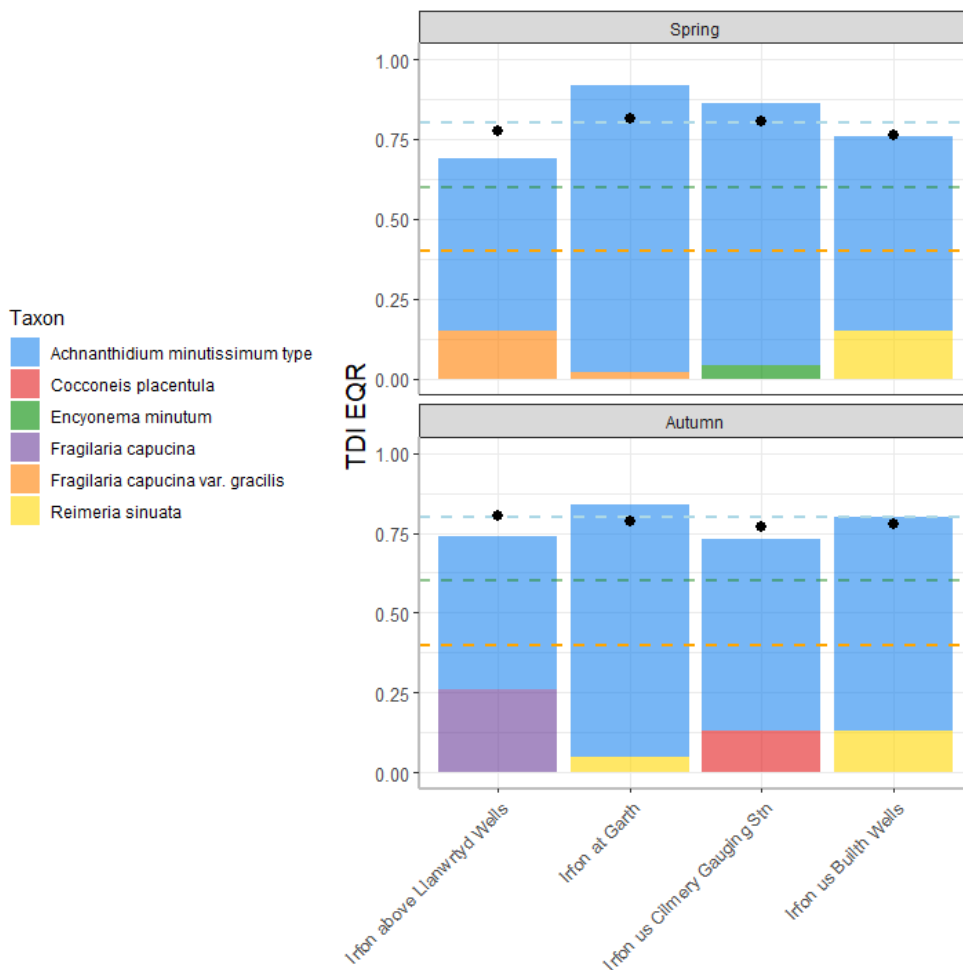


Figure 10. Downstream progression of Trophic Diatom Index scores and dominant taxa at sites on the River Irfon.

| Site ID   | EFMI167                     | 109794         | EFMI173                       | EFMI176                |
|-----------|-----------------------------|----------------|-------------------------------|------------------------|
| Site name | Irfon above Llanwrtyd Wells | Irfon at Garth | Irfon u/s Cilmery Gauging Stn | Irfon u/s Builth Wells |
| Spring    | 0.45                        | 1.62           | 4.08                          | 1.40                   |
| Autumn    | 2.06                        | 3.52           | 2.66                          | 0.51                   |

Table 5. Downstream progression of %motile taxa at sites on the River Irfon.

## Ithon (upper and lower)

The headwaters of the Ithon are indicative of Good Status class (Figure 6 and Figure 7), only one site (on the Gwenlas Brook) records a Moderate Status class in spring. Many sites in the upper reaches improved to reflect High Status in autumn. The Llymwynt Brook (Upper Ithon) however drops from reflecting Good in spring to Poor Status in autumn.

The Aran is a large tributary of the Ithon and diatom assemblages reflect High Status throughout spring. The Ithon downstream of this confluence also improves until the confluence with Clywedog Brook, where assemblages begin to reflect a Good Status classification. This is also true of autumn samples, though two sites towards the lower reaches of the Aran reflect Good Status at this time. A site on Nantmel Dulas, along with one site along the Ithon nearing the Wye confluence (which is below the Llandrindod Wells Water Treatment Works) falls to a Moderate Status class equivalent.

Like the Wye and Irfon, diatom assemblages are again dominated by *A. minutissimum*, other taxa rarely representing more than 10% relative abundance (Figure 11). In spring, these are *Gomphonema pumilum* which corresponds with an EQR below the High Status class boundary (downstream of the Camnant), *Amphora pediculus*, *Gomphonema calcifugum*, *Reimeria sinuata*, which also corresponds with a drop in status classification (Maes-y-Helm Bridge), and *Encyonema minutum*, which becomes more typical from Llanbister Bridge to Penybont.

In autumn, *A. minutissimum* remains dominant in all locations except for at Maes-y-Helm Bridge, where *R. sinuata* becomes very dominant (50% relative abundance), and at Llananno. The persistence of *R. sinuata* at Maes-y-Helm Bridge and its dominance in autumn may reflect a specific habitat at this location. Index scores remain High in the lower reach of the Ithon, only falling below the High Status class boundary below Lower Cellws to Pont a'r Ithon in autumn where *Cocconeis* spp. and *Rhoicosphenia abbreviata* becoming more important in these assemblages (Figure 12).

Motile taxa are elevated downstream at Penybont in spring, and upstream near the Camnant confluence and Upper Crochan in autumn (Table 6). Lower downstream the proportion of motile taxa is large at Mithil Brook confluence, Lower Cellws and Rock Park, and Llandrindod Wells in spring, but only at Pont a'r Ithon in autumn (Table 7).

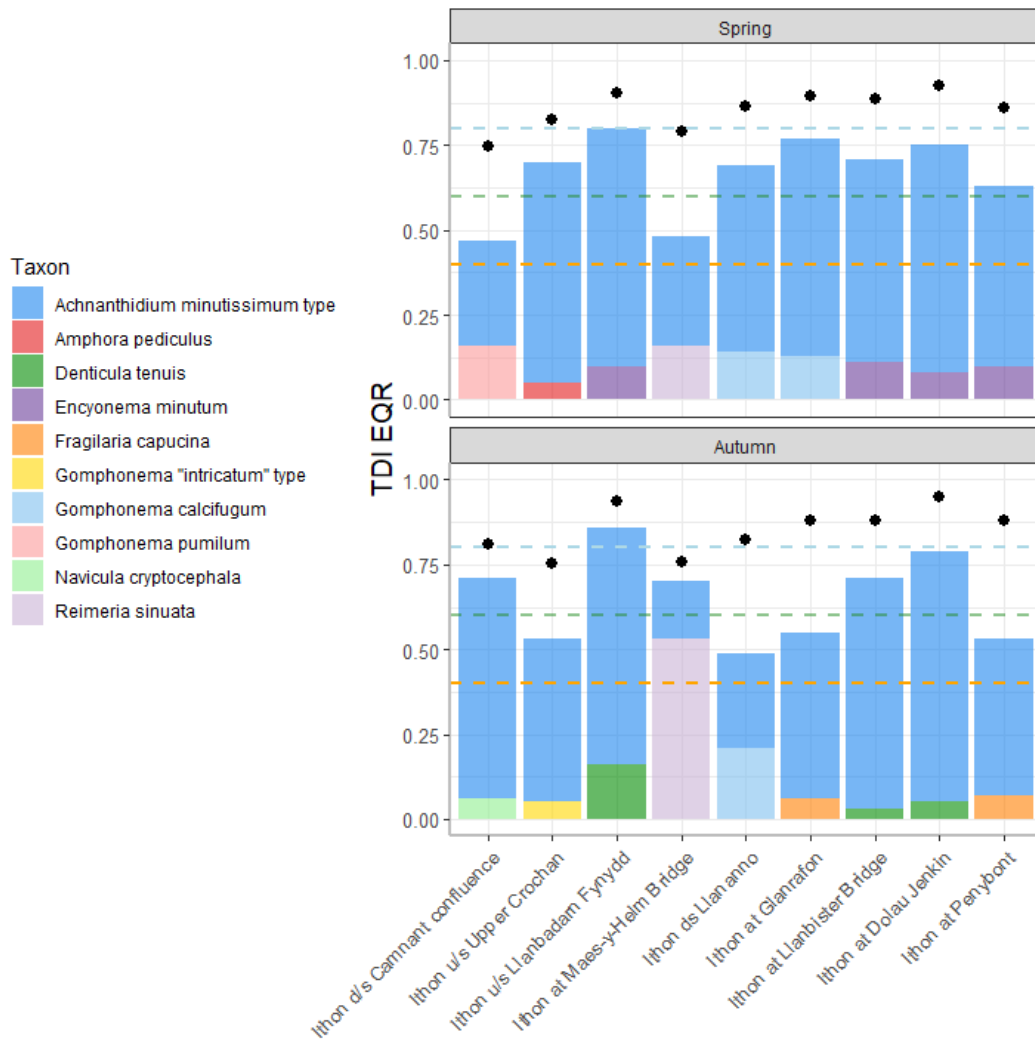


Figure 11. Downstream progression of Trophic Diatom Index scores and dominant taxa at sites on the upper River Ithon.

| Site ID   | EFMI 133                | EFM I134                | EFMI 136                    | EFMI 142                    | EFMI 145          | EFMI 146           | 170556                     | EFMI 149              | EFMI 159          |
|-----------|-------------------------|-------------------------|-----------------------------|-----------------------------|-------------------|--------------------|----------------------------|-----------------------|-------------------|
| Site name | Ithon d/s Camnant conf. | Ithon u/s Upper Crochan | Ithon u/s Llanbadarn Fynydd | Ithon at Maes-y-Helm Bridge | Ithon ds Llananno | Ithon at Glanrafon | Ithon at Llanbister Bridge | Ithon at Dolau Jenkin | Ithon at Penybont |
| Spring    | 2.15                    | 6.58                    | 2.37                        | 2.90                        | 1.94              | 2.12               | 5.63                       | 13.55                 | 17.51             |
| Autumn    | 17.60                   | 21.72                   | 1.86                        | 3.55                        | 8.14              | 13.53              | 6.72                       | 4.77                  | 11.47             |

Table 6. Downstream progression of %motile taxa at sites on the upper River Ithon.

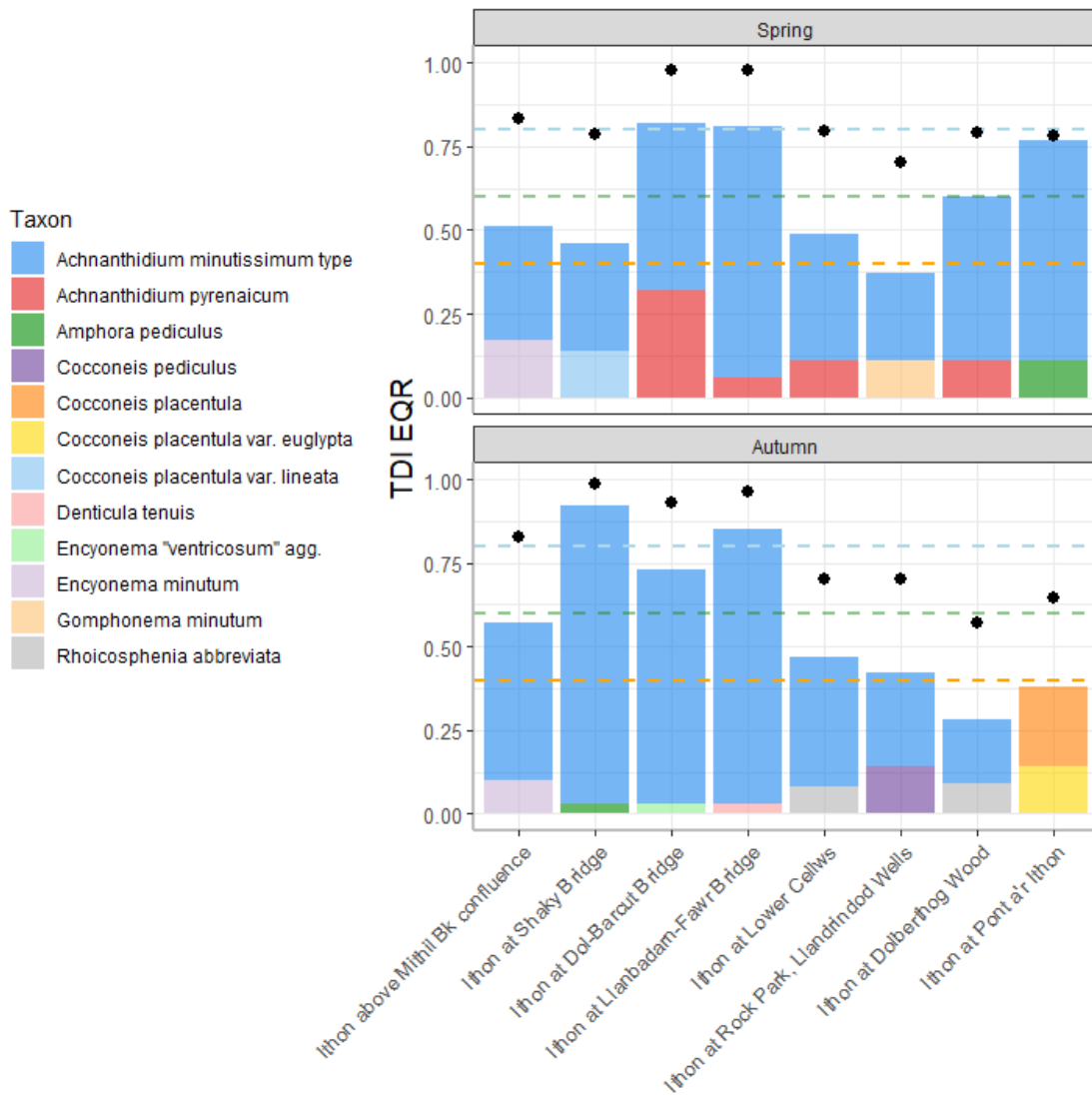


Figure 12. Downstream progression of Trophic Diatom Index scores and dominant taxa at sites on the lower River Ithon.

| Site ID   | 45391                            | EFMI160               | EFMI161                    | EFMI163                         | EFMI164               | EFMI165                               | EFMI166                  | 45388                   |
|-----------|----------------------------------|-----------------------|----------------------------|---------------------------------|-----------------------|---------------------------------------|--------------------------|-------------------------|
| Site name | Ithon above Mithil Bk confluence | Ithon at Shaky Bridge | Ithon at Dol-Barcut Bridge | Ithon at Llanbadarn-Fawr Bridge | Ithon at Lower Cellws | Ithon at Rock Park, Llandrindod Wells | Ithon at Dolberthog Wood | Ithon at Pont a'r Ithon |
| Spring    | 19.93                            | 3.79                  | 0.96                       | 2.11                            | 21.68                 | 22.88                                 | 11.97                    | 12.34                   |
| Autumn    | 9.90                             | 1.71                  | 10.07                      | 4.13                            | 13.24                 | 13.15                                 | 32.17                    | 22.06                   |

Table 7. Downstream progression of %motile taxa at sites on the lower River Ithon.

## Llynfi

The Llynfi has the highest nutrient concentrations in the Welsh part of the River Wye SAC (Hatton-Ellis and Jones 2021). It flows from Llangorse Lake which is considered eutrophic and is still recovering from past eutrophication (Hatton-Ellis 2016). Trophic Diatom Index (TDI) Ecological Quality Ratios (EQR) fall within the Good Status classifications boundary above the lake in spring, but drops to a Moderate Status class in autumn. Two sites just below the lake are consistently Moderate Status class during spring and autumn (Figure 6 and Figure 7). As the Llynfi approaches the confluence with the Wye, diatom index scores improve, indicating High Status in spring and Good Status in autumn.

The diatom assemblages in the Llynfi are quite different to that in the rest of the catchment. Here, *Achnantheidium minutissimum* does not appear as a major fraction of the assemblage until Pont Nichol, and not until Pontithel is this more than 20% relative abundance. Instead, the upper reaches of the Llynfi are characterised by *Amphora pediculus*, *Gomphonema intricatum*, *Cocconeis* spp. and *Navicula* spp.

*A. pediculus* appear as a feature of assemblages along this reach (~20% relative abundance) in both spring and autumn samples, only being replaced in spring by *Achnantheidium* spp. and *Gomphonema* spp. at two locations at the bottom of the reach: at Pont Nichol and Pontithel.

The proportion of motile taxa is elevated at Pont Hemley, Glandwr Bridge, and Pont Nichol in spring, and at Pontithel in autumn. The lowest TDI EQR is recorded at Pont Hemley in both seasons, though this tends to increase to at least reflect Good Status with distance downstream in both seasons.

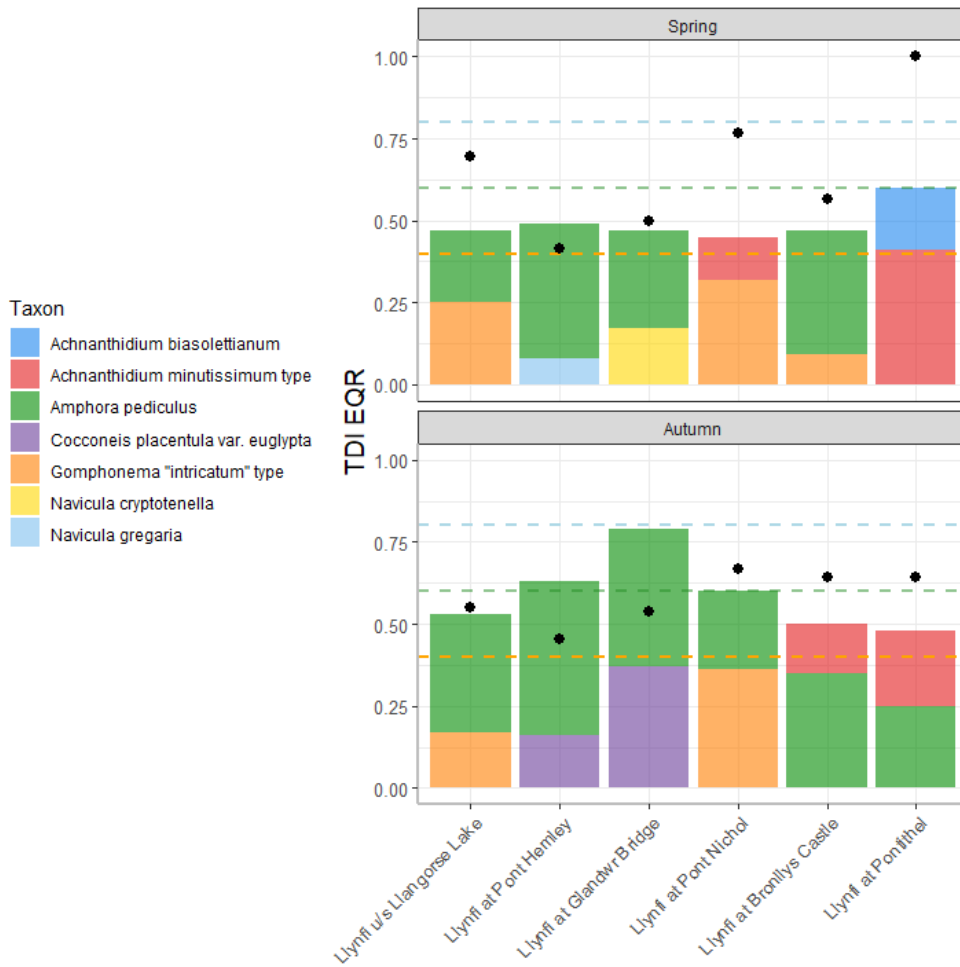


Figure 13. Downstream progression of Trophic Diatom Index scores and dominant taxa at sites on the River Llynfi.

| Site ID   | 163640                    | EFMI186               | EFSE1                    | EFSE2                 | 45371                     | EFSE7               |
|-----------|---------------------------|-----------------------|--------------------------|-----------------------|---------------------------|---------------------|
| Site name | Llynfi u/s Llangorse Lake | Llynfi at Pont Hemley | Llynfi at Glandwr Bridge | Llynfi at Pont Nichol | Llynfi at Bronllys Castle | Llynfi at Pontithel |
| Spring    | 4.85                      | 19.64                 | 31.82                    | 16.19                 | 8.96                      | 9.20                |
| Autumn    | 3.10                      | 6.94                  | 5.40                     | 1.57                  | 5.48                      | 35.09               |

Table 8. Downstream progression of %motile taxa at sites on the River Llynfi.

# Invertebrate indices

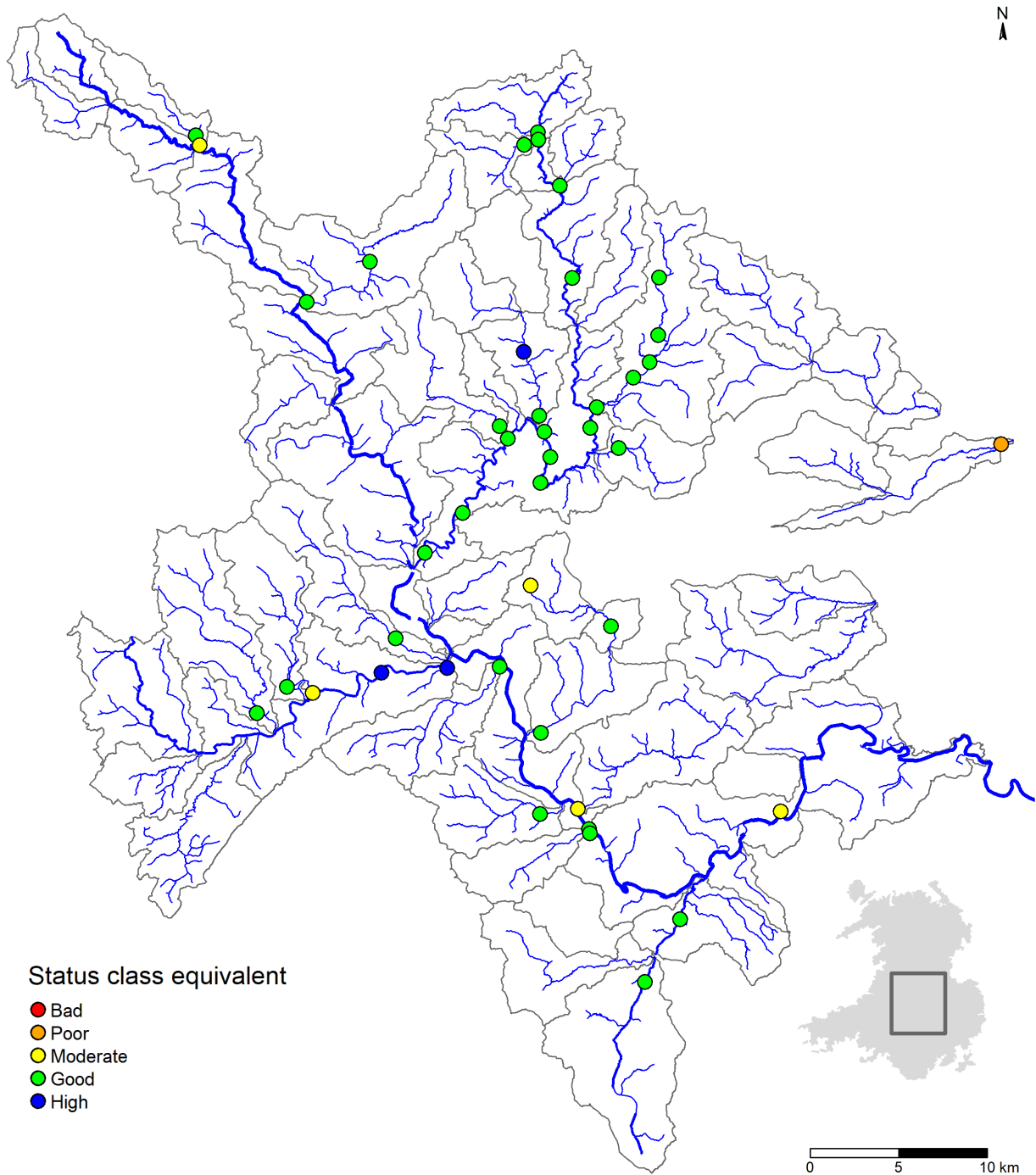


Figure 14. Macroinvertebrate sample sites coloured by equivalent status class.

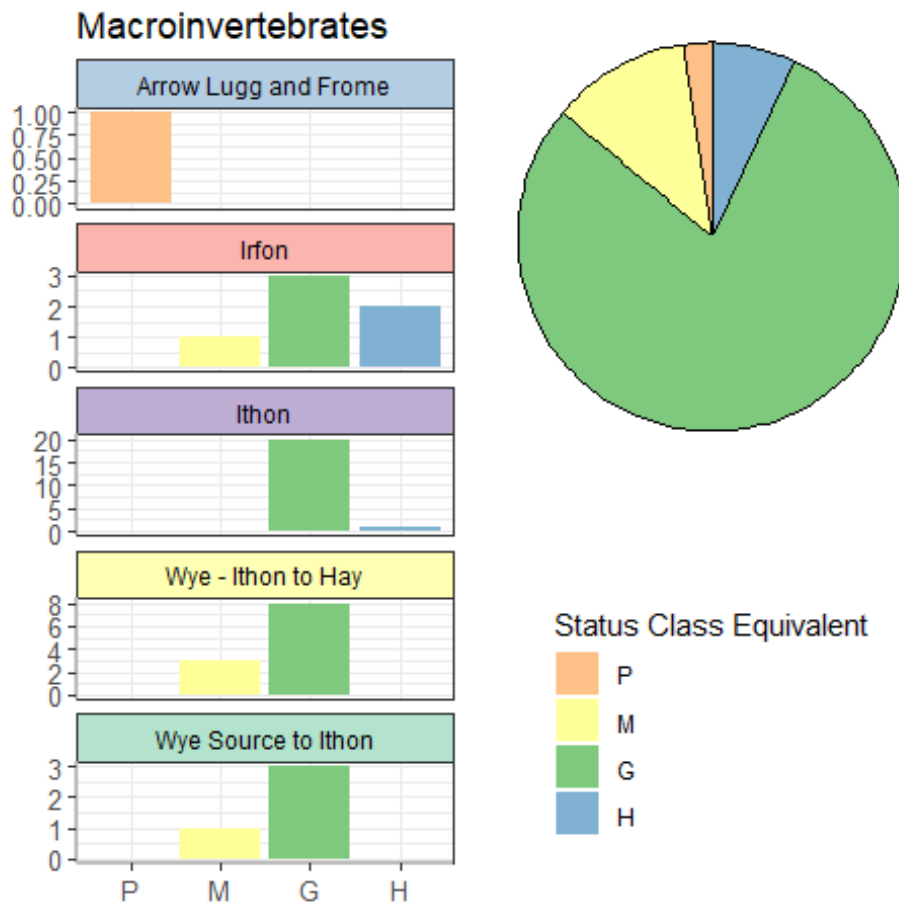


Figure 15. Number of macroinvertebrate sites within operational catchments by equivalent Status class – High (H); blue, Good (G); green, Moderate (M); yellow and Poor (P); orange.

## Interpretation of Whalley, Hawkes, Paisley and Trigg metric

Invertebrate samples were collected at 43 locations which are based within 6 WFD Regulations operational catchments, namely Arrow Lugg and Frome; Irfon; Ithon; Wye - Ithon to Hay; Wye Operational Catchment; and Wye Source to Ithon. The interpretation of the WHPT metric data calculated for each sample site is detailed in the following subsections using the NTAXA EQRs and ASPT EQRs to estimate WFD Regulations status classification boundaries (Table 3) for each site. A summary of the ecological conditions using classification status equivalents are calculated based on WHPT NTAXA EQR and WHPT ASPT EQR values for each site within the operational catchments assessed can be found in Table 9.

| Operational catchment | River            | Site ID | Classification status equivalent |
|-----------------------|------------------|---------|----------------------------------|
| Wye - Source to Ithon | Afon Bidno       | EFMI129 | Good                             |
| Wye - Source to Ithon | Afon Marteg      | EFMI130 | Good                             |
| Wye - Source to Ithon | Afon Marteg      | 45400   | Good                             |
| Wye - Source to Ithon | Wye              | 170543  | Moderate                         |
| Wye - Ithon to Hay    | Afon Llynfi      | EFSE2   | Good                             |
| Wye - Ithon to Hay    | Afon Llynfi      | EFSE7   | Good                             |
| Wye - Ithon to Hay    | Bach Howey Brook | 45377   | Moderate                         |
| Wye - Ithon to Hay    | Camnant Brook    | EFMI179 | Moderate                         |
| Wye - Ithon to Hay    | Clettwr Brook    | EFMI182 | Good                             |
| Wye - Ithon to Hay    | Duhonw           | EFMI178 | Good                             |
| Wye - Ithon to Hay    | Edw              | EFMI181 | Good                             |
| Wye - Ithon to Hay    | Edw              | EFSE26  | Good                             |
| Wye - Ithon to Hay    | Scithwen Brook   | 45376   | Good                             |
| Wye - Ithon to Hay    | Wye              | 45259   | Good                             |
| Wye - Ithon to Hay    | Wye              | EFMI132 | Moderate                         |
| Ithon                 | Aran             | EFMI153 | Good                             |
| Ithon                 | Aran             | EFMI154 | Good                             |
| Ithon                 | Aran             | EFMI155 | Good                             |
| Ithon                 | Aran             | EFMI156 | Good                             |
| Ithon                 | Aran             | 45396   | Good                             |
| Ithon                 | Clywedog Brook   | 45395   | Good                             |
| Ithon                 | Clywedog Brook   | EFMI188 | High                             |
| Ithon                 | Ithon            | EFMI134 | Good                             |
| Ithon                 | Ithon            | EFMI136 | Good                             |
| Ithon                 | Ithon            | 170556  | Good                             |
| Ithon                 | Ithon            | EFMI159 | Good                             |

| Operational catchment | River            | Site ID | Classification status equivalent |
|-----------------------|------------------|---------|----------------------------------|
| Ithon                 | Ithon            | EFMI160 | Good                             |
| Ithon                 | Ithon            | EFMI161 | Good                             |
| Ithon                 | Ithon            | EFMI163 | Good                             |
| Ithon                 | Ithon            | EFMI164 | Good                             |
| Ithon                 | Ithon            | EFMI166 | Good                             |
| Ithon                 | Ithon            | 45388   | Good                             |
| Ithon                 | Llaethdy Brook   | EFMI135 | Good                             |
| Ithon                 | Llaethdy Brook   | 143475  | Good                             |
| Ithon                 | Mithil Brook     | 45672   | Good                             |
| Ithon                 | Nantmel Dulas    | 81324   | Good                             |
| Irfon                 | Afon Cammarch    | EFMI170 | Good                             |
| Irfon                 | Afon Chwefru     | EFMI175 | Good                             |
| Irfon                 | Afon Garth Dulas | EFMI172 | Good                             |
| Irfon                 | Irfon            | 109794  | Moderate                         |
| Irfon                 | Irfon            | EFMI173 | High                             |
| Irfon                 | Irfon            | EFMI176 | High                             |
| Arrow Lugg and Frome  | Hindwell Brook   | 45350   | Poor                             |

Table 9. Summary of indicative ecological condition of sampling sites based on invertebrate sample data analysis and Whalley, Hawkes, Paisley and Trigg (WHPT) metric results. The indicative condition for each site is based on the Water Framework Directive Regulations class boundaries (Table 2). The SAC target is High Status.

## Arrow Lugg and Frome

Analysis of the samples collected at site 45350 (Hindwell Brook at Combe Bridge) yielded an ASPT EQR of 1.07 which falls within High condition range, however, the NTAXA EQR calculated at the site was 0.55 which falls within Poor, thus resulting in a poor condition. This sampling site scored the lowest of all invertebrate sampling sites assessed. While the ASPT was High at this site suggesting no specific nutrient load issues, the NTAXA EQR indicates a lower than expected taxonomic richness indicating a response to potential environmental pressures such as acidification, metal toxicity or habitat degradation. Of note: this sampling site is located in England, in a water body managed by the Environment Agency. There is an NRW site on Hindwell Brook that was last sampled in 2021 (143465 – Hindley Brook U/S Knobley Brook) which was classified as Good in 2024. ASPT EQR 0.97 (Good) and NTAXA EQ 0.88 (High). This site is approximately 8.4 Km upstream of site 45350. Further investigation would be required to determine the reason for the Poor classification at site 45350 but the indices indicate it is not due to a nutrient impact.

## Irfon

The NTAXA EQRs and ASPT EQRs varied across sampling sites within the Irfon operational catchment. The highest proportion of High Status sites were recorded within this operational catchment. The EFM1173 and EFM1176 sampling sites yielded NTAXA EQRs of 0.98 and 0.99 (High) and ASPT EQRs of 0.99 and 0.99 (High), indicating a High Status at both sites. However, the analysis of the samples collected at site 109794 along the Irfon yielded an NTAXA EQR of 0.73 (Good) and a ASPT EQR of 0.86 (Moderate) indicating a Moderate Status.

The samples collected at sites EFM170 (Afon Cammarch), EFM172 (Afon Garth Dulas), and EFM175 (Afon Chwefru) yielded NTAXA EQRs between 0.70 and 1.02 (Good – High) for each of the three sites where samples were collected, while the ASPT EQRs ranged between 0.89 and 0.96 (Good). Therefore, the indicative ecological condition of each of these sites is Good Status.

## Ithon

The NTAXA EQRs and ASPT EQRs differed between the two sampling sites along the Clywedog Brook. Sampling site 45395 yielded an NTAXA EQR of 1.04 (High) and an ASPT EQR of 0.93 (Good), indicating a Good Status for the river at this site. While the EFM1188 sampling site yielded an NTAXA EQR of 1.05 (High) and ASPT EQR of 0.98 (High), resulting in High Status at this site. The EFM1188 site is upstream of site 45395 which indicates a modest decrease in ecological condition of the brook in relation to slight organic pollution between the two sampling points.

The samples collected at the nineteen sites along the Aran, Ithon, Llaethdy Brook, Mithil Brook, and Nantmel Dulas watercourses yielded NTAXA EQRs between 0.90 and 1.33 (High) for each of the nineteen sites where samples were collected, while the ASPT EQRs ranged between 0.86 and 0.96 (Good). Therefore, the indicative ecological condition is Good for each of the nineteen sampling sites. While the taxonomic richness was High across the aforementioned watercourses, the lower ASPT EQRs indicate absence of some more pollution-sensitive taxa within the macroinvertebrate communities recorded at these sites. There was little spatial variation in these results.

## Wye – Ithon to Hay

The samples collected at two sites along Bach Howey Brook and Camnant Brook yielded NTAXA EQRs of 0.66 (Moderate) and 0.73 (Good) respectively, while the ASPT EQRs calculated were 0.91 (Good) and 0.74 (Moderate) respectively, thus indicating Moderate Status of the watercourses at both sampling sites, although potentially from different pressures.

The samples collected along the Afon Llynfi, Clettwr Brook, Duhonw, Edw, and Scithwen Brook yielded NTAXA EQRs between 0.81 and 1.19 (High) for each of the seven sites where samples were collected, while the ASPT EQRs ranged between 0.88 and 0.96 (Good). Therefore, the indicative ecological condition of the aforementioned rivers is Good for each of the seven sampling sites.

Analysis of samples collected at site 45259 (Wye at Llanstephan) yielded an NTAXA EQR of 1.18 (High). The ASPT EQR calculated for this site was 0.96 (Good), resulting in an overall classification of Good Status based on the macroinvertebrate samples collected. In contrast, analysis of samples collected at site EFMI132 (Wye at The Warren, Hay-on-Wye), located downstream of Scithwen Brook (site 45376), yielded an NTAXA EQR of 0.97 (High), while the ASPT EQR was 0.86 (Moderate). This results in an overall classification of Moderate Status at this site.

Although taxonomic richness was classified as High at both sites, the lower ASPT EQR recorded at the downstream site indicates that the macroinvertebrate assemblage comprised taxa with lower average sensitivity scores. This suggests a greater presence of pollution-tolerant taxa at site EFMI132, consistent with a response to organic pollution pressures.

It should be noted that the Environment Agency monitors two further sites downstream within this waterbody: 215594 (SO2288042639 at Hay-on-Wye) and 203045 (SO3167846170). Both of which were used in the 2024 WFD Regulations classification and were classified as Good and High, respectively. This suggests that the Moderate classification recorded at site EFMI132 is likely to reflect a localised or site-specific issue, rather than being representative of the wider waterbody.

## Wye - Source to Ithon

The samples collected at three sites along the Afon Bidno and Afon Marteg yielded NTAXA EQRs between 0.81 (High) and 1.25 (High), while the ASPT EQRs calculated were between 0.90 and 0.96 (Good). These scores indicate a Good Status at each of the three sites where samples were collected.

The samples collected at site 170543 along the Wye yielded an NTAXA EQR of 0.61 (Moderate), while the ASPT EQR calculated for the waterbody was 0.9 (Good), which indicates a Moderate Status at this site. The lower status class on the main river, driven by worse NTAXA, has been investigated by NRW and shown to be due to pollution from abandoned metal mines (Dyson 2021).

## Discussion

### Diatoms

Diatom assemblages across the Upper Wye catchment were typically dominated by few taxa: often only two taxa would account for more than 50% of individuals. Here, *Achnantheidium minutissimum* type was the most abundant taxon in most samples, which may be typical of the region. Jüttner *et al.* (2021) observed that, in the River Irfon, as the impacts of acidification lessened, a gradient is reflected by a transition from acid tolerant taxa, such as *Eunotia* species, to acid sensitive taxa such as *Achnantheidium minutissimum*. Acid tolerant taxa such as *Eunotia* were observed at some locations in this study, though not in any great abundance (<5% relative abundance).

The abundance and distribution of *A. minutissimum* across a wide range of conditions is not uncommon but raises questions of the processes giving rise to this phenomenon. *A.*

*minutissimum* is a pioneer species and will quickly recolonise surfaces after a disturbance (Rimet & Bouchez, 2012), giving this species a competitive advantage in dynamic systems. This species thrives over a wide range of conditions, though is often thought of as an indicator of Good Status, which serves to compound the competitive advantage its colonisation strategy.

*Achnanthydium minutissimum* can also dominate under heavy metal pollution, such as can occur from abandoned mines. Such conditions often lead to deformations in the appearance of *A. minutissimum* (Falasco *et al.* 2009); making the identification of a notoriously difficult taxa, due to its size, more difficult; which may have led to the large proportion of individuals being assigned to this group. However, apart from the Upper Wye above the Marteg and the Tarenig, the impact of mining on the Wye is relatively restricted, so this explanation cannot explain its dominance in other parts of the river.

A recent taxonomic review suggests that there may yet be more information to be gleaned from these data as designations of *A. minutissimum* can be distinguished into four distinct taxa and monitoring concerned with water quality assessments would benefit from separating these ecologically distinct species (Jüttner *et al.*, 2022).

Many of the dominant taxa, *Amphora*, *Achnanthydium*, and *Cocconeis*, are adapted to low nutrient concentrations (Rimet & Bouchez, 2012), and so most sites fall within the classification boundaries for High and Good. Only 17 out of 202 samples resulted in a Moderate or Poor classification; these were on the Afon Llynfi, Camnant Brook, Arrow, Ithon, Nantmel Dulas, Bach Howey Brook, Camddwr Brook, Gladestry Brook and Gwenlas Brook.

The status class equivalent given by diatom assemblages in the headwaters of the River Wye fall short of the desired High Status class boundary. This either alludes to the presence of pressures near the source of the river, causing a deviation from reference condition (and therefore High Status), or that the concept of reference conditions in the upper Wye catchment requires a nuanced approach (M. Kelly 2020; Kelly *et al.* 2020); the best achievable conditions may be those recorded here. Metal mines are a known pressure in the upper Wye and this may have caused the diatom tool to behave unpredictably in this area. The 2021 WFD Regulations classification reported diatoms in the Wye water bodies above Marteg and Bidno as High Status, indicating that this is achievable in this part of the Wye.

The trophic diatom index scores did not reveal specific areas that failed to achieve EQRs equivalent to the desired High Status class, instead large areas fell below this boundary and downstream reaches maintained EQRs equivalent to the Good Status classification. For example, Camnant Brook (a tributary of the River Edw) records a Moderate Status class, and though downstream sites improve to reflect Good Status, in autumn High Status is not achieved for some distance downstream until near the Wye confluence. Other areas of note include the headwaters of the Ithon upstream of Dolau Jenkin where TDI scores were highly variable (between tributaries and seasons), and below the confluence with Clywedog Brook were EQRs again fall below the High Status class boundary. The Llynfi stands out from the other Welsh tributaries of the River Wye due to the difference in taxonomic composition and the proportion of Moderate classifications, reflecting high P concentrations (Hatton-Ellis & Jones 2021).

## Macroinvertebrates

Ecological conditions and status classification equivalents derived from invertebrate indices were largely in agreement with those from diatom indices except for one location on the Hindwell Brook where the ecological condition of the river was deemed poor; two equivalent status classes below that indicated by diatom metrics. Additional surveys are recommended within the Arrow, Lugg and Frome operational catchment to determine whether the ecological condition at this sampling site is indicative of the wider area or whether this is a localised anomaly. As stated in the section above, the biotic indices suggest that this is not a nutrient driven issue but further work is required to determine the reason for the Poor classification.

The sites of lower ecological condition were located along the Wye, Bach Howey Brook, Camnant Brook, Irfon and Hindwell Brook – with NTAXA EQRs and/or ASPT EQRs falling within equivalent Moderate or Poor Status class boundaries. The dominant taxa recorded at these sites include mayflies (Baetidae), riffle beetles (Elmidae) and non-biting midges (Chironomidae). Further surveys are recommended along these watercourses to determine what is driving the lower scores at these sites. Due to the Good/High (respectively) classification for Environment Agency sites 215594 and 203045 on the Wye it would appear that the scores for site EFMI132 may be a localised issue or an issue with the site itself.

While the taxonomic richness of invertebrates was relatively High across the majority of sites assessed (Table 9), the ASPT EQRs fell between Good and Moderate Status class equivalent boundaries, indicating lower scoring taxa observed at the relevant sampling sites compared to expected results.

Low flows were recorded across the operational catchments in spring 2022 which may have affected the invertebrate communities present within the waterbodies. Further research relating to flow stress and drought response of the invertebrate communities recorded within the site is recommended, including calculation of biotic indices such as Lotic-invertebrate Index for Flow Evaluation (LIFE – Extence *et al.* 1999) and Drought Effect of Habitat Loss on Invertebrates (DEHLI – Chadd *et al.* 2017).

It should be noted that although sampling aimed to follow WFD Regulations-compliant methods (UKTAG, 2014), the results presented here do not constitute WFD Regulations classifications or formal SAC condition assessments. NRW will integrate these data with other evidence sources when reporting WFD Regulations classification, protected site condition and assessing trends over time.

## Summary

These data provide a snapshot of ecological condition of the upper River Wye SAC and its tributaries in Wales. In general, most of the study area showed evidence of slight impact (i.e. equivalent to Good rather than High Status) using one or both of the diatom and invertebrate tools. However, contrary to expectations, the tools provided little evidence of spatial variation in quality that might have been associated with markedly poor practices in specific tributaries (Figure 6, 7, 14), including the specific locations of intensive poultry units (Figure 2). Instead, the general pattern was of slight widespread degradation, especially for invertebrates. We do not have data on the locations and timing of spreading

of manures that could be compared to the ecological data so further analysis is needed to identify the key drivers of this pattern.

Classification results published on [Water Watch Wales](#) suggest that many of these sample locations have regularly achieved High Status in the past, although checks are required to ensure that the apparent deterioration is not due to method changes.

It was possible to identify areas of the upper Wye catchment with impacted biotic communities, though those sites characterised as Good or High Status using diatom-based metrics containing a high proportion of motile or organic tolerant taxa should not be ruled out of further investigation, particularly in the headwaters of the catchment.

Interpretation of the biotic indices provided in this report need to be considered in the context of the sampling programme; each site contains data for a single year, though this may not be the same period for nearby sites, and sites are distributed over a large spatial scale. Also, the survey programme was conducted over two years with atypical seasonal conditions; both 2022 and 2023 experienced wet winters followed by low flows and hot dry early summers compared to long-term climatic averages. This may have resulted in worse invertebrate results than expected, either alone or in combination with elevated nutrients. There is very strong and increasing evidence that the structure and composition of invertebrate communities are affected by climate driven events (Bradley & Ormerod 2001; Vaughan & Ormerod 2014; Sandin *et al.* 2014; Larsen *et al.* 2024) including low flows (e.g. Hille *et al.* 2014).

TDI scores may not accurately reflect nutrient stressors in acid-sensitive peat-fed catchments (O'Driscoll *et al.* 2014), and particularly in upland streams (Kelly, 2003). Conversely, some sites exceed an alkalinity of  $120\text{mgL}^{-1}$   $\text{CaCO}_3$ , and so scores may not accurately reflect nutrient concentrations in these reaches (Kelly *et al.* 2001).

## Recommendations

Calculations and analyses of additional biotic indices are recommended for further study relating to invertebrate communities within the assessed area, including Species at Risk (SPEAR), Lotic-invertebrate Index for Flow Evaluation (LIFE), and Drought Effect of Habitat Loss on Invertebrates (DEHLI). The SPEAR index can be used to assess the presence of pesticides in the watercourse. The LIFE index can be used to assess the flow regimes to which the macroinvertebrate communities are adapted to. While the DEHLI index can be used to assess the drought conditions to which the macroinvertebrate communities are adapted to.

Assessment of the impact of acidification (Diatom Acidification Metric: DAM; Juggins *et al.*, 2016) is recommended given the recent efforts to quantify and address this issue in the region (Jüttner *et al.*, 2021; Lewis *et al.*, 2007). Though concerns of acidification are currently limited to the River Irfon and some parts of the Upper Wye, this surveillance programme can be used to evidence the extent of this influence via application of the Diatom Acidification Metric.

An in-depth statistical approach is recommended to interrogate the spatio-temporal variation of the community data to better understand the underlying patterns. Multivariate ordination, or generalised additive modelling (GAM) techniques could be applied to these

data if accompanied by land-use, underlying geology and soil type, and river typology parameters to assess the influence of environmental factors on assemblages of species.

A possible future approach is to conduct a more targeted study of the Ithon, Edw or Llynfi at a higher (monthly) temporal resolution. To maximise understanding of the processes in these reaches, diatom samples with accompanying water chemistry, flow and habitat variables should be monitored for a period of 6 to 12 months at regular intervals.

Management actions on the Upper Wye should continue to examine possible sources of nutrient enrichment, reflecting high phosphorus levels previously recorded (Hatton-Ellis & Jones 2021).

The invertebrate results from 2022–23 suggest that much of the catchment is vulnerable to the impacts of climate change. Strengthening the catchment's resilience should therefore be a priority. Actions that help moderate extreme flows and improve overall river condition include expanding tree cover along riverbanks, creating wider riparian corridors, managing runoff pathways through features such as sediment-trap ponds and wetlands, and critically, providing land-management advice to support farmers in improving soil structure and infiltration. Together, these measures would help the Upper Wye cope better with both current and future climate pressures while also reducing the risk and severity of nutrient and pollutant inputs.

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## Appendix A: Rivers

Table 10. Presence of each watercourse within each operational catchment.

| Rivers           | Arrow Lugg and Frome | Irfon | Ithon | Wye - Ithon to Hay | Wye Source to Ithon |
|------------------|----------------------|-------|-------|--------------------|---------------------|
| Afon Bidno       | -                    | -     | -     | -                  | x                   |
| Afon Cammarch    | -                    | x     | -     | -                  | -                   |
| Afon Chwefru     | -                    | x     | -     | -                  | -                   |
| Afon Elan        | -                    | -     | -     | -                  | x                   |
| Afon Garth Dulas | -                    | x     | -     | -                  | -                   |
| Afon Llynfi      | -                    | -     | -     | X                  | -                   |
| Afon Marteg      | -                    | -     | -     | -                  | x                   |
| Afon Tarenig     | -                    | -     | -     | -                  | x                   |
| Aran             | -                    | -     | x     | -                  | -                   |
| Arrow            | x                    | -     | -     | -                  | -                   |
| Bach Howey Bk    | -                    | -     | -     | X                  | -                   |
| Bleddfa Bk       | x                    | -     | -     | -                  | -                   |
| Builth Dulas Bk  | -                    | -     | -     | X                  | -                   |
| Camddwr Bk       | -                    | -     | x     | -                  | -                   |
| Camnant Brook    | -                    | -     | -     | X                  | -                   |
| Cledan           | -                    | x     | -     | -                  | -                   |
| Clettwr Bk       | -                    | -     | -     | X                  | -                   |
| Clywedog Bk      | -                    | -     | x     | -                  | -                   |
| Duhonw           | -                    | -     | -     | X                  | -                   |
| Dulas Bk         | -                    | -     | -     | X                  | -                   |
| Edw              | -                    | -     | -     | X                  | -                   |
| Gladestry Bk     | x                    | -     | -     | -                  | -                   |
| Gwenlas Bk       | -                    | -     | x     | -                  | -                   |
| Hindwell         | x                    | -     | -     | -                  | -                   |

| Rivers        | Arrow Lugg and Frome | Irfon | Ithon | Wye - Ithon to Hay | Wye Source to Ithon |
|---------------|----------------------|-------|-------|--------------------|---------------------|
| Irfon         | -                    | x     | -     | -                  | -                   |
| Ithon         | -                    | -     | x     | -                  | -                   |
| Knobley Bk    | x                    | -     | -     | -                  | -                   |
| Llaethdy Bk   | -                    | -     | x     | -                  | -                   |
| Lugg          | x                    | -     | -     | -                  | -                   |
| Lugg Bk       | x                    | -     | -     | -                  | -                   |
| Mithil Bk     | -                    | -     | x     | -                  | -                   |
| Nantmel Dulas | -                    | -     | x     | -                  | -                   |
| Scithwen Bk   | -                    | -     | -     | x                  | -                   |
| Tirabad Dulas | -                    | x     | -     | -                  | -                   |
| Wye           | -                    | -     | -     | X                  | x                   |

## Appendix B: Indicative classifications for biotic indices

Table 11. Indicative classifications for biotic indices. Seasonal Trophic Diatom Index (TDI) Ecological Quality Ratio (EQR) scores are presented, while NTAXA EQR, ASPT EQR, and WHPT equivalent status classification are annual calculations. TDI EQR value classification boundaries can be seen in Table 2. Whalley Hawks, Paisley and Trigg (WHPT) EQR and NTAXA EQR value classification boundaries can be seen in Table 3. EQRs and indicative classes are coloured by WFD Regulations status classification boundaries recorded: High (H): blue, Good (G): green, Moderate (M): yellow, Poor (P): orange, and Bad (B): red.

| Trophic Diatom Index EQR value boundaries | Invertebrate WHPT NTAXA EQR value boundaries | Invertebrate WHPT ASPT EQR value boundaries | Ecological status classification |
|---|--|---|----------------------------------|
| ≥ 0.80                                    | > 0.80                                       | > 0.97                                      | High                             |
| ≥ 0.60                                    | ≥ 0.68                                       | ≥ 0.86                                      | Good                             |
| ≥ 0.40                                    | ≥ 0.56                                       | ≥ 0.72                                      | Moderate                         |
| ≥ 0.20                                    | ≥ 0.47                                       | ≥ 0.53                                      | Poor                             |
| < 0.20                                    | < 0.47                                       | < 0.53                                      | Bad                              |

| Operational catchment | Waterbody ID    | River       | Site ID | Diatoms Spring | Diatoms % motile | Diatoms Autumn | Diatoms % motile | Invertebrate NTAXA EQR | Invertebrate ASPT EQR | Invertebrate indicative equivalent status class |
|-----------------------|-----------------|-------------|---------|----------------|------------------|----------------|------------------|------------------------|-----------------------|---|
| Wye Source to Ithon   | GB109055 042340 | Afon Bidno  | EFMI129 | 0.75           | 0.29             | 0.76           | 0.78             | 0.83                   | 0.96                  | G   |
| Wye Source to Ithon   | GB109055 042260 | Afon Elan   | EFMI131 | 0.93           | 0.73             | 0.93           | 7.91             | -                      | -                     | -   |
| Wye Source to Ithon   | GB109055 042260 | Afon Elan   | 45397   | 0.88           | 1.29             | 0.75           | 4.07             | -                      | -                     | -   |
| Wye Source to Ithon   | GB109055 042310 | Afon Marteg | EFMI130 | 0.79           | 1.45             | 0.77           | 5.57             | 1.25                   | 0.93                  | G   |
| Wye Source to Ithon   | GB109055 042310 | Afon Marteg | 45400   | 0.77           | 0.43             | 0.72           | 3.65             | 0.81                   | 0.95                  | G   |

| Operational catchment | Waterbody ID    | River           | Site ID | Diatoms Spring | Diatoms % motile | Diatoms Autumn | Diatoms % motile | Invertebrate NTAXA EQR | Invertebrate ASPT EQR | Invertebrate indicative equivalent status class |
|-----------------------|-----------------|-----------------|---------|----------------|------------------|----------------|------------------|------------------------|-----------------------|---|
| Wye Source to Ithon   | GB109055 042350 | Afon Tarenig    | 45402   | 0.75           | 0                | 0.76           | 0.26             | -                      | -                     | -   |
| Wye Source to Ithon   | GB109055 042360 | Wye             | 45264   | 0.76           | 1.08             | 0.78           | 2.73             | -                      | -                     | -   |
| Wye Source to Ithon   | GB109055 042330 | Wye             | 170543  | 0.75           | 0.38             | 0.77           | 0.15             | 0.61                   | 0.9                   | M   |
| Wye Source to Ithon   | GB109055 042320 | Wye             | 45263   | 0.74           | 0                | 0.67           | 9.67             | -                      | -                     | -   |
| Wye Source to Ithon   | GB109055 042280 | Wye             | 45636   | 0.71           | 9.66             | 0.87           | 9.94             | -                      | -                     | -   |
| Wye Source to Ithon   | GB109055 042250 | Wye             | 45261   | 0.78           | 1.22             | 0.76           | 4.36             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036900 | Afon Llynfi     | 163640  | 0.69           | 4.85             | 0.55           | 3.1              | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036900 | Afon Llynfi     | EFMI186 | 0.42           | 19.64            | 0.46           | 6.94             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036900 | Afon Llynfi     | EFSE1   | 0.5            | 31.82            | 0.54           | 5.4              | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036900 | Afon Llynfi     | EFSE2   | 0.77           | 16.19            | 0.67           | 1.57             | 0.83                   | 0.92                  | G   |
| Wye - Ithon to Hay    | GB109055 036950 | Afon Llynfi     | 45371   | 0.57           | 8.96             | 0.64           | 5.48             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036950 | Afon Llynfi     | EFSE7   | 1              | 9.2              | 0.64           | 35.09            | 0.94                   | 0.95                  | G   |
| Wye - Ithon to Hay    | GB109055 037060 | Bach Howey Bk   | 45377   | 0.76           | 4.59             | 0.3            | 9.11             | 0.66                   | 0.91                  | M   |
| Wye - Ithon to Hay    | GB109055 037160 | Builth Dulas Bk | 45669   | 0.82           | 4.61             | 0.71           | 13.33            | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 042370 | Camnant Brook   | EFMI179 | 0.6            | 23.57            | 0.57           | 29.39            | 0.73                   | 0.74                  | M   |
| Wye - Ithon to Hay    | GB109055 042370 | Camnant Brook   | EFMI180 | 0.75           | 12.71            | 0.76           | 7.21             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 037030 | Clettwr Bk      | EFMI182 | 0.89           | 0.46             | 0.83           | 2.15             | 0.81                   | 0.88                  | G   |

| Operational catchment | Waterbody ID    | River       | Site ID | Diatoms Spring | Diatoms % motile | Diatoms Autumn | Diatoms % motile | Invertebrate NTAXA EQR | Invertebrate ASPT EQR | Invertebrate indicative equivalent status class |
|-----------------------|-----------------|-------------|---------|----------------|------------------|----------------|------------------|------------------------|-----------------------|---|
| Wye - Ithon to Hay    | GB109055 037050 | Duhonw      | EFMI177 | 0.91           | 0                | 0.91           | 0.67             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 037050 | Duhonw      | EFMI178 | 0.93           | 0.9              | 0.75           | 0.63             | 1.19                   | 0.91                  | G   |
| Wye - Ithon to Hay    | GB109055 036920 | Dulas Bk    | EFMI187 | 0.83           | 4.06             | 0.72           | 7.14             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 037130 | Edw         | EFMI181 | 0.88           | 9.29             | 0.66           | 23.82            | 1.03                   | 0.87                  | G   |
| Wye - Ithon to Hay    | GB109055 037080 | Edw         | EFSE26  | 0.96           | 3.2              | 1              | 3.52             | 1.04                   | 0.91                  | G   |
| Wye - Ithon to Hay    | GB109055 037080 | Edw         | EFMI189 | 0.88           | 3.59             | 0.75           | 12.34            | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036990 | Scithwen Bk | EFMI183 | 0.9            | 4.37             | 0.99           | 8.15             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036990 | Scithwen Bk | EFMI184 | 0.91           | 6.34             | 0.97           | 1.42             | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036990 | Scithwen Bk | EFMI185 | 0.82           | 2.37             | 0.68           | 6.6              | -                      | -                     | -   |
| Wye - Ithon to Hay    | GB109055 036990 | Scithwen Bk | 45376   | 0.83           | 0                | 0.69           | 6.75             | 0.95                   | 0.96                  | G   |
| Wye - Ithon to Hay    | GB109055 037115 | Wye         | 45259   | 0.71           | 17.8             | 0.71           | 6.74             | 1.18                   | 0.96                  | G   |
| Wye OC                | GB109055 037116 | Wye         | EFMI132 | 0.73           | 29.85            | 0.86           | 6.42             | 0.97                   | 0.86                  | M   |
| Ithon                 | GB109055 042110 | Aran        | EFMI150 | 0.95           | 1.62             | 0.62           | 4.13             | -                      | -                     | -   |
| Ithon                 | GB109055 042110 | Aran        | EFMI151 | 1              | 1.72             | 0.89           | 8.33             | -                      | -                     | -   |
| Ithon                 | GB109055 042110 | Aran        | EFMI152 | 0.83           | 0.3              | 1              | 4.98             | -                      | -                     | -   |
| Ithon                 | GB109055 042110 | Aran        | EFMI153 | 0.92           | 1.15             | 0.87           | 4.64             | 0.92                   | 0.93                  | G   |
| Ithon                 | GB109055 042110 | Aran        | EFMI154 | 0.8            | 0.09             | 1              | 6.77             | 0.97                   | 0.93                  | G   |

| Operational catchment | Waterbody ID    | River       | Site ID | Diatoms Spring | Diatoms % motile | Diatoms Autumn | Diatoms % motile | Invertebrate NTAXA EQR | Invertebrate ASPT EQR | Invertebrate indicative equivalent status class |
|-----------------------|-----------------|-------------|---------|----------------|------------------|----------------|------------------|------------------------|-----------------------|---|
| Ithon                 | GB109055 042110 | Aran        | EFMI155 | 1              | 5.25             | 0.87           | 13.92            | 0.98                   | 0.9                   | G   |
| Ithon                 | GB109055 042110 | Aran        | EFMI156 | 1              | 2.24             | 0.8            | 33.13            | 0.9                    | 0.88                  | G   |
| Ithon                 | GB109055 042110 | Aran        | EFMI157 | 1              | 2.1              | 0.99           | 7.02             | -                      | -                     | -   |
| Ithon                 | GB109055 042110 | Aran        | EFMI158 | 1              | 0.91             | 0.76           | 8.77             | -                      | -                     | -   |
| Ithon                 | GB109055 042110 | Aran        | 45396   | 1              | 0.58             | 0.97           | 2.91             | 1.18                   | 0.91                  | G   |
| Ithon                 | GB109055 042130 | Camddwr Bk  | EFMI147 | 0.79           | 15.16            | 0.53           | 11.76            | -                      | -                     | -   |
| Ithon                 | GB109055 042130 | Camddwr Bk  | EFMI148 | 0.77           | 9.97             | 0.62           | 0.98             | -                      | -                     | -   |
| Ithon                 | GB109055 042130 | Camddwr Bk  | 45673   | 0.73           | 0.46             | 0.74           | 44.73            | -                      | -                     | -   |
| Ithon                 | GB109055 042070 | Clywedog Bk | 45395   | 0.64           | 23.74            | 0.63           | 21.76            | 1.04                   | 0.93                  | G   |
| Ithon                 | GB109055 042090 | Clywedog Bk | 143471  | 0.71           | 12.54            | 0.76           | 4.65             | -                      | -                     | -   |
| Ithon                 | GB109055 042070 | Clywedog Bk | EFMI188 | 0.73           | 9.04             | 0.79           | 6.76             | 1.05                   | 0.98                  | H   |
| Ithon                 | GB109055 042170 | Gwenlas Bk  | EFMI137 | 0.59           | 3.64             | 0.75           | 1.87             | -                      | -                     | -   |
| Ithon                 | GB109055 042170 | Gwenlas Bk  | EFMI138 | 0.72           | 3.77             | 0.8            | 14.52            | -                      | -                     | -   |
| Ithon                 | GB109055 042170 | Gwenlas Bk  | EFMI139 | 0.76           | 23.62            | 0.7            | 37.01            | -                      | -                     | -   |
| Ithon                 | GB109055 042180 | Ithon       | EFMI133 | 0.75           | 2.15             | 0.81           | 17.6             | -                      | -                     | -   |
| Ithon                 | GB109055 042180 | Ithon       | EFMI134 | 0.83           | 6.58             | 0.76           | 21.72            | 1.1                    | 0.89                  | G   |
| Ithon                 | GB109055 042140 | Ithon       | EFMI136 | 0.9            | 2.37             | 0.94           | 1.86             | 1.03                   | 0.94                  | G   |

| Operational catchment | Waterbody ID       | River | Site ID | Diatoms Spring | Diatoms % motile | Diatoms Autumn | Diatoms % motile | Invertebrate NTAXA EQR | Invertebrate ASPT EQR | Invertebrate indicative equivalent status class |
|-----------------------|--------------------|-------|---------|----------------|------------------|----------------|------------------|------------------------|-----------------------|---|
| Ithon                 | GB109055<br>042140 | Ithon | EFMI140 | 0.71           | 7.33             | 0.34           | 4.87             | -                      | -                     | -   |
| Ithon                 | GB109055<br>042140 | Ithon | EFMI141 | 0.65           | 3.2              | 0.76           | 0.19             | -                      | -                     | -   |
| Ithon                 | GB109055<br>042140 | Ithon | EFMI142 | 0.79           | 2.9              | 0.76           | 3.55             | -                      | -                     | -   |
| Ithon                 | GB109055<br>042140 | Ithon | EFMI143 | 0.65           | 0.37             | 0.72           | 7.34             | -                      | -                     | -   |
| Ithon                 | GB109055<br>042140 | Ithon | EFMI144 | 0.77           | 0.95             | 0.85           | 2.55             | -                      | -                     | -   |
| Ithon                 | GB109055<br>042140 | Ithon | EFMI145 | 0.87           | 1.94             | 0.82           | 8.14             | -                      | -                     | -   |
| Ithon                 | GB109055<br>042140 | Ithon | EFMI146 | 0.9            | 2.12             | 0.88           | 13.53            | -                      | -                     | -   |
| Ithon                 | GB109055<br>042140 | Ithon | 170556  | 0.89           | 5.63             | 0.88           | 6.72             | 1.21                   | 0.89                  | G   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI149 | 0.93           | 13.55            | 0.95           | 4.77             | -                      | -                     | -   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI159 | 0.86           | 17.51            | 0.88           | 11.47            | 1.41                   | 0.93                  | G   |
| Ithon                 | GB109055<br>042270 | Ithon | 45391   | 0.83           | 19.93            | 0.83           | 9.9              | -                      | -                     | -   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI160 | 0.79           | 3.79             | 0.99           | 1.71             | 1.2                    | 0.95                  | G   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI161 | 0.98           | 0.96             | 0.93           | 10.07            | 1.4                    | 0.95                  | G   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI162 | 0.95           | 1.88             | 0.86           | 16.67            | -                      | -                     | -   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI163 | 0.98           | 2.11             | 0.96           | 4.13             | 1.05                   | 0.88                  | G   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI164 | 0.79           | 21.68            | 0.7            | 13.24            | 1.23                   | 0.92                  | G   |
| Ithon                 | GB109055<br>042270 | Ithon | EFMI165 | 0.7            | 22.88            | 0.7            | 13.15            | -                      | -                     | -   |

| Operational catchment | Waterbody ID    | River            | Site ID | Diatoms Spring | Diatoms % motile | Diatoms Autumn | Diatoms % motile | Invertebrate NTAXA EQR | Invertebrate ASPT EQR | Invertebrate indicative equivalent status class |
|-----------------------|-----------------|------------------|---------|----------------|------------------|----------------|------------------|------------------------|-----------------------|---|
| Ithon                 | GB109055 042270 | Ithon            | EFMI166 | 0.79           | 11.97            | 0.57           | 32.17            | 1.1                    | 0.94                  | G   |
| Ithon                 | GB109055 042270 | Ithon            | 45388   | 0.78           | 12.34            | 0.64           | 22.06            | 1.07                   | 0.96                  | G   |
| Ithon                 | GB109055 042160 | Llaethdy Bk      | EFMI135 | 0.7            | 36.14            | 0.86           | 2.85             | 1.33                   | 0.95                  | G   |
| Ithon                 | GB109055 042160 | Llaethdy Bk      | 143475  | 0.77           | 18.07            | 0.86           | 5.09             | 1.1                    | 0.93                  | G   |
| Ithon                 | GB109055 041960 | Mithil Bk        | 45672   | 0.94           | 0.76             | 0.71           | 8.75             | 1.02                   | 0.86                  | G   |
| Ithon                 | GB109055 042080 | Nantmel Dulas    | 81324   | 0.72           | 18.81            | 0.57           | 46.34            | 1.12                   | 0.93                  | G   |
| Irfon                 | GB109055 041880 | Afon Cammarc h   | EFMI168 | 0.77           | 0.67             | 0.82           | 1.49             | -                      | -                     | -   |
| Irfon                 | GB109055 041880 | Afon Cammarc h   | EFMI169 | 0.77           | 6.24             | 0.76           | 3.06             | -                      | -                     | -   |
| Irfon                 | GB109055 041880 | Afon Cammarc h   | EFMI170 | 0.83           | 2.13             | 0.72           | 2.14             | 0.7                    | 0.95                  | G   |
| Irfon                 | GB109055 042190 | Afon Chwefru     | EFMI174 | 0.86           | 0.09             | 0.91           | 3.83             | -                      | -                     | -   |
| Irfon                 | GB109055 042190 | Afon Chwefru     | EFMI175 | 0.81           | 1.52             | 0.72           | 1.97             | 1.02                   | 0.89                  | G   |
| Irfon                 | GB109055 042190 | Afon Chwefru     | 45384   | 0.8            | 7.04             | 0.76           | 9.67             | -                      | -                     | -   |
| Irfon                 | GB109055 041890 | Afon Garth Dulas | EFMI171 | 0.8            | 0.38             | 0.8            | 0.27             | -                      | -                     | -   |
| Irfon                 | GB109055 041890 | Afon Garth Dulas | EFMI172 | 0.78           | 0.12             | 0.74           | 2.89             | 0.97                   | 0.94                  | G   |

| Operational catchment | Waterbody ID    | River         | Site ID | Diatoms Spring | Diatoms % motile | Diatoms Autumn | Diatoms % motile | Invertebrate NTAXA EQR | Invertebrate ASPT EQR | Invertebrate indicative equivalent status class |
|-----------------------|-----------------|---------------|---------|----------------|------------------|----------------|------------------|------------------------|-----------------------|---|
| Irfon                 | GB109055 036680 | Cledan        | 45668   | 0.85           | 0.52             | 0.81           | 2.82             | -                      | -                     | -   |
| Irfon                 | GB109055 036760 | Irfon         | EFMI167 | 0.77           | 0.45             | 0.8            | 2.06             | -                      | -                     | -   |
| Irfon                 | GB109055 037090 | Irfon         | 109794  | 0.81           | 1.62             | 0.79           | 3.52             | 0.73                   | 0.86                  | M   |
| Irfon                 | GB109055 037090 | Irfon         | EFMI173 | 0.81           | 4.08             | 0.77           | 2.66             | 0.99                   | 1                     | H   |
| Irfon                 | GB109055 037090 | Irfon         | EFMI176 | 0.76           | 1.4              | 0.78           | 0.51             | 0.98                   | 0.99                  | H   |
| Irfon                 | GB109055 036690 | Tirabad Dulas | 45387   | 0.89           | 1.65             | 0.83           | 9.32             | -                      | -                     | -   |
| Arrow Lugg and Frome  | GB109055 036590 | Arrow         | 45653   | 0.75           | 2.42             | 0.32           | 5.4              | -                      | -                     | -   |
| Arrow Lugg and Frome  | GB109055 042050 | Bleddfa Bk    | 143469  | 1              | 2.06             | 0.85           | 1.31             | -                      | -                     | -   |
| Arrow Lugg and Frome  | GB109055 036600 | Gladestry Bk  | 178270  | 0.79           | 4.23             | 0.52           | 7.21             | -                      | -                     | -   |
| Arrow Lugg and Frome  | GB109055 041930 | Hindwell      | 45350   | 0.94           | 1.9              | 0.67           | 46.13            | 0.55                   | 1.07                  | P   |
| Arrow Lugg and Frome  | GB109055 041980 | Knobley Bk    | 143466  | 0.97           | 10.37            | 1              | 3.68             | -                      | -                     | -   |
| Arrow Lugg and Frome  | GB109055 042020 | Lugg          | 45647   | 0.88           | 0.51             | 1              | 0.1              | -                      | -                     | -   |
| Arrow Lugg and Frome  | GB109055 042010 | Lugg          | 153480  | 0.97           | 1.85             | 1              | 0                | -                      | -                     | -   |
| Arrow Lugg and Frome  | GB109055 042100 | Lugg Bk       | 159509  | 1              | 0.58             | 1              | 8.22             | -                      | -                     | -   |

## Appendix C: Occurrence of taxa as dominant or subdominant species

Table 12. Dominant diatom taxa.

| Taxon  | Dominant | Subdominant | Total |
|--|----------|-------------|-------|
| <i>Achnanthes oblongella</i>                     | 0        | 4           | 4     |
| <i>Achnantheidium biasoletianum</i>              | 2        | 5           | 7     |
| <i>Achnantheidium minutissimum</i> type          | 145      | 28          | 173   |
| <i>Achnantheidium pyrenaicum</i>                 | 5        | 10          | 15    |
| <i>Amphora pediculus</i>                         | 14       | 14          | 28    |
| <i>Cocconeis placentula</i>                      | 1        | 9           | 10    |
| <i>Cocconeis placentula</i> var. <i>euglypta</i> | 0        | 9           | 9     |
| <i>Cocconeis placentula</i> var. <i>lineata</i>  | 0        | 2           | 2     |
| <i>Denticula tenuis</i>                          | 0        | 5           | 5     |
| <i>Encyonema minutum</i>                         | 0        | 7           | 7     |
| <i>Fragilaria capucina</i>                       | 1        | 14          | 15    |
| <i>Fragilaria capucina</i> var. <i>gracilis</i>  | 0        | 10          | 10    |
| <i>Gomphonema "intricatum"</i> type              | 25       | 22          | 47    |
| <i>Gomphonema angustatum</i>                     | 0        | 2           | 2     |
| <i>Gomphonema calcifugum</i>                     | 1        | 10          | 11    |
| <i>Gomphonema olivaceoides</i>                   | 0        | 6           | 6     |
| <i>Gomphonema pumilum</i>                        | 1        | 2           | 3     |
| <i>Navicula cryptotenella</i>                    | 0        | 2           | 2     |
| <i>Navicula gregaria</i>                         | 0        | 3           | 3     |
| <i>Navicula lanceolata</i>                       | 0        | 2           | 2     |
| <i>Nitzschia dissipata</i>                       | 0        | 3           | 3     |
| <i>Nitzschia fonticola</i>                       | 0        | 2           | 2     |
| <i>Planothidium frequentissimum</i>              | 0        | 3           | 3     |
| <i>Reimeria sinuata</i>                          | 2        | 8           | 10    |
| <i>Rhoicosphenia abbreviata</i>                  | 0        | 6           | 6     |
| <i>Tabellaria flocculosa</i>                     | 3        | 4           | 7     |

# Appendices

## Data Archive Appendix

Data outputs associated with this project are archived in NRW's Document Management System and geospatial datasets on server-based storage at Natural Resources Wales.

- [A] The final report in Microsoft Word and Adobe PDF formats.
- [B] Diatom and macroinvertebrate data collected by the project is available on NRW's KiEco systema and as geospatial data.

Metadata for this project is publicly accessible through Natural Resources Wales' Data Discovery Service <https://metadata.naturalresources.wales/geonetwork/srv> (English version) and <https://metadata.cyfoethnaturiol.cymru/geonetwork/cym/> (Welsh Version). The metadata is held as record no NRW\_DS161502.

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