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AN INVESTIGATION OF THE IMPACTS OF A DAIRY INDUSTRY WASTE ON RIVER WATER QUALITY AND THE APPROPRIATENESS OF CURRENT MONITORING APPROACHES AND REGULATION

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Copyright Statement

An investigation of the impacts of a dairy industry waste on river water quality and the appropriateness of current monitoring approaches and regulation.

by

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in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

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[In collaboration with
Saputo Dairy UK]

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Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

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University of Plymouth Research Festival 2020, University of Plymouth, Plymouth, UK. 'Investigating the impact of a dairy processing plant on a river invertebrate community' (Poster).

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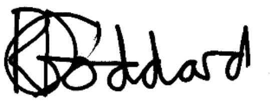
Signed 

Date: 19 December 2021

Abstract

Rupert Goddard

AN INVESTIGATION OF THE IMPACTS OF A DAIRY INDUSTRY WASTE ON RIVER WATER QUALITY AND THE APPROPRIATENESS OF CURRENT MONITORING APPROACHES AND REGULATION.

The modern dairy industry is a key contributor to global food security, with diverse production practices reflecting different geographic, economic and cultural contexts. Across the globe, the dairy industry has a significant contribution to global employment and wealth, health and land use. However, untreated or partially treated dairy waste entering a river system can be detrimental, increasing eutrophication, changing community structure or in the worst case scenario, causing death to organisms. Dairies are located near the milk supply, and therefore are in rural locations, potentially near head waters of catchments with limited potential for dilution of wastewater. This project sought to systematically assess the impacts of a dairy on the headwaters of a tributary of the River Tamar in SW England.

UK river chemical and ecological quality is regulated through the European Union Water Framework Directive (WFD). Over a two year period, water chemistry, freshwater invertebrates, diatoms and macrophytes were monitored on the River Inny in SW England, upstream and downstream of a significant diary wastewater discharge, to assess the condition of the river and compared with twenty years of historic water quality data. Sample sites were of three types: impacted by dairy waste, not impacted or possibly impacted. To support the study design, laboratory based ecotoxicological

experiments were undertaken, to determine the toxicity of potassium, sodium and chloride, owing to their elevated concentrations within the dairy discharge and lack of existing data.

Water chemistry was determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Optical Emission Spectrometry (ICP-OES) and Ion chromatography, and compared with Environmental Quality Standards (EQS) and historic data. The status of the river biota was determined using existing methods adopted by the regulator and modelled using standard metrics and compared against historic data for diatoms, invertebrates and macrophytes.

Of the current elements in the discharge permit (phosphate and iron), only phosphate showed a marginal exceedance downstream at the end of the mixing zone (Trewinnow Bridge site), a significant improvement over historical impacts the discharge had on the receiving water, reflecting continuous upgrading of the waste treatment. This study, however, highlighted the major ions without WFD EQS (potassium, sodium and chloride) present in the dairy discharge at elevated concentrations, may impact on sensitive invertebrates such as *Gammarus*, immediately downstream of the discharge within the mixing zone, which would benefit from further investigation.

By combining water quality, ecotoxicological and ecological assessments, this study has shown that recent improvements in the wastewater treatment engineering process has contributed to 'Good' overall ecological status within the receiving water for the first time, with little, if any, deterioration in water and ecological quality caused by the effluent discharge.

The research demonstrated the benefits of assessing water quality using soluble reactive phosphorus (i.e. bioavailable) rather than just reactive phosphorus that is currently the case, and illustration is made of the link between diatom status and Soluble reactive versus Total reactive phosphorus. Novel ecotoxicological data suggests possible impacts from potassium directly downstream of the discharge within the mixing zone to the invertebrate, Gammarus.

By combining biological and chemical monitoring and modelling, along with providing additional toxicological data for major ions, this study provides a significant step forward in terms of understanding and better regulating dairy industry wastewater discharges.

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1 Introduction, Aims and Objectives

1.1 Introduction

The modern dairy industry is a key contributor to global food security, with diverse production practices reflecting different geographic, economic and cultural contexts (Douphrate *et al*., 2013). The UK is the eleventh largest milk producer in the world and within the UK, milk accounts for 17% of UK agricultural output by economic value (Uberoi, 2020). At 2020 prices, the industry was worth an estimated £4.5 billion. Untreated milk entering the riverine environment system can be detrimental to the system, leading to reduced oxygen levels and associated impacts on biota. The rural production zone of milk and associated transport costs make a rural setting for milk processing highly desirable. However the infrastructure to treat any generated waste needs to be specific, in terms of managing composition and generated volumes. Thus, owing to the nature of plant location, close to the site of milk production, final disposal of treated liquid waste is likely to be in the upper reaches of a river catchment, where the channel flow is low. If composition of the treated waste is not similar to receiving waters, impacts to the biology of the river channel could be expected. In addition, these impacts are likely to be of greater significance when the river is experiencing lower flows when potential for dilution is reduced.

The review of literature on dairy processing, water chemistry, stream invertebrates and diatoms established numerous gaps in knowledge which are summarised below.

1. The localised effects of a treated dairy waste industrial discharge in the receiving waters of a river headwater
2. How does the speciation of phosphorus impact a river system with regard to permits, EQSs and effects on different biota?

3. What are the directly harmful effects of anions and cations present in dairy processing waste

From this and the wider review of literature, six research objectives have been established.

Figure 1.1: Objectives of the study

Research questions and individual work packages have been developed from the above objectives and are summarised in Figure 1.2.

1.2 Scope of the study

The aim of the study (Figure 1.2) will be to undertake a rigorous investigation to elucidate the environmental risk associated with a significant industrial discharge on the head waters of a river. The study will concentrate on the effects of treated liquid waste generated through the processing of milk by a dairy products factory and their impacts on the river to which they are discharged. Thorough monitoring of spatial and temporal changes in water chemistry and river biology, (specifically freshwater invertebrates, diatoms and macrophytes) both at sites impacted and unimpacted by the discharge will make up the primary data collection within the study, which will be compared with historic data.

Study aim	To undertake a scientifically rigorous investigation to elucidate the environmental risk associated with a significant industrial discharge on the head waters of a river					
Objectives	1. To review temporal water quality as assessed through regular monitoring by the Environment Agency monitoring (WIMS data).	2. To conduct a comprehensive physico-chemical monitoring programme of water quality within the freshwater ecosystem receiving dairy processing waste.	3. To monitor the ecological patterns of diatom and invertebrate biodiversity using established regulatory protocols for water quality protection.	4. To address critical knowledge gaps on the directly harmful effects of anions and cations present in treated dairy processing waste through laboratory ecotoxicity studies.	5. To conduct a deterministic risk assessment of anion and cation exposures versus laboratory ecotoxicology data, supported by ecological monitoring indicators of water quality.	6. To provide a clear impact study to be used in any future negotiation of revision of consent to discharge treated dairy waste into a river.
Research Questions	1. What temporal changes have occurred to the water quality of the study catchment?	2. How does current water quality compare with historic data? What is the impact on river water quality of consented discharge to receiving waters?	3. What is the quality of the river, based on freshwater invertebrates, macrophytes and diatoms?	4. How do chemicals with no Environmental Quality Standard impact on freshwater invertebrates?	5. How do the chemical inputs from treated dairy waste impact a river course?	6. How does treated dairy waste affect receiving waters of a head water river?
Work Packages	• Find historic data of chemical measurements for the River Inny. • Undertake temporal study of water quality based on chemical measurements.	• Measure water chemistry in the River Inny • Assess the water quality based on consented chemical discharge and Environmental Quality Standards.	• Survey sites on River Inny for freshwater invertebrates, diatoms and macrophytes. • Apply regulatory metrics to survey data to determine water quality classes.	• Undertake bioassay of identified chemicals with locally relevant taxon. • Determine an Environmental Quality Standard for identified chemicals.	• Interpretation of bioassay in association with invertebrate survey data.	• Report on findings of the study that combine interactions of chemistry and biota.

Figure 1.2 Breakdown of study aim, objectives and research questions

1.3 Project structure

The structure of this thesis is illustrated in Figure 1.3, where chapter 1 introduces the context and rationale for the study and defines the aim and objectives of the study. Chapter 2 describes the location and rationale behind the site selection for the study, summarising the physical characteristics and land use of the area. Chapter 3 reviews historical water quality data archived by the Environment Agency. Three experimental chapters (Chapters 4 – 6) directly address each of the identified research objectives (Figure 1.1). In chapter 7, modelling of river flow and water chemistry is investigated with particular reference to current and derived EQSs. Concentrations are forced within the model in an attempt to determine the required concentrations needed to meet compliance. Chapter 8 summarises the study, with final discussions on the impact of a dairy processing unit on a riverine environment and offers options for further research and the implications of the findings of this research.

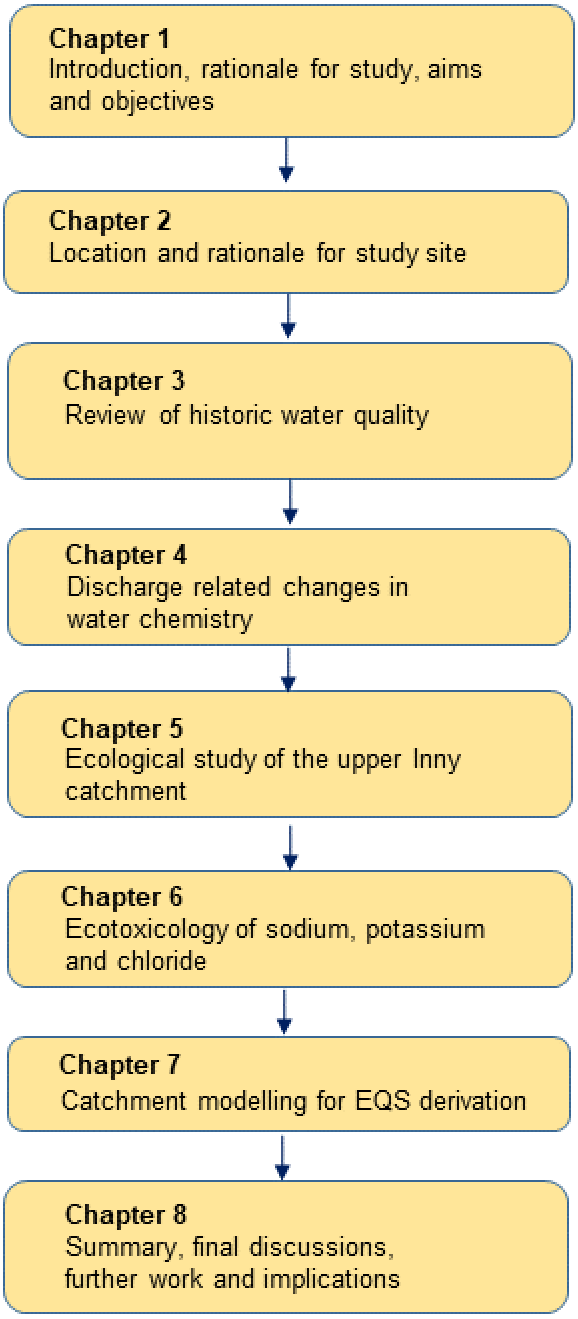


Figure 1.3 Schematic diagram of thesis structure

1.4 Introduction to the dairy Industry

From an international perspective, the Food and Agriculture Organisation (FAO) of the United Nations reports that over the last three decades, world milk production has increased by more than 59%, from 530 million tonnes in 1988 to 843 million tonnes in

2018. Around the world nearly 150 million households are engaged in milk production (FAO, 2021). Across the globe, the dairy industry has a significant contribution to global employment and wealth, health and land use (Figure 1.4). The industry includes animal husbandry of dairy cattle to produce milk, logistics to transport milk from farm to factory and the processing of milk into products for sale or further process.

In the UK, there has been a reduction in stock numbers from 2.6 million dairy cows in 1996 to 1.9 million in 2018, however since 1975, the milk yield per cow has increased by 94% (Uberoi, 2020). Between 1998 and 2018, milk usage for the production of cheese increased by 35.7%.

Dairy cattle have been selectively bred over time to give high milk yields. Depending on the area of the country and local weather conditions, cattle are grass fed outdoors or housed in barns and fed with silage (fermented grass), manufactured feed nuts, or a mixture. In Northern Europe, often a combination of barn and outdoor accommodation occurs but alternative husbandry practices are followed in other regions (Douphrate *et al*., 2013).

The physical and chemical composition of milk can vary according to the composition of the feed, time of year and condition of the cow – i.e. health and stage of lactation. Chen *et al.* (2014) measured composition including total P as 8.22 to 10 mMol [0.26 to 0.31 mg L^{-1}], total calcium as 24.5 to 31.5 mMol [0.98 to 1.3 mg L^{-1}], and magnesium as 4.21 to 5.81 mMol [0.1 to 0.23 mg L^{-1}]. Foroutan *et al*., (2019), undertook a literature mining exercise to obtain the most comprehensive and up-to-date characterization of the chemical constituents in commercial cow's milk. They found literature values of trace elements in milk of 19,000 to 23,000 µMol phosphorus [0.59 to 0.71 mg L^{-1}], 26,000 to 32,000 µMol calcium [1.04 to 1.28 mg L^{-1}], 4000 to 6000 µMol magnesium

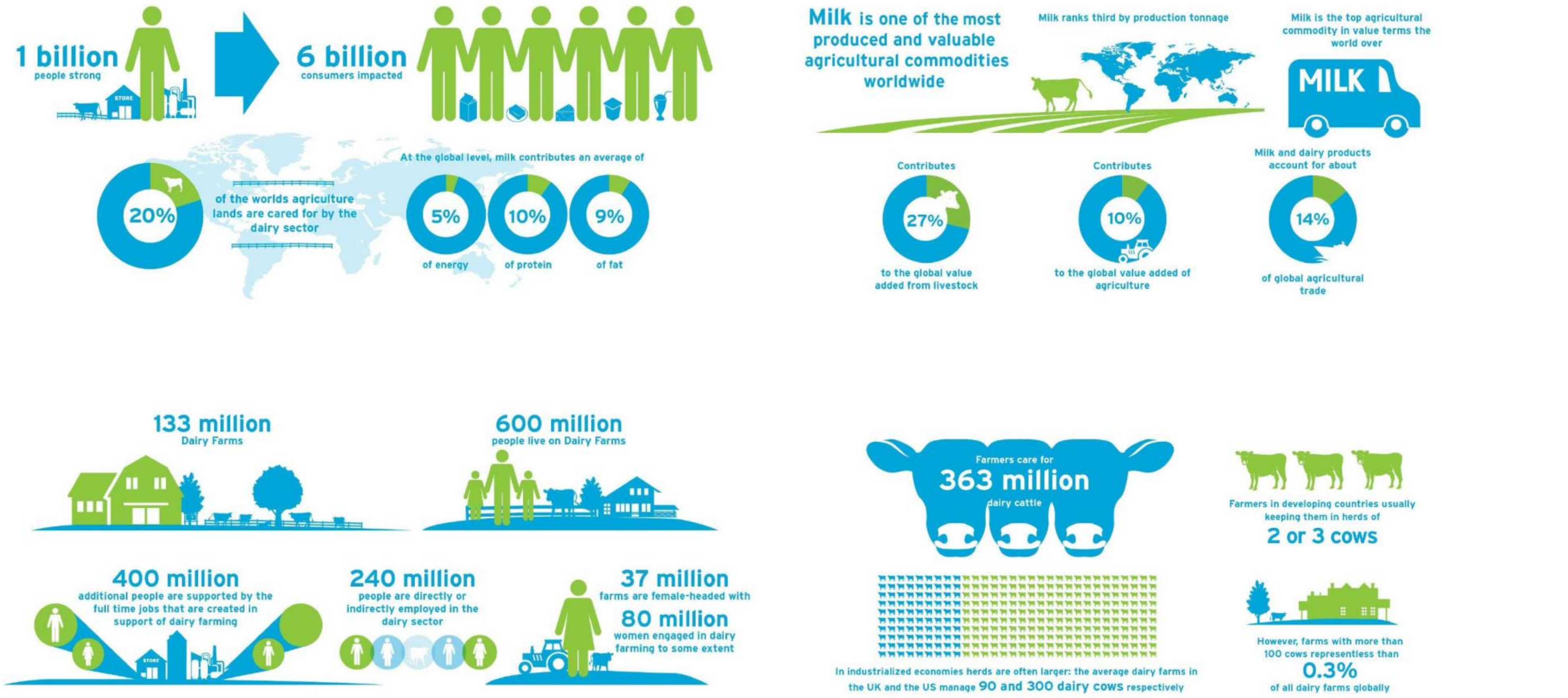


Figure 1.4 Schematic of global dairy industry illustrating the global significance through numbers of people involved and impacted, the importance as a commodity, the significance to the wider economy and the relative size of global milk production (DairyUK, 2020).

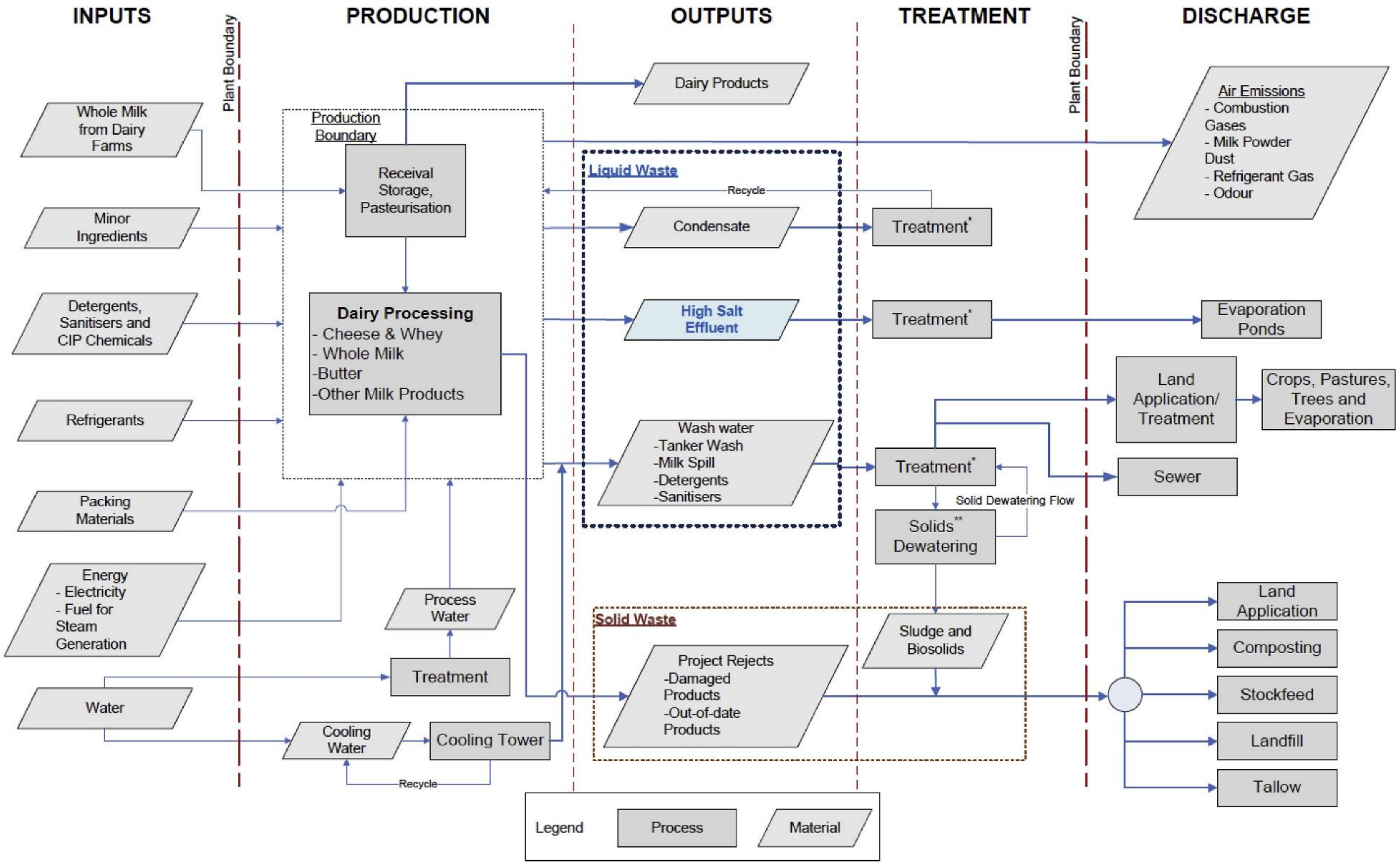


Figure 1.5 A typical approach for dairy processing waste management in Australia and New Zealand. *Wastewater treatments include various arrangements of standard technologies, which are not shown in detail; ** Sludge and biosolids are generated from biological treatment and wastewater separation processes such as Dissolved Air Flotation (Chen *et al*., 2018).

[0.10 to 0.15 mg L^{-1}], 17,000 to 28,000 µMol sodium [0.39 to 0.64 mg L^{-1}] and 31,000 – 43,000 µMol potassium [1.21 to 1.68 mg L^{-1}]. Protein and fat levels demonstrated seasonal trends, whilst minerals and many physical characteristics although displaying much variation were unrelated to season. (Chen *et al*., 2014). Some of this composition will enter the dairy waste stream.

1.5 Summary of hard cheese production

A schematic of typical dairy process waste management can be seen in Figure 1.5. Hard cheese manufacture is a complex multi-step process which takes milk, specific bacterial cultures for inoculation and managed conditions to create a dairy product that has a reduced water content and a modified protein structure. The natural process takes specific bacteria to produce the enzyme rennet which coagulates the milk resulting in a separation of the liquid and solid phases (the curds and whey). From this point of the process, steps taken will result in cheeses of different characteristics e.g. soft ricotta to hard cheddar. Whey is drawn off of the curds with salt (NaCl) added to flavour and further draw out whey. Pressure is applied to give a final removal of whey before the cheese curd enters a period of maturation. The manufacture process is summarised in Figure 1.6.

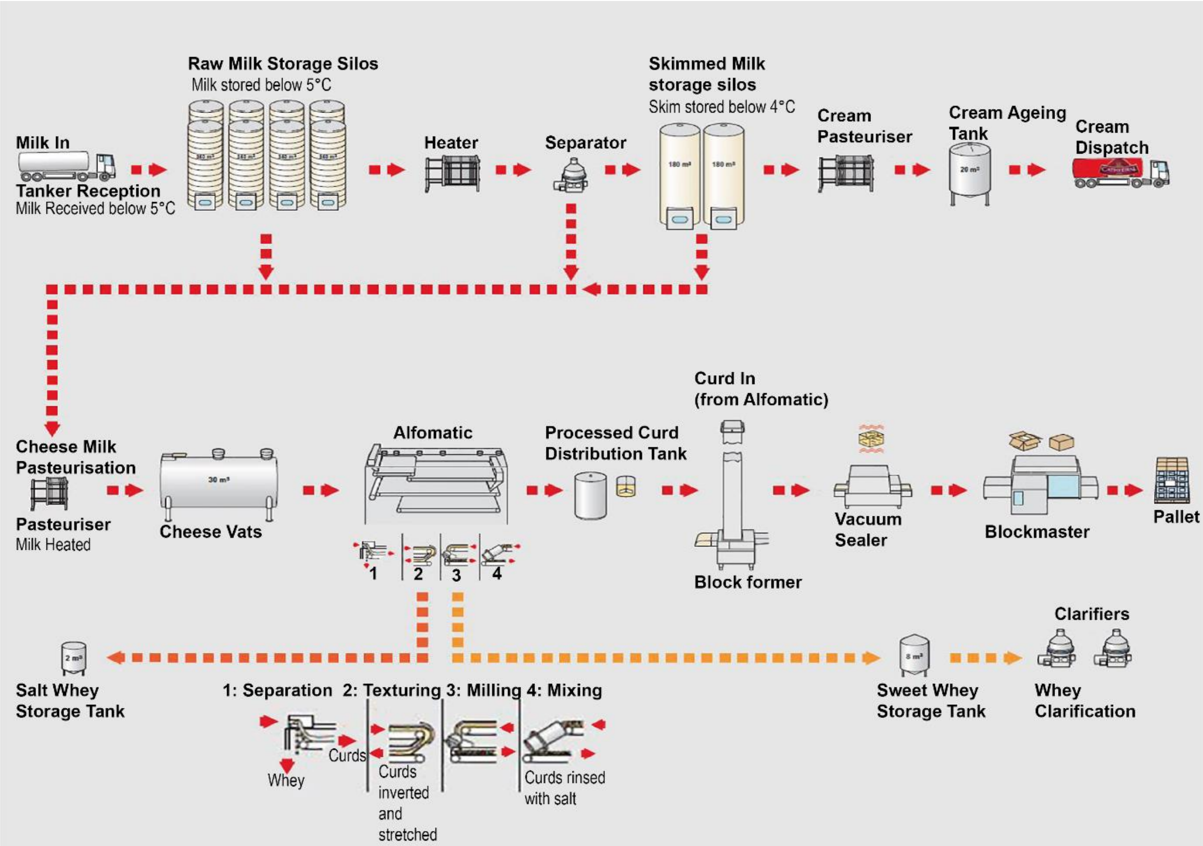


Figure 1.6 Schematic of hard cheese production. Redrawn from image supplied by Saputo UK.

1.6 Dairy industry waste composition

The high organic load contained in milk degrades quickly under the action of river biota, leading to a dramatic fall in dissolved oxygen, illustrated in the high BOD, in the range 100 – 170g O_2 L^{-1} (Elliott *et al*., 2001) and in whey of 40 - 60g O_2 L^{-1} (Alvarez *et al*., 2011) compared with untreated slurry, 6.8g O_2 L^{-1} (Clemens, 2001), brewery waste 1.2 – 3.6 g O_2 L^{-1} (Simate *et al*., 2011). Increases in nutrients such as nitrogen and phosphorus can lead to eutrophication of the receiving waters. (Dhall *et al*., 2012). Globally, the dairy industry varies considerably in its products and processes, generating quantities of liquid waste of the order 0.2 – to 10 litres of effluent per litre of milk processed (Vourch *et al*., 2008).

Once separated from the curd, (sweet) whey can be used as a resource as it is rich in protein and lactose (Okawa *et al.*, 2015). More than 145 x 10^6 tonnes of whey liquid waste is produced per year worldwide (Alvarez *et al*., 2011). Historically, whey was used as an animal feed for pigs. This is still feasible as long as food safety conditions are adhered to (gov.uk, 2014). Markets have developed to process whey for ingredients for pro-biotic products and infant formula milk. The composition of whey will vary according to the type of cheese being made, with softer cheeses generating less whey. Goyal and Gandhi, (2009) undertook a comparative analysis of Indian paneer and cheese whey for electrolyte whey drink. The electrolyte composition of a whey-based drink make it suitable to replace lost minerals in a treatment for conditions such as diarrhoea in animals. However, the environmental impacts of whey can be high as the product is often dumped when it is seen to have no value (Goyal and Gandhi, 2009). The rich organic composition of whey has a high biochemical oxygen demand (BOD), which can lead to serious environmental and water pollution problems (Jindal, *et al*., 2004).

Treatment of whey to demineralise its composition can add financial benefit to a by-product and reduce the amount of waste being generated. Approximately 35% of the total production of liquid whey in the United States is processed into whey products for human food and animal feed (Alvarez *et al.*, 2011). The mineral content of whey includes sodium, potassium and chloride in quantities unsuitable for use in products such as infant formula, supplements and food industry additives (Okawa *et al*., 2015). Within their study, Goyal and Gandhi (2009) found that cheese whey contained, amongst other elements, 260 ± 1.78 mg Na L^{-1}, 291 ± 3.2 mg Ca L^{-1}, 1300 ± 1.56 mg K L^{-1}, 36 ± 0.21 mg Mg L^{-1}, 1167 ± 1.49 mg Cl^{-} L^{-1} and 210 ± 0.21 mg Zn L^{-1}. Removal can take place using techniques including ion exchange, electro-dialysis or nanofiltration. It is the loss of calcium phosphate from the curd and its effect on the properties of the protein aggregates in cheese that contributes to the cheese type, and this is dependent on the pH of the whey at drainage during the manufacturing process (Mullan, 2005). Calcium phosphate has the potential for capture and use as a high nutrient component of fertiliser (Urbanowicz, 2018). Any significant chemical loading or physical characteristics of the waste discharge will impact on that of the receiving waters. A length of watercourse from the point of discharge downstream acts as a mixing zone (European Communities, 2010; Jirka *et al.*, 2004) before an altered, homogenous water composition is apparent across the width of the channel.

2 Locations and rationale for study

2.1 Introduction

In this chapter, the rationale behind site selection is discussed. Maps introduce the location of the sites used by the Environment Agency for routine monitoring, together with the sites used within this study. Sites are described and defined in terms of whether they are influenced by the dairy discharge

2.2 Sample site locations

The study area is in the southwest of England (Figure 2.1). In the first instance, the selection of sites from which to sample was drawn up from a study of former monitoring undertaken by the Environment Agency within the Upper Inny catchment (Chapter 3). Further refinement took place to ensure a combination of geographic spread through the catchment coupled with ease of access to the sites, to ensure the sample collection event could be achieved in one working day.

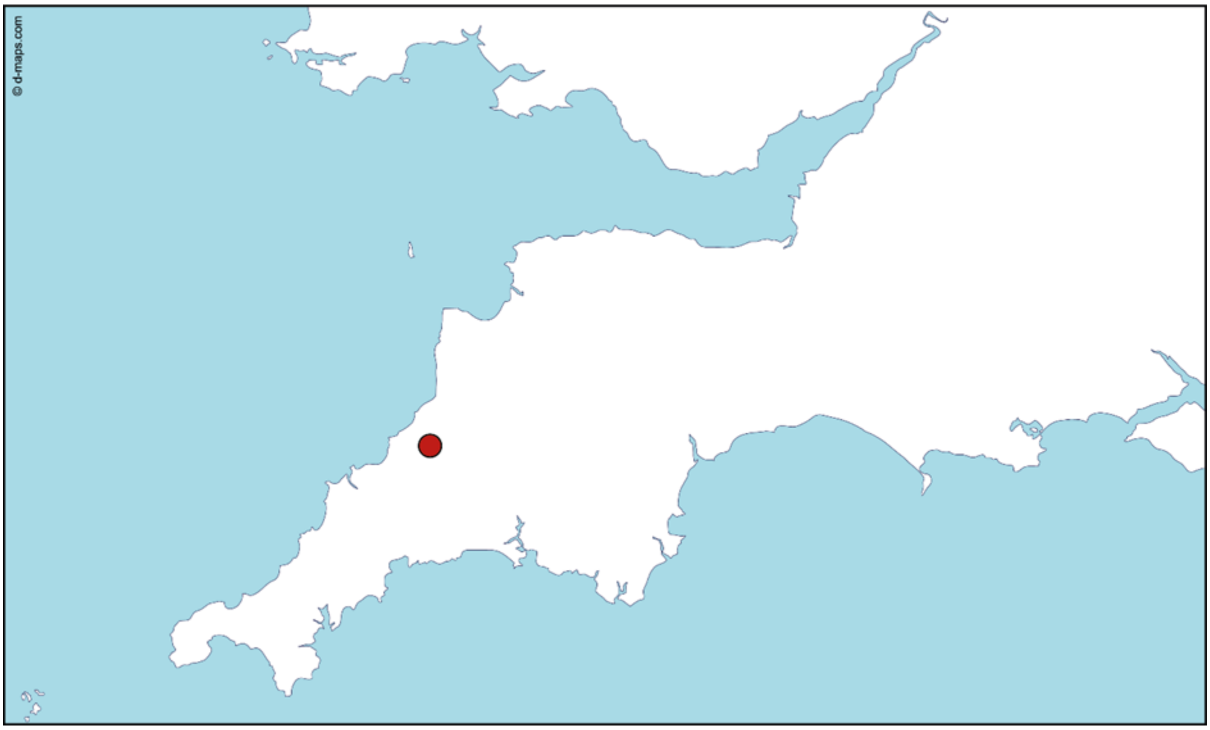


Figure 2.1 Location of study area

The selected sample sites for the study, with their locations, are shown in Figures 2.2 and 2.3 and are listed in Table 2.1, with site photographs in Figure 2.6. Where possible, sites are married with historic Environment Agency sampling (Figure 2.4), to allow data comparison and to attempt a BACI approach to the research by including sample sites that are unimpacted by any dairy discharge, potentially impacted and fully impacted, i.e receiving waters and downstream of the discharge.

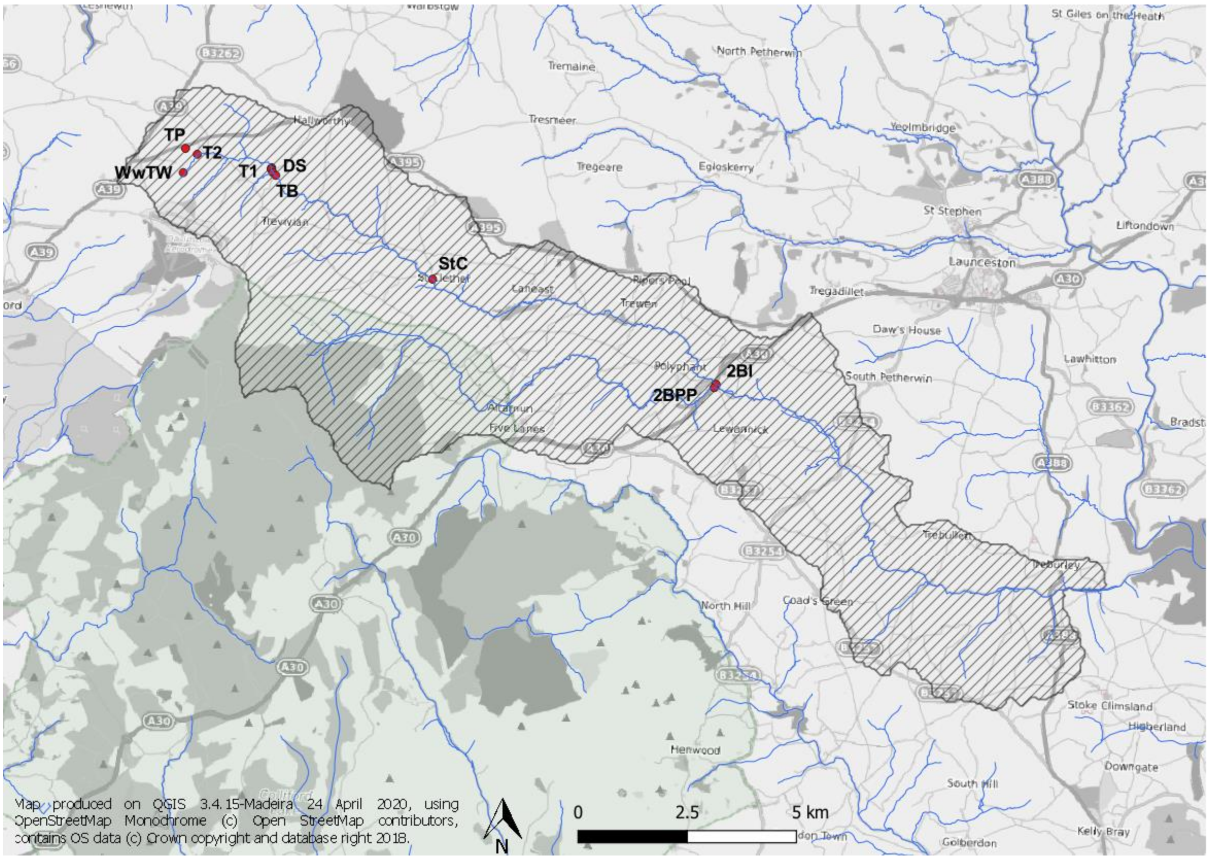


Figure 2.2 Study sample sites, showing river Inny catchment hashed.

The most upstream sample, Top of catchment (TP) is accessible from a footpath, close to Davidstow church. Dairy WwTW (WwTW1) and composite sample (WwTW2) are collected from within the wastewater treatment works (WwTW), post-treatment.

WwTW2 is a composite sample, collected for use by the WwTW for compliance measurements. The sampler draws 40 ml every 10 minutes to build a time proportional sample of approximately 6 L per day. Availability of this sample was dependent on when the last sample had been collected. Geographically, WwTW1 and 2 are the same site with WwTW1 being collected from running effluent and WwTW2 being collected from an autosampler set for temporal collection. Differentiation between WwTW1 and 2 will be seen later in the results sections.

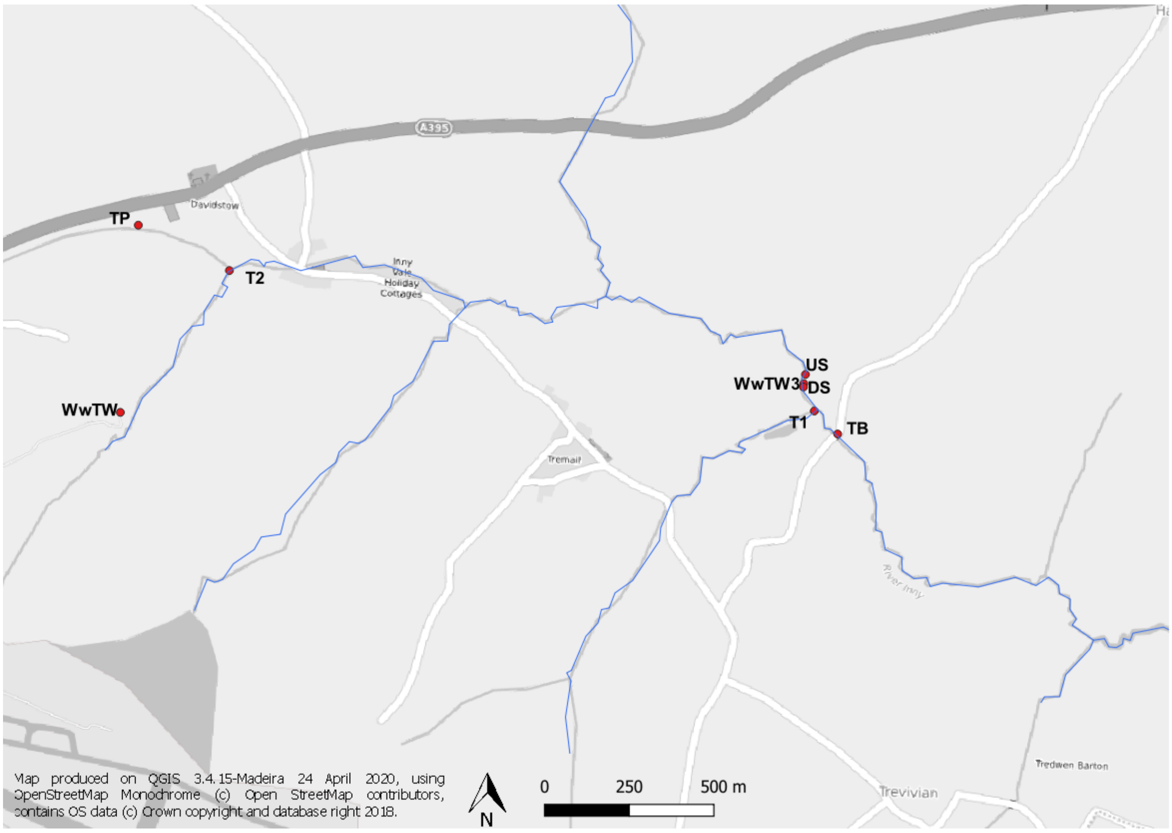


Figure 2.3 Upper catchment study sample sites.

A schematic diagram of the WwTW can be seen in appendix 2. Tributary 2 (T2) is a larger channel which joins the Inny; it flows around the perimeter of the water treatment works. Some mapping data shows conflict as to which of these two channels (TP or T2) is the course of the River Inny. Upstream (US) is collected upstream of the discharge pipe and Discharge to Inny (WwTW3), is collected from the discharge pipe itself. DS is collected downstream of the discharge input. Beyond this cluster of sample points, Tributary 1 (T1) joins the Inny below the DS site and upstream of Trewinnow Bridge (TB). St Clether Bridge (StC) is the next downstream site followed by the final sampling site on the Inny, Two Bridges – Inny (2BI). Two Bridges Penpont Water (2BPP) has been selected as a control water body, exhibiting similar land use, (Figure 2.5) geology and weather but not having a large dairy processing unit discharging into its channel. Penpont Water contributes 45% of the annual discharge as modelled at the Two Bridges Inny site (Chapter 7).

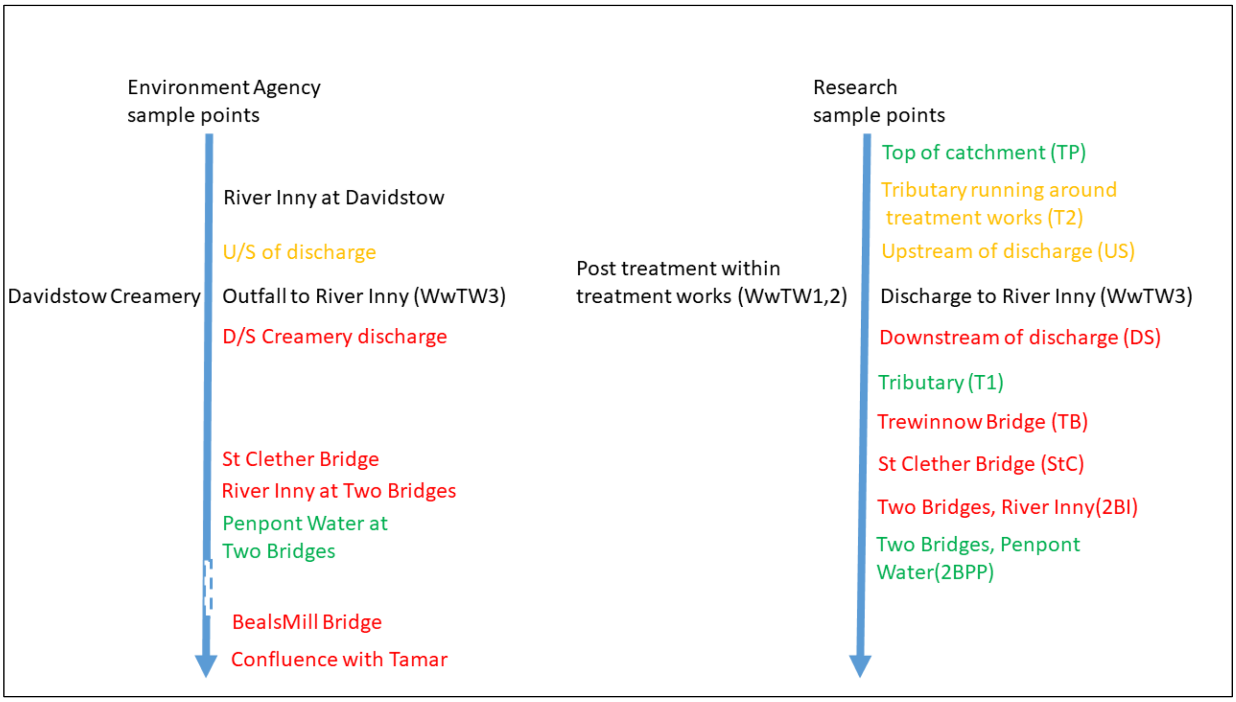


Figure 2.4 Schematic of Environment Agency (historic sampling) and study sample sites. Green text indicates sites not influenced by discharge, red sites are influenced by discharge and orange have potential to be influenced by the discharge. BealsMill Bridge and Confluence with the Tamar, although River Inny sites, were outside of the geographical area of the study.

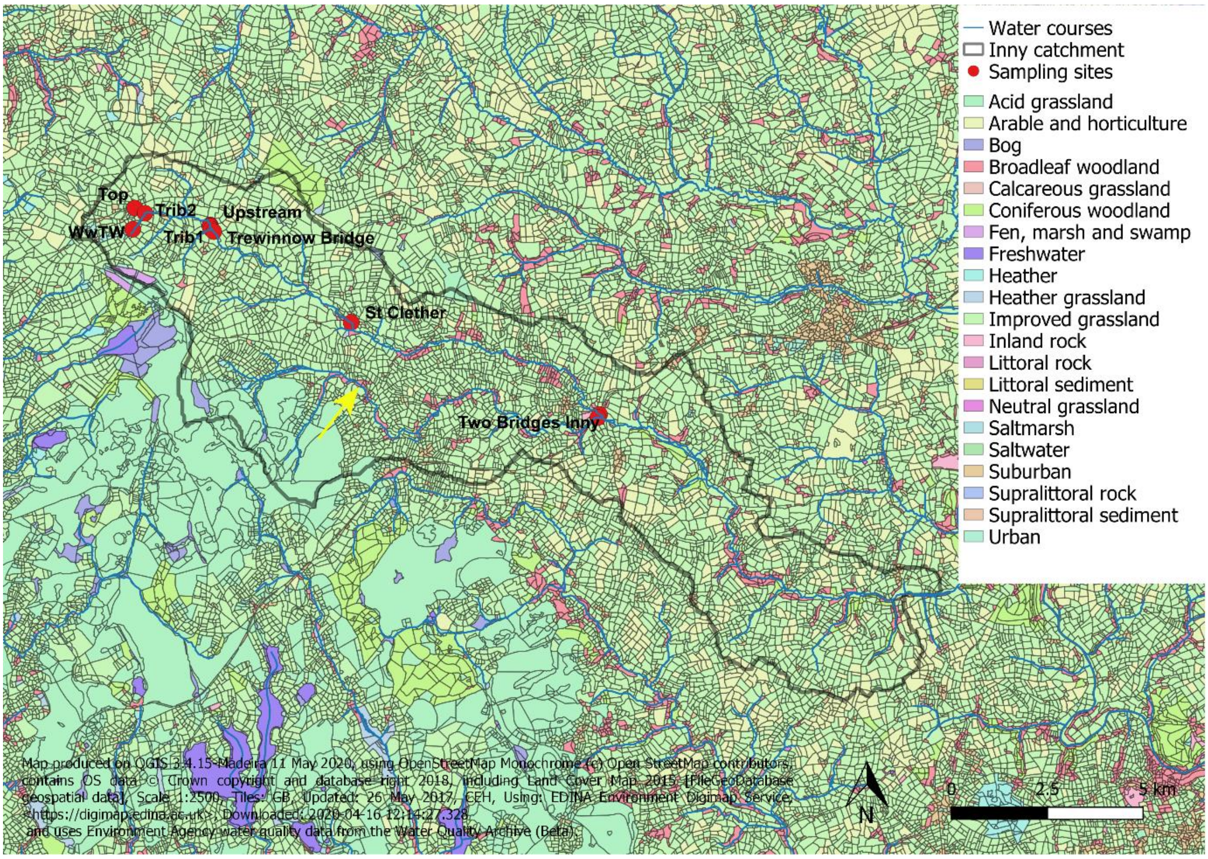


Figure 2.5 Landuse within the river Inny catchment. Yellow arrow indicates Penpont water, 2nd order stream within the catchment.

Table 2.1 Sample site locations with sample codes, distance from source and National Grid Reference.

	Site reference	Distance from source (m)	NGR
Top of catchment	TP	580	SX14934 87137
Post treatment	WwTW1	Not applicable	SX14909 86648
Post treatment (composite)	WwTW2	Not applicable	SX14909 86648
Tributary 2	T2	Enters Inny at 890	SX15203 87003
Upstream of discharge	US	2240	SX16904 86696
Discharge	WwTW3	Joins Inny at 2260	SX16899 86669

	Site reference	Distance from source (m)	NGR
Downstream of discharge	DS	2300	SX16898 86659
Tributary 1	T1	Joins Inny at 2340	SX16930 86588
Trewinnow Bridge	TB	2450	SX16999 86520
St Clether Bridge	StC	8130	SX20589 84144
Two Bridges – Penpont Water	2BPP	14580	SX27068 81663
Two Bridges – River Inny	2BI	17730	SX27081 81738

TP August 2019

T2 August 2019

WwTW1 November 2019

WwTW2 November 2019

US August 2020

WwTW3 August 2019

DS April 2019

T1 May 2019

TB August 2019

StC May 2019

2BPP May 2019

2BI April 2019

Figure 2.6 Sample site photographs

2.3 Rationale for study

Nutrient enrichment of watercourses and the prospect of finite inorganic nutrient stocks has increased the importance of understanding the nutrient flows and balances within the processing industry.

Environmental Science academics at the University of Plymouth have developed a working relationship with Saputo Dairy (Davidstow) (formally Dairy Crest (Davidstow)) over the last fifteen years. University industry links have enabled students studying for a Master's Degree in Environmental Consultancy to assist the dairy in cost benefit investigations of their processes in an attempt to improve environmental performance and efficiency.

Saputo Dairy's (Davidstow) effluent discharges to the River Inny, a tributary of the River Tamar and has to meet a phosphorus (P) permit of 1 mg L^{-1} total P (absolute), issued by the Environment Agency. Over £12m has been spent on upgrading the wastewater treatment plant (2015 to 2020, Saputo, Pers. com) prior to discharge and the phosphorus permit is now being achieved (Saputo, pers. com.). The use of iron for phosphorus precipitation means that discharges from the factory are likely to attract permits for iron and the use of salt within the production process has also drawn the attention of the Environment Agency.

A student monitoring nutrient cycling within the dairy approached the university academics to discuss the prospect of a wider investigation of perceived nutrient enrichment from the treated liquid waste produced by the dairy unit and its impact on the receiving waters.

The impact of the sites discharge(s) have been a concern to the Environment Agency regarding the impact on water quality of the River Inny downstream. Monitoring data do show elevated P, K, Na, chloride and iron concentrations downstream of the site. There is, however, a lack of clarity to the actual impacts on the stream's diatoms, invertebrates and macrophytes. Furthermore, the use of iron dosing of the effluent also affects the form of the phosphorus, potentially making it significantly less bioavailable (Comber *et al*., 2015) and hence potentially reducing its impact on the receiving waters than measurement of total phosphorus would suggest.

Coupled with a future perceived to have more stringent nutrient control from environmental regulators, the basis of a long-term research project was instigated.

2.4 Field measurements

During fieldwork, measurements were taken of pH, temperature, conductivity, mean channel depth, dissolved oxygen (ppm), saturated oxygen (%), turbidity (FAU) and suspended solids (mg L^{-1}). Readings of pH were taken using Oakton Ion 6+ meter with Mettler Toledo pH probe, calibrated with pH 7 and 4 buffer before use. Conductivity and temperature were measured using an Orion 105 Conductivity meter with results recorded with automatic temperature compensation (ATC). Channel depth was measured manually with a folding 1 m rule, across the channel at 3 points to give a mean depth. Dissolved oxygen (ppm) and saturated oxygen (%) were measured using EcoSense DO200A Dissolved oxygen and temperature instrument, calibrated with air pressure forecast at Davidstow viewed on Met Office weather app on the day of sampling. Turbidity and suspended solids were measured on Hach DR900 using programmes 745 FAU and 630 respectively. Formazin Attenuation Units (FAU) signify that the instrument is measuring the decrease in transmitted light through the sample at an angle of 180 degrees to the incident light (HACH, 2019). Field data can be seen in Appendix 2. Methodologies used for water sampling, invertebrate and diatom sampling and macrophyte sampling are addressed in chapters 4 and 5.

3 Review of historic water quality

3.1 Introduction

In this chapter, context will be given to regulation and monitoring of water quality. Background is provided regarding the principal tools that drive water quality in England. The work contained therein fulfils objective 1 of the study (Figure 1.1).

3.2 Water Framework Directive

Across the globe, governments are becoming more aware of the importance of managing watercourses in a healthy condition. The protection of water quality and water-related ecosystems are explicitly included within the UN Sustainable Development Goals (Carvalho *et al*., 2019).The Water Framework Directive is the cornerstone of European Union water policy with the objective to protect and enhance the status of aquatic ecosystems (Carvalho *et al.*, 2019).

On the 23 October 2000, the EU Water Framework Directive (WFD) was adopted. The rationale behind the directive was to '*Get Europe's waters cleaner by managing water on a river basin scale*'. Under the European Union WFD (2015) (Directive 2000/60/EC of the European Parliament and of the Council of 23rd October 2000), the UK Government agreed environmental quality standards in the field of water policy and technical specifications for chemical analysis and monitoring of water status of water bodies (lakes and rivers) in the UK. The aim of the directive is for waterbodies to achieve good ecological and chemical status via compliance with standards and guidelines on how waterbodies are managed and monitored. In an attempt to show water quality comparison across the European Union, a range of environmental quality bands have been established to grade water quality from 'Bad', to 'Poor', to 'Moderate', to 'Good', to 'High'. The grading considers the water chemistry, hydrological modification, fish, invertebrates and phytobenthos with overall status defined by the worst performing element. (European Union, 2015; Carvalho *et al*., 2019).

For the chemistry, Environmental Quality Standards (EQS) are set at a European level for priority and priority hazardous substances (such as persistent organic pollutants, solvents, pesticides and metals) and legacy pollutants such as organochlorine pesticides and poly chlorinated biphenyls (PCBs). At a Member State level chemicals of local concern can be identified as specific pollutants (e.g. copper, zinc, chromium, cyanide for the UK) and physico-chemical parameters that support the ecology such as pH, dissolved oxygen, suspended solids, nitrate (estuarine and coastal waters) and phosphate (river waters).

In addition to achievement of 'Good' status of its rivers by 2015, member states were requested by the Directive to ensure no deterioration of their waterbodies occurred. If failure was expected, the regulatory body of each member state needed to develop a framework to establish reasons for not meeting the good status, together with planned actions for how to achieve it (termed programmes of measures). Owing to the poor condition of some waterbodies, it was accepted that some could not meet good status owing to disproportionate burdens', i.e. disproportionate cost versus the ecological benefit that would be gained. Member states reported substantial delays in implementing many of the measures planned. Only around 20% of WFD basic measures were reported as completed by 2015, and only 10% of supplementary measures to tackle hydromorphological and diffuse sources have been completed (75% are ongoing, 15% have not yet started) (Carvalho *et al*., 2019).

3.3 Environmental quality assessment standards of a riverine environment

Across EU member states great effort and success has been made in developing robust and comparable methods for ecological status assessment (Carvalho *et al*., 2019). The UK contains a network of rivers and waterways amounting to over 200,000 kilometres (National River Flow Archive, 2019). Water quality within these channels varies considerably and it is challenging to find a riverine environment that is not impacted in some way by anthropogenic activities (Heathwaite, 2010; Kelly *et al*., 2008; UKTAG, 2014)

A healthy riverine environment will contain a complex interactive community of mammals, fish, plants, invertebrates, and phyto-benthos, including mosses and bryophytes, algae and diatoms. These organisms require physico-chemical parameters noted above to be within an optimum range for any given river typology. Their specific environmental requirements have been identified and utilised for modelling water quality based on their presence and or absence within the water body. The chemical status of a waterbody is determined by analysing and assessing concentrations of 45 (groups of) priority / hazardous substances. A good chemical status is reached when the concentrations of all priority substances are below the annual average and maximum allowable concentration (Escher *et al*., 2018). Other supporting parameters include pH, DO, and nutrient status associated with P and N (European Commission, 2013, Schedule 3).

Where a planned waste discharge is proposed from an industrial plant, e.g. milk processing, brewery, the regulatory authority, the Environment Agency in England, will work with the organisation to agree a set of discharge permits whereby the composition of any liquid discharge to surface water does not exceed the agreed levels. This is to ensure that the waste discharge does not cause a failure of water quality standards in the downstream ecosystem (Environment Agency, 2019).

The restrictions attached to the discharge permit are arrived at through an assessment of the volume of waste to be discharged, based on the population equivalent[1] of the wastewater treatment works' (WwTW) size, together with the addition of any parameters of scheduled chemicals as identified within Part 3 of the WFD (European Union, 2015) and to where the final destination of the post treatment discharge will be. Some water bodies are considered 'sensitive areas', for example eutrophic freshwater, estuarine or coastal waters; nitrate sensitive areas and areas requiring additional treatment to ensure compliance with related EU directives, for example the bathing water directive (Environment Agency, 2019). Upon entering the WwTW, the waste must be subjected to 'appropriate' treatment, which on completion will allow the discharge entering receiving waters to meet relevant regulations. Industrial discharges require a minimum of secondary treatment, involving biological digestion, and more likely a chemical and/or mechanical tertiary treatment process, to reduce potential nutrient loading of the receiving waters.

The sample point from where the effluent sample is taken must be representative of the treated discharge. This might require the sample being regularly collected via an auto sampler rather than a grab sample, in order to get a more accurate temporal measurement and avoiding inconsistencies that may occur in effluent concentrations owing to process variability. Specific conditions might be agreed upon how the composite sample should be collected and stored, in order to represent a 24h

[1] Population equivalent can be calculated as 60g of BOD being equivalent to 1 person per day.

representative mixed sample. Inline monitoring equipment will need to be compliant with the conditions set by the environmental permit.

An element of self-monitoring or monitoring by an external accredited agency of the discharge composition is required at pre-defined intervals, typically monthly. The frequency is determined by the size of the WwTW and may result in monitoring requirements for BOD and COD, as well as total phosphorus, total and ammoniacal nitrogen, flow, pH, conductivity and suspended solids. Results must be submitted to the Environment Agency at an agreed frequency for compliance assessment to be undertaken. If agreed conditions are breached, they need to be communicated to the Environment Agency and this will start an investigation as to how and why the breach has occurred. Failure to submit records to agreed timescales is classed as a breach of conditions. Following the issue of any discharge conditions, any subsequent planned change to production that is likely to result in changes in waste volume production and composition will require a review of existing permits with the Environment Agency.

3.4 Environment Agency historic data

Within England, the quality of designated waterbodies is monitored by the Environment Agency. Frequency of testing is determined by the Environment Agency and has reduced over the last twenty years as financial pressures impact the wider monitoring work undertaken (Greenpeace, 2018; 2019).

Measurements are taken for a variety of reasons, from routine monitoring for Water Framework Directive Compliance monitoring (European Union, 2015), to monitoring for adherence to permitted discharge consents to reactive monitoring following a reported pollution event. A wide variety of different parameters are measured: chemical, biological and physical.

Historic monitoring data for the River Inny was accessed from the Environment Agency's Water Quality Archive (Environment Agency, 2020) which uses Environment Agency water quality data from the Water Quality Archive (Beta). Datasets for Devon and Cornwall from 2000 to 2019 were downloaded and filtered to select River Inny sites subject to a routine and compliance monitoring regime (Figure 3.1) using Microsoft Excel. Monitoring associated with specific pollution incidences were excluded from the review so that trends in data were not subject to bias.

Where available, measurements for Penpont Water, a neighbouring river were downloaded from Two Bridges for comparative purposes with the River Inny (see 2.0 Locations and rationale for study) but were not consistent in their range of parameters. Data for orthophosphate, iron, chloride, potassium, sodium, dissolved oxygen and temperature were plotted for sites in close proximity to those monitored within this study (see Figures 2.2 and 2.3). These parameters were reviewed as initial analysis of water quality suggested them to be of significance due to their concentrations within the Saputo effluent at elevated levels and their potential impact on biota. Owing to the considerable variation in concentrations, the axes do not report the same values in each chart. Variability in the data is plotted on the charts as two x the standard deviation. About 95% of observations will fall within the 2 standard deviation limits (Altman & Bland, 2005).

In terms of nomenclature, historic data were not available for the same phosphorus forms as those measured throughout the fieldwork. Orthophosphate is measured by the Environment Agency indicative of the 'bioavailable form of phosphorus,' it cannot be seen as soluble reactive phosphorus, as it is not filtered unless the analyst considers it to be too turbid to analyse, leading to settlement or filtration prior to analysis. It may be considered to be broadly comparable with total reactive phosphorus as defined in this study.

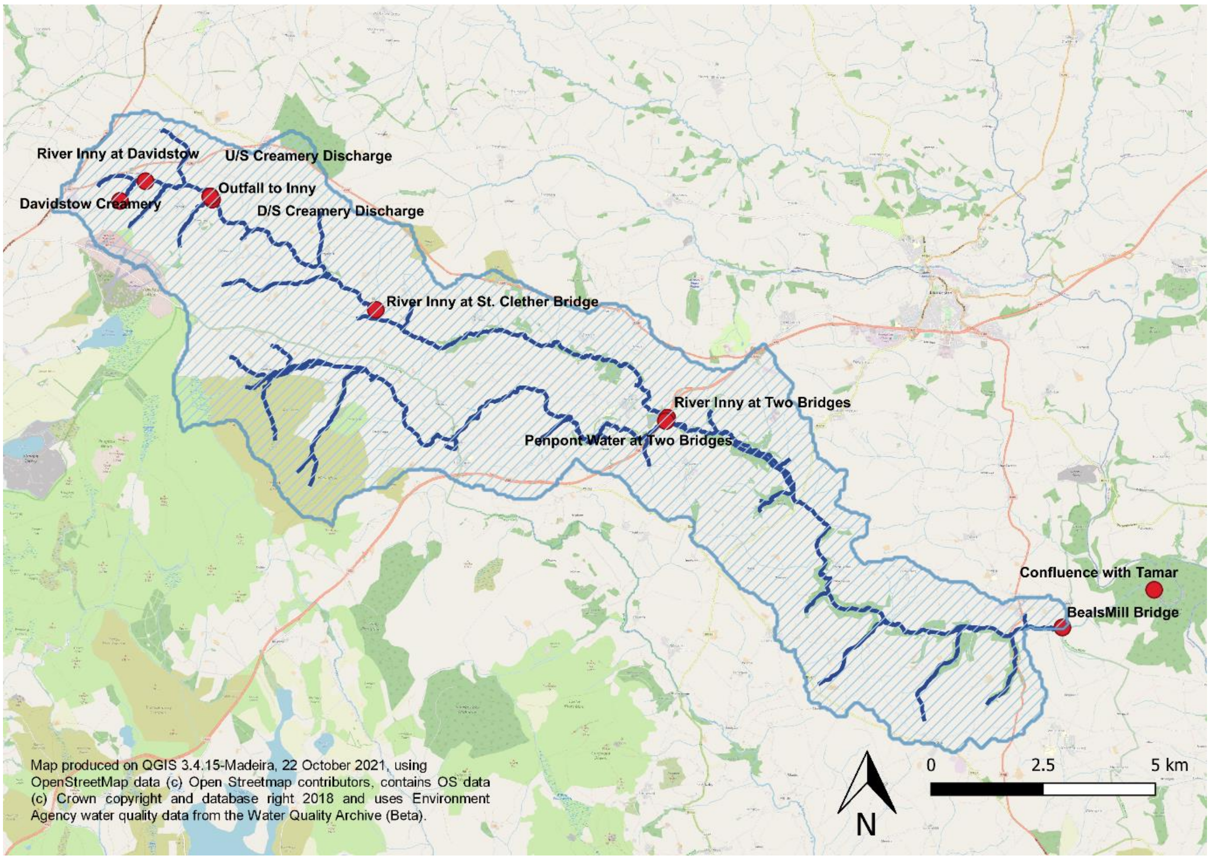


Figure 3.1 Locations of River Inny Environment Agency monitoring sites used for historic data comparison. Hashed area highlights the Upper Inny catchment Penpont Water was sampled adjacent to 2B Inny. Davidstow Creamery is the WwTW.

3.5 Orthophosphate

Data for orthophosphate was accessed for upstream (US) of the outfall, WwTW, the outfall, downstream (DS) of the outfall, St Clether Bridge, 2B Inny, Bealsmill Bridge and the Inny Tamar confluence. Around 2003 (Saputo pers.com), the discharge point to the River Inny from the WwTW was moved downstream to its current location. Prior to this, the discharge entered the river upstream of Inny Vale holiday Park (Figure 3.2). Figure 3.4 shows the concentration of P as orthophosphate, US of discharge. Mean concentrations across the data period, show a range of 29 to 183 µg P L^{-1} as orthophosphate.

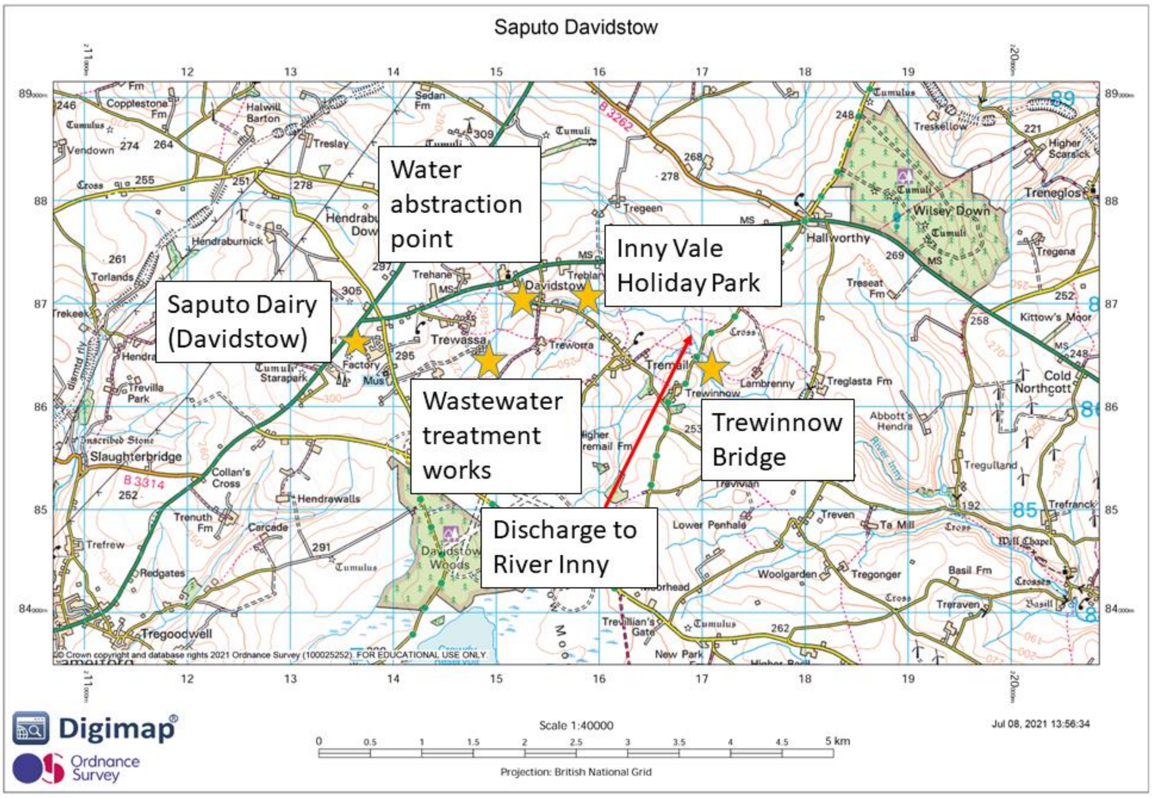


Figure 3.2 Location map of head of River Inny catchment

Around 2011/2012, in an attempt to improve P removal, investment within the WwTW modified the treatment process to include additional aeration within the biological treatment tanks. Observations have been made of an overflow from the WwTW outfall pipe entering the River Inny (Figure 3.3) at Inny Vale. This could have resulted in the spikes observed in this data set since the outfall point was moved downstream. The following graphs with green horizontal lines are showing

Figure 3.3 Outfall drain overflow at Inny Vale, November 2019

the site-specific upper boundary concentration for ‘Good’ status for the phosphorus Environmental Quality Standard (EQS). This threshold is only available for river sites where a value for alkalinity could be determined from the existing EA data sets. They are presented to illustrate how measured phosphorus concentrations comply with the ‘Good/Moderate’ status boundary for environmental quality.

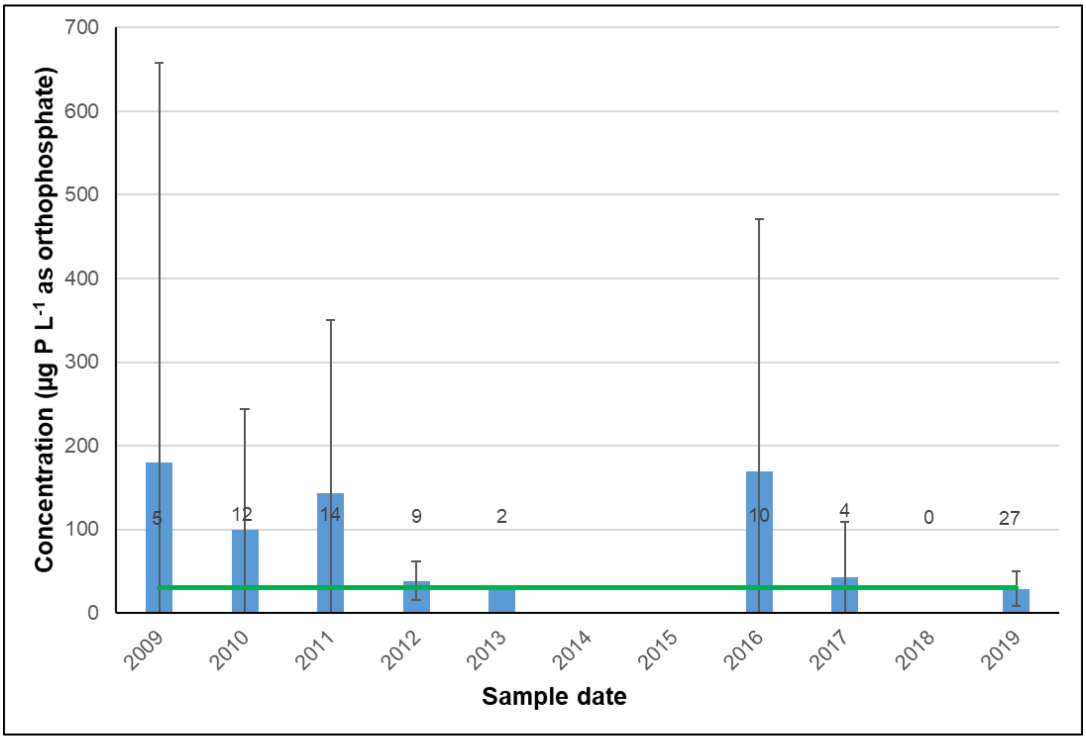


Figure 3.4 Concentration of orthophosphate, US of discharge. Error bars represent 2xSt Dev. Number on bar = n. EQS represents site-specific upper boundary for 'good' status.

Data for 2017 (Figure 3.5) were not available and for 2019 the frequency of sampling was reduced compared with other years. The spike in orthophosphate in 2016 coincides with the start of demineralisation of whey at the dairy to produce galacto-oligosaccharides (GOS) and probiotics for the food industry. This increased the concentration of phosphorus within the WwTW effluent which can be seen in Figure 3.5 together with a large variation around the mean. Effective management of phosphorus within the modified discharge was challenging until an additional dissolved air flotation unit (DAF) came online in March 2017. The DAF assists in the removal of suspended solids from wastewater.

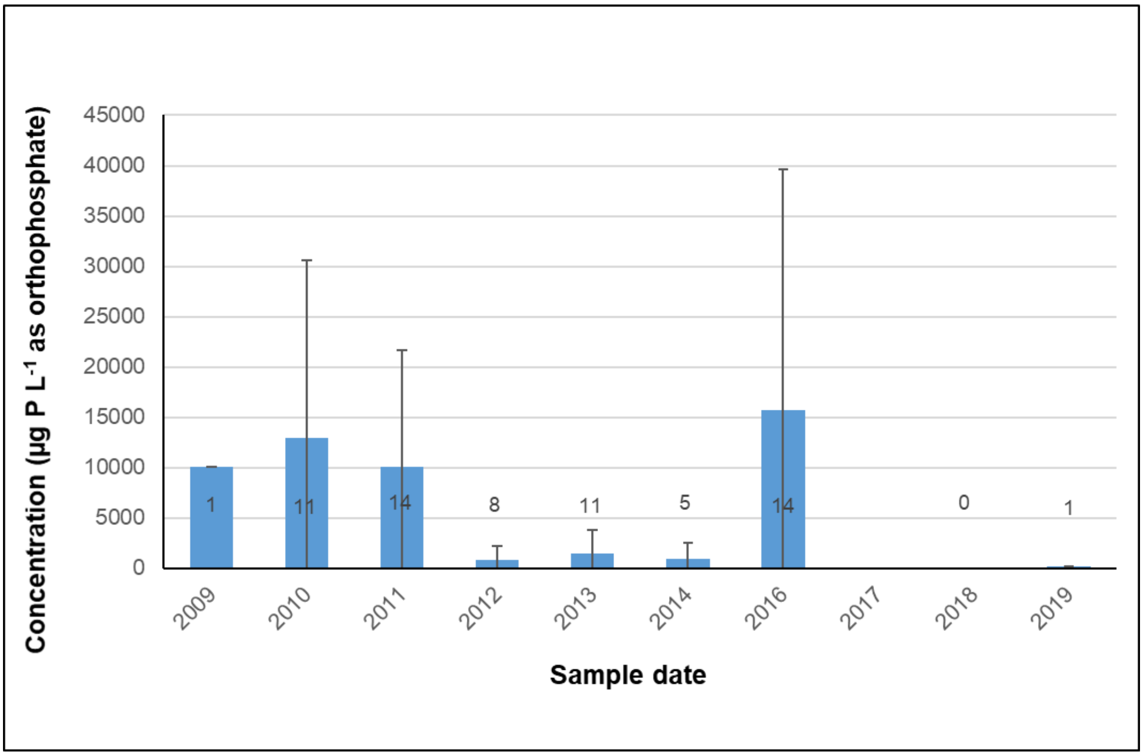


Figure 3.5 Concentration of orthophosphate, post treatment at Davidstow WwTW. Error bars represent 2xSt. Dev. Number on bar = n.

Insufficient historic data was available to show concentration of orthophosphate within the discharge to the River Inny across multiple years, but data for this site were collected frequently during 2019 (Figure 3.6).

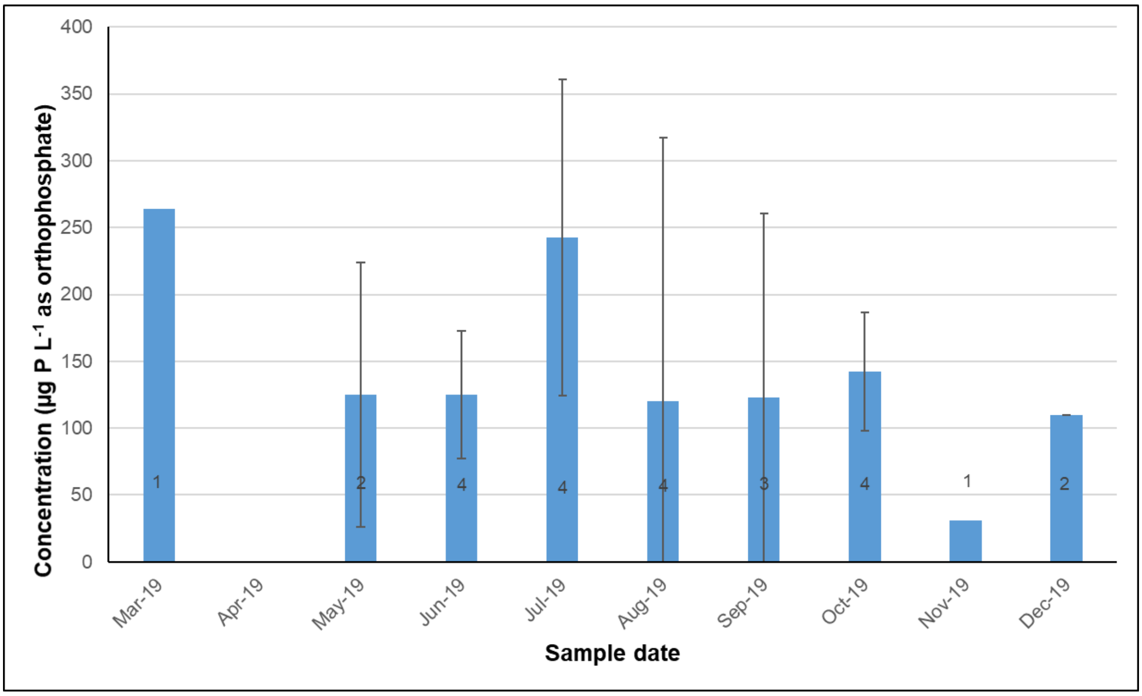


Figure 3.6 Concentration of orthophosphate, within outfall. Error bars represent 2x St Dev. Number on bar = n.

Downstream of the discharge to the River Inny, considerable variation in concentration is again observed (50 to 2147 µg L^{-1} orthophosphate as P) (Figure 3.7). Data graphed were averaged but not all years have the same monthly measurements, n=2 to 25. Variation in concentration through 2016 range from 92 µg L^{-1} orthophosphate as P in November, possibly low due to plant shutdown and maintenance, to 6220 µg L^{-1} orthophosphate as P in August. Of the 10 data points for 2016, 4 were >1000 µg L^{-1} orthophosphate as P. Concentrations observed within the receiving waters are also affected by the volume of water in the river, which has seasonal variation. (Mean depth range 0.08 – 0.43 cm) (See Appendix 2 and Figure 7.2).

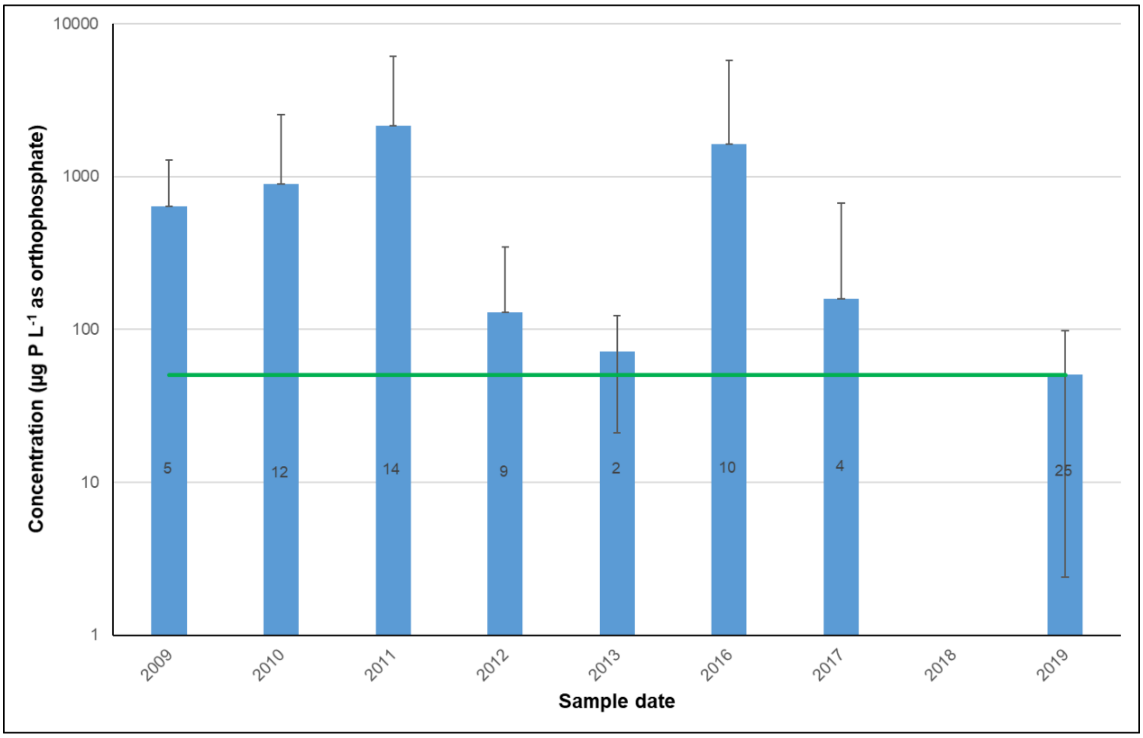


Figure 3.7 Concentration of orthophosphate, DS of discharge. Error bars represent 2xSt. Dev. Number on bar = n. Environmental Quality Standard represents site-specific upper boundary for 'good' status. Presented using log axis in order to illustrate lower concentration data

Comparison of in channel orthophosphate concentrations upstream with those downstream of the discharge point (Figure 3.8) during 2019, illustrates a clear impact on the channel chemistry, accentuated by seasonal flow patterns. Throughout the year, the upstream concentration (mean) remains below the upper boundary for good EQS, within a range of 18 to 53 µg L^{-1}. As expected, downstream of the discharge point, orthophosphate range is higher, at 23 to 110 µg L^{-1}. There is considerable variation in the downstream concentration until October 2019. Planned maintenance occurs for one week in mid-November with the residence time within the WwTW of the influent/effluent around five days.

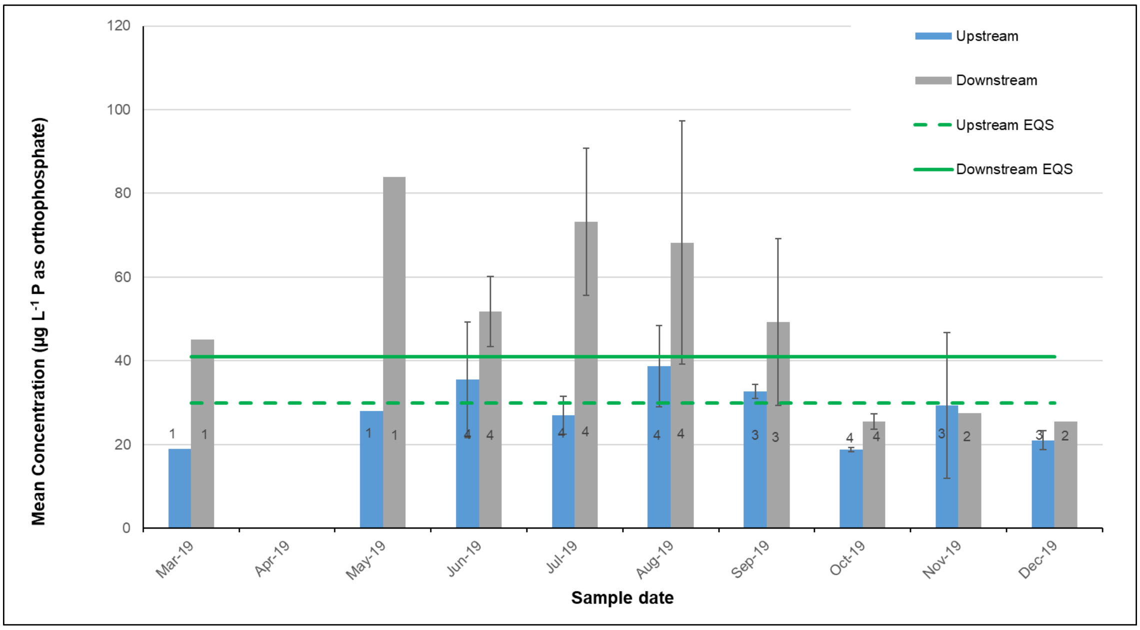


Figure 3.8 Concentration of orthophosphate, US and DS of discharge for 9 months during 2019. Error bars represent 2x St Dev. Number on bar = n. EQS represents site-specific upper boundary for 'good' status.

St Clether Bridge is 5 km downstream from the outfall. Figure 3.9 shows P as orthophosphate, where the mean range is 15 – 819 µg L^{-1} P as orthophosphate. Once again, the data shows considerable variation by season and year on year, with 7 of the last 8 years showing the lowest concentrations within the 20 year review period.

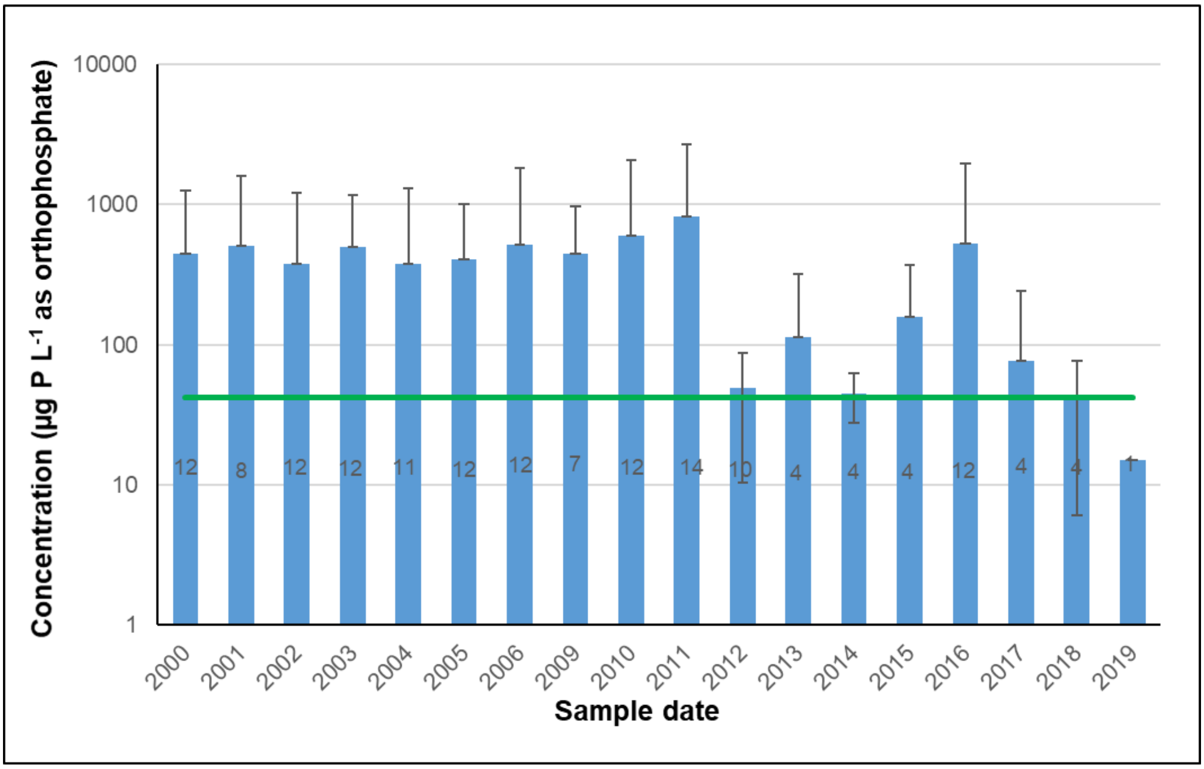


Figure 3.9 Concentration of orthophosphate, St Clether Bridge. Error bars represent 2x St. Dev. Number on bar = n. Green line represents site-specific Environmental Quality Standard of upper boundary for 'Good' status. Presented using log axis in order to illustrate lower concentration data.

Two Bridges picnic stop on the A30 is the sample location for both 2B Inny and 2B Penpont. At 2B Inny, 15 km downstream from the outfall, the mean concentration of orthophosphate as P ranges 28 – 458 µg L^{-1}. Figure 3.10 shows that the sampling at the Inny shows a similar pattern to that measured at St Clether, with a spike in 2016, resulting from the two high P discharges in August and September of that year, likely to be associated with the demineralisation plant. The step change in 2011 / 2012 can also be seen when the additional DAF capability came online.

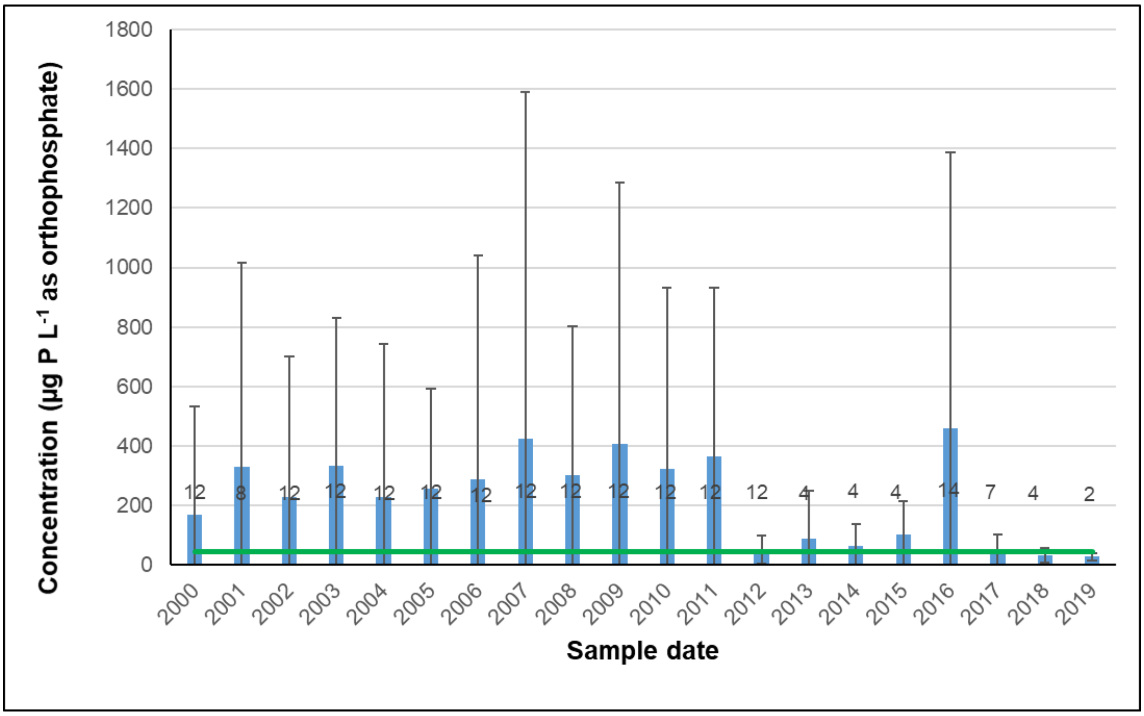


Figure 3.10 Concentration of orthophosphate, 2B Inny. Error bars represent 2xSt. Dev. Number on bar = n. Environmental Quality Standard represents site-specific lower boundary for 'good' status.

The last monitoring point before the Inny catchment drains into the River Tamar is at Bealsmill Bridge (Figure 3.11) Environment Agency data were less readily available from this site. Mean concentrations of orthophosphate are of the range 32 to 102 µg L^{-1}.

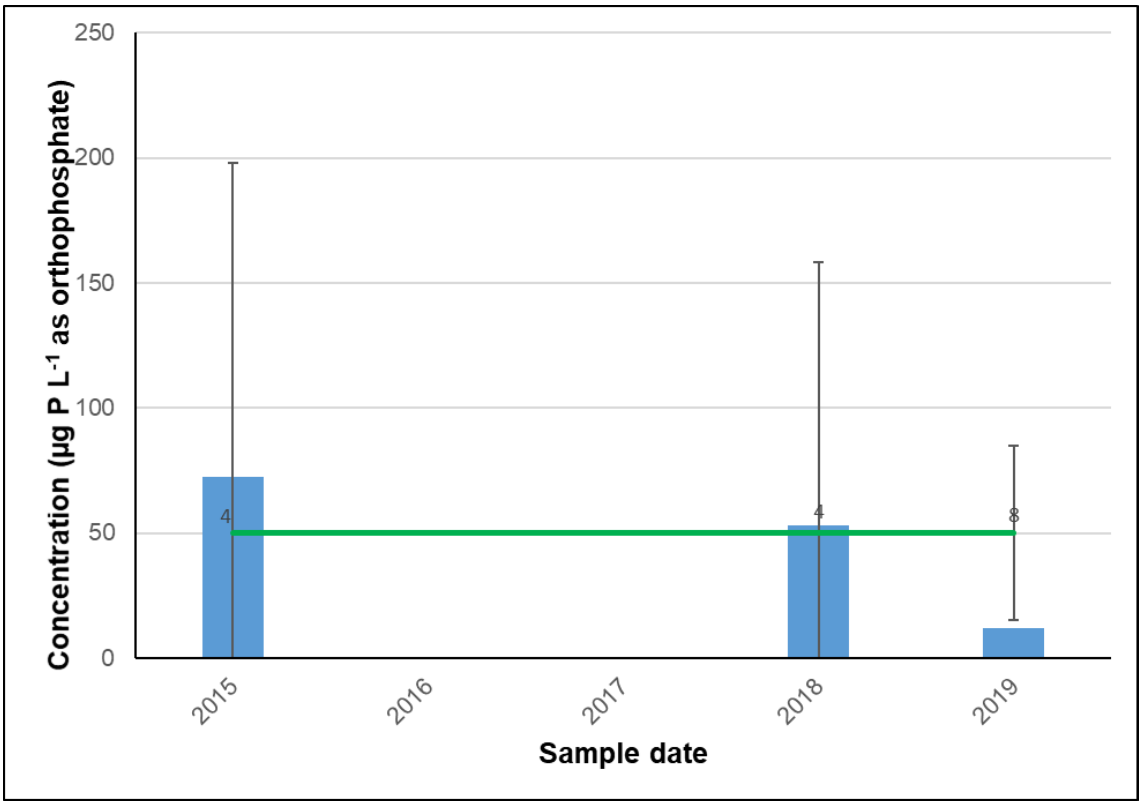


Figure 3.11 Concentration of orthophosphate, Bealsmill Bridge. Error bars represent 2xSt. Dev. Number on bar = n. Environmental Quality Standard represents site-specific lower boundary for 'good' status.

A final historical sample point on the River Inny was identified as 'Miscellaneous Inny' and is located at the Inny/Tamar confluence. The majority of the data measured at this site (36 of 38, across the years 2001-2002, 2009-2012, 2014 and 2018-2019 were 'Unplanned Reactive Monitoring (Pollution Incident)' visits. Data is not in line with patterns discussed so far and will not be included in further discussions.

3.6 Iron

The EQS for dissolved iron is 1 mg L^{-1} (Environment Agency, 2007). However, owing to the complex chemistry of iron, and interaction with other elements, toxicity of iron can vary under differing water conditions (e.g. differing concentration DOC). Further studies have proposed a threshold of 0.73 mg L^{-1} total iron for the protection of sensitive taxa, and a threshold of 1.84 mg L^{-1} total iron for the protection of the whole community (Peters *et al*., 2012).

Hydrologically, this area holds a considerable number of springs and background geological iron concentrations are around 5% in sediment (British Geological Survey, 2000) (Appendix 3). Historic data for total iron concentrations over the period 2000-2019 are less readily available than those for orthophosphate. Measurements were taken upstream of the discharge point, from within the WwTW, from the outfall, downstream of the outfall and from the confluence.

Upstream of the outfall, data were only available for four months during 2019. Figure 3.12 shows a mean concentration range of 151 – 403 µg Fe L^{-1}. Insufficient historic data were collected from within the WwTW to plot, however data was available to show concentration of iron within the post treatment effluent for this site collected as a part of this study and is shown in Figures 4.23 and 4.24.

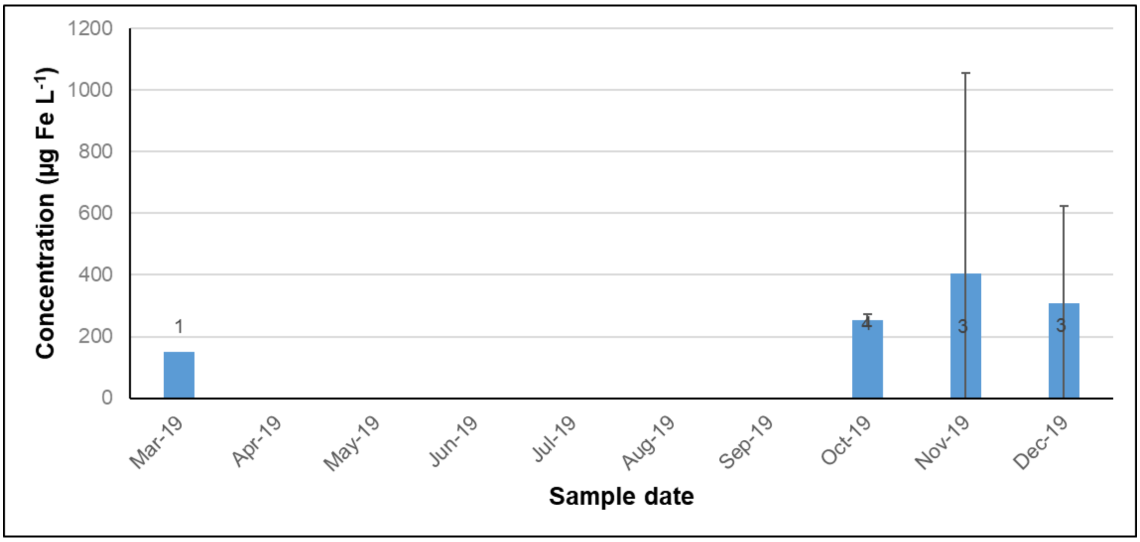


Figure 3.12 Concentration of iron as Fe (total iron), US of outfall. Error bars represent 2xSt. Dev. Number on bar = n.

Iron concentrations within the discharge (Figure 3.13) are in the range 1140 – 1900 µg Fe L^{-1} around three times higher than that of the receiving waters (Figure 3.12). Within the waste treatment process, ferric chloride is added to the influent to flocculate out the reactive phosphorus to meet the statutory permit. This can increase the concentration of residual iron within the effluent.

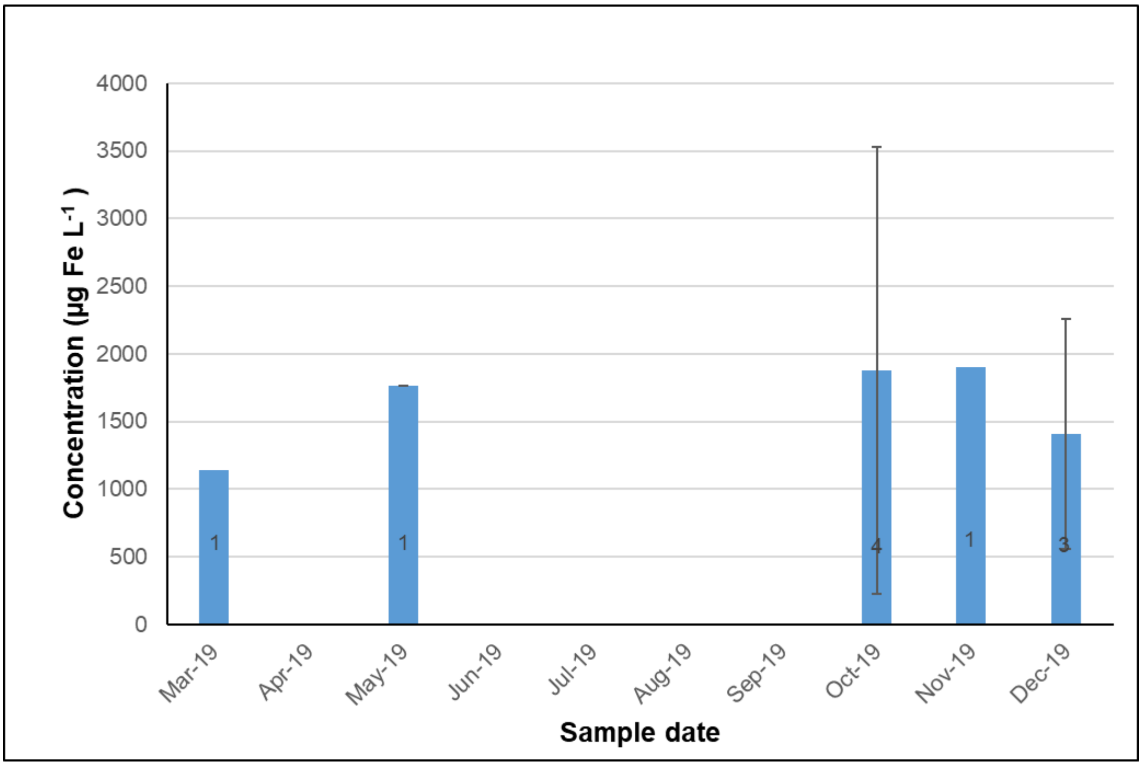


Figure 3.13 Concentration of iron as Fe in discharge. Error bars represent 2xSt. Dev. Number on bar = n.

Downstream of the discharge (Figure 3.14), mean concentrations of iron are around 240 – 510 µg Fe L^{-1}. Variation is high for November and December. During late November, annual planned plant maintenance takes place and this variation could be associated with waste composition changes during the plant shut down and subsequent resuspension of iron deposits from the discharge pipe. Increased river flows could also be re-suspending iron rich sediments.

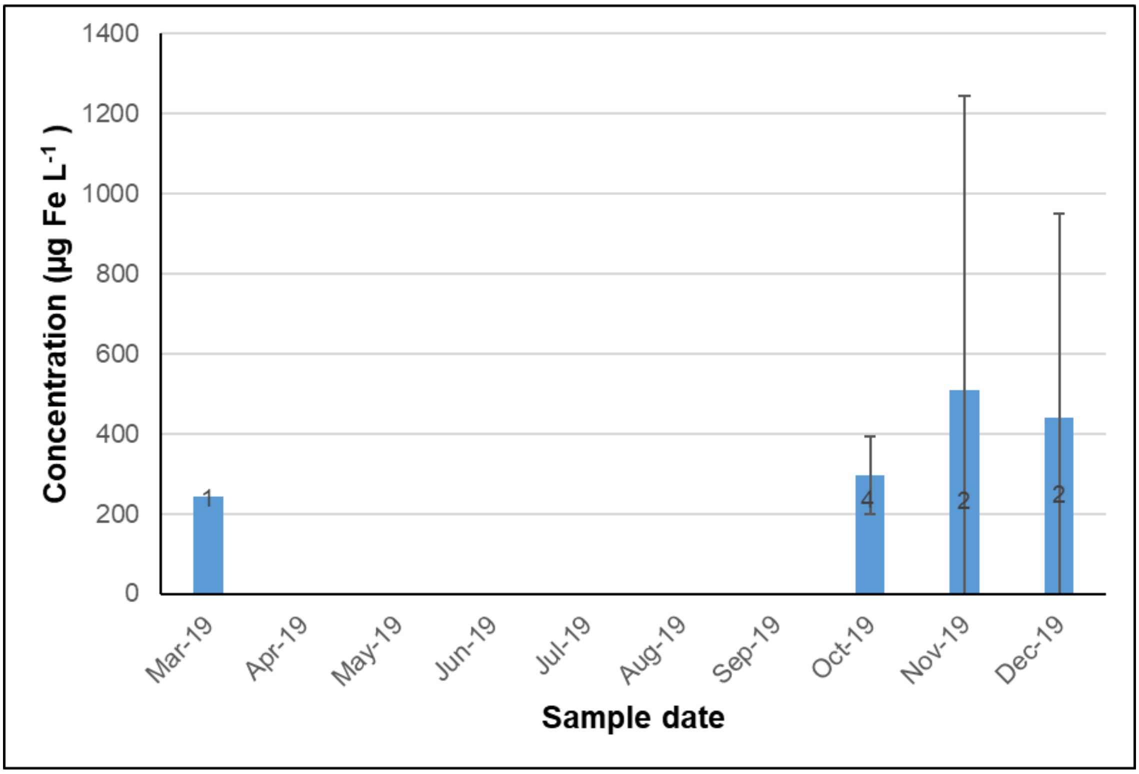


Figure 3.14 Concentration of iron as Fe, DS of discharge. Error bars represent 2xSt. Dev. Number on bar = n.

3.7 Chloride

Chloride data of varying frequency for the sites were downloaded for the period 2000 – 2019. Chloride concentrations upstream of the outfall are shown in (Figure 3.15). The earliest measurement available was 2016. Mean concentrations range from 51 mg L^{-1} in 2019 to 79 mg L^{-1} in 2016.

Post treatment within the WwTW, mean chloride concentrations within the effluent range 3698 mg L^{-1} in 2016 to 2680 mg L^{-1} in 2019. Chloride concentrations are raised due to waste composition generated during the reconstitution of demineralisation columns using hydrochloric acid.

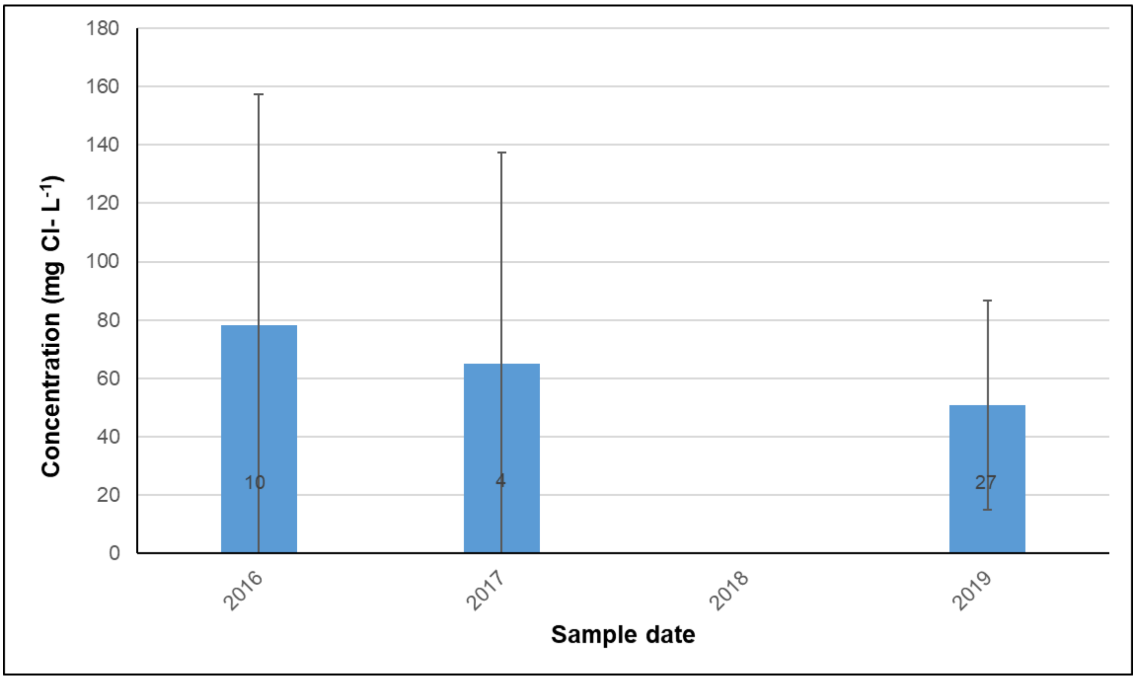


Figure 3.15 Concentration of chloride US of discharge. Error bars represent 2xSt. Dev. Number on bar = n.

At the outfall (Figure 3.16), mean chloride concentrations were measured as 3617 mg L^{-1} in 2019. There is no consistency in the frequency of measurements across the 20 year period monitored, nor the frequency of monitoring episodes in each year.

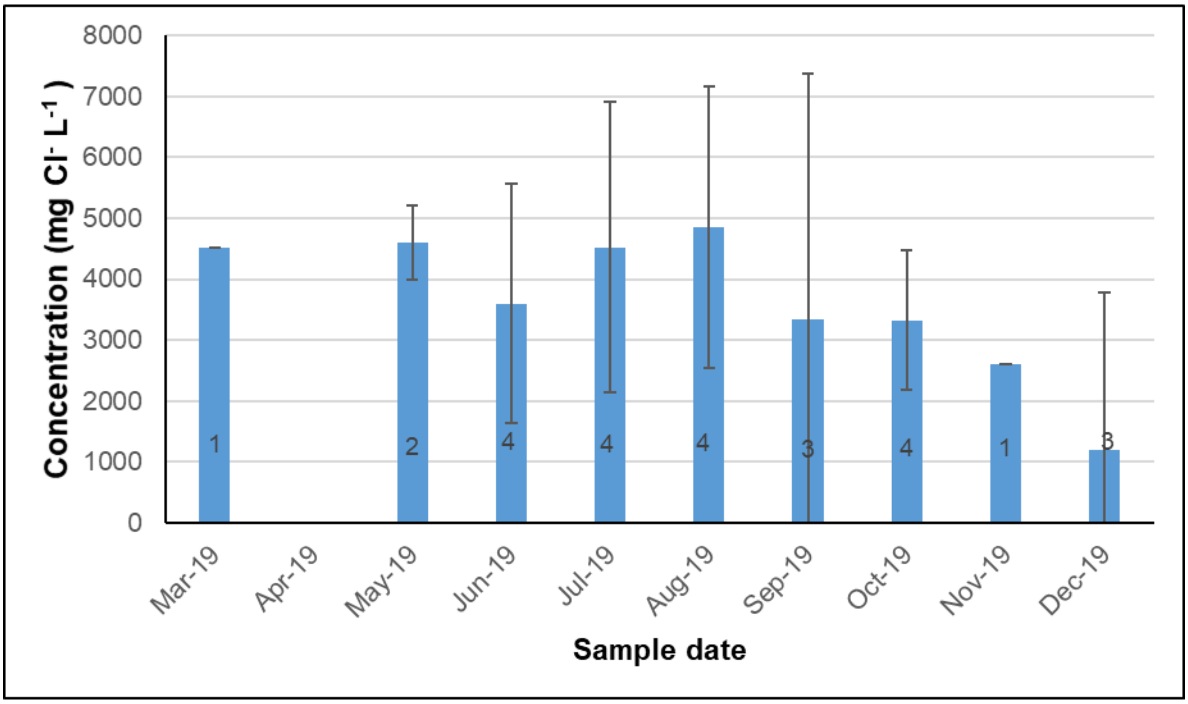
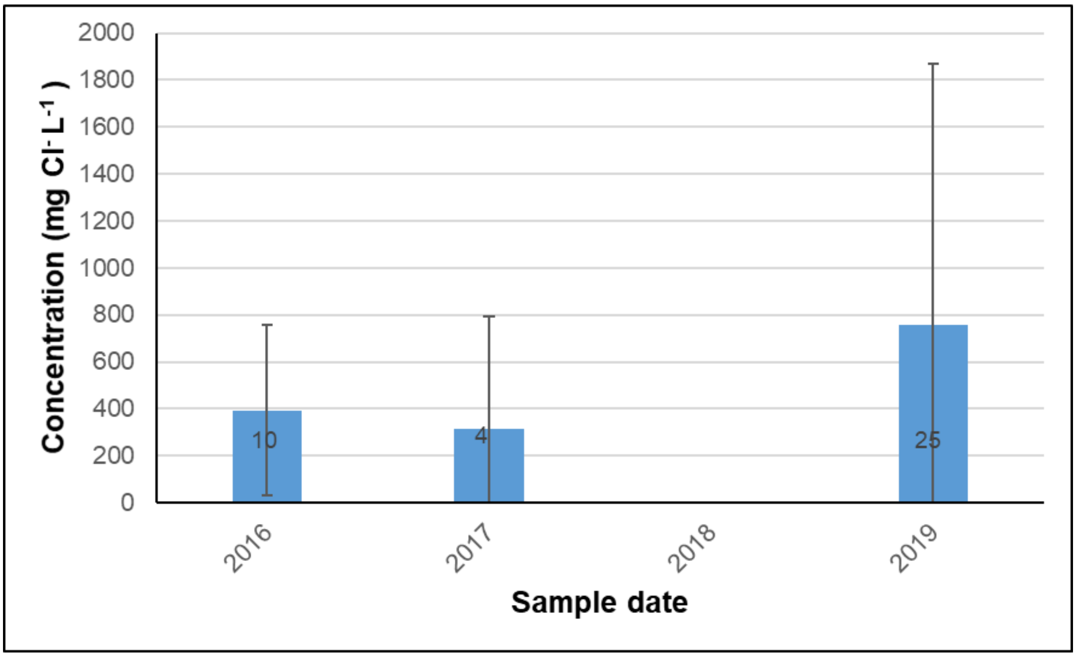


Figure 3.16 Concentration of chloride within outfall discharge. Error bars represent 2xSt. Dev. Number on bar = n.

Downstream of the outfall (Figure 3.17A) mean concentrations of chloride range from 394 mg L^{-1} in 2016 to a high of 1420 mg L^{-1} in 2018, a pollution monitoring episode and 756 mg L^{-1} in 2019. Compared with the concentrations upstream of the outfall, 2016 saw a 295 mg L^{-1} increase in chloride concentration, 2017 saw a 249 mg L^{-1} increase in concentration and 2019 saw a 705 mg L^{-1} increase in chloride concentration. The dilution resulting from the effluent mixing with the receiving waters gave a reduction in chloride concentration of 2356 mg L^{-1} in 2016 and 3132 mg L^{-1} in 2019, comparing outfall concentration with downstream concentration. 2019 Saw a more intensive sampling regime and mean monthly data are shown in Figure 3.17B.

A



B

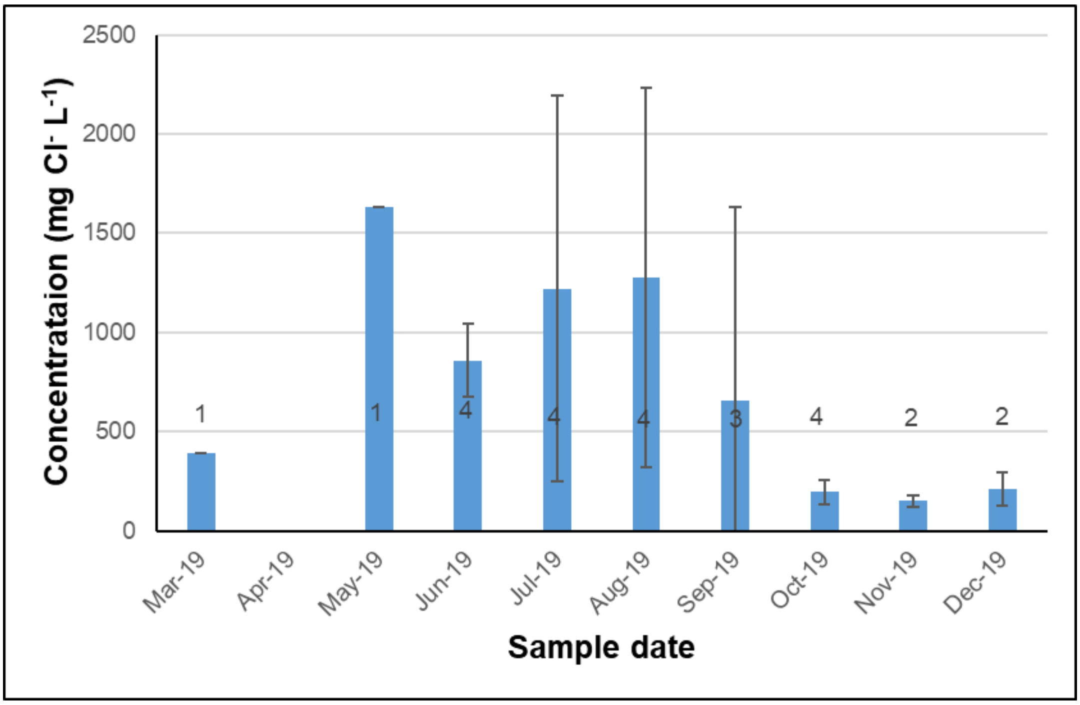


Figure 3.17 Concentration of chloride DS of outfall. A) Available historic data 2000 to 2019, excluding pollution incidence (2018). B) Mean monthly concentrations for 2019. Error bars represent 2xSt. Dev. Number on bar = n.

Environment Agency data were only available for 2016 at St Clether Bridge (Figure 3.18). Apart from November, there is little variation in concentration across the 5 month data set. During November, the dairy has a full maintenance shut down during which cheese production stops. This will influence the composition and volume of the discharge, resulting in lower concentrations of phosphorus, chloride, etc.

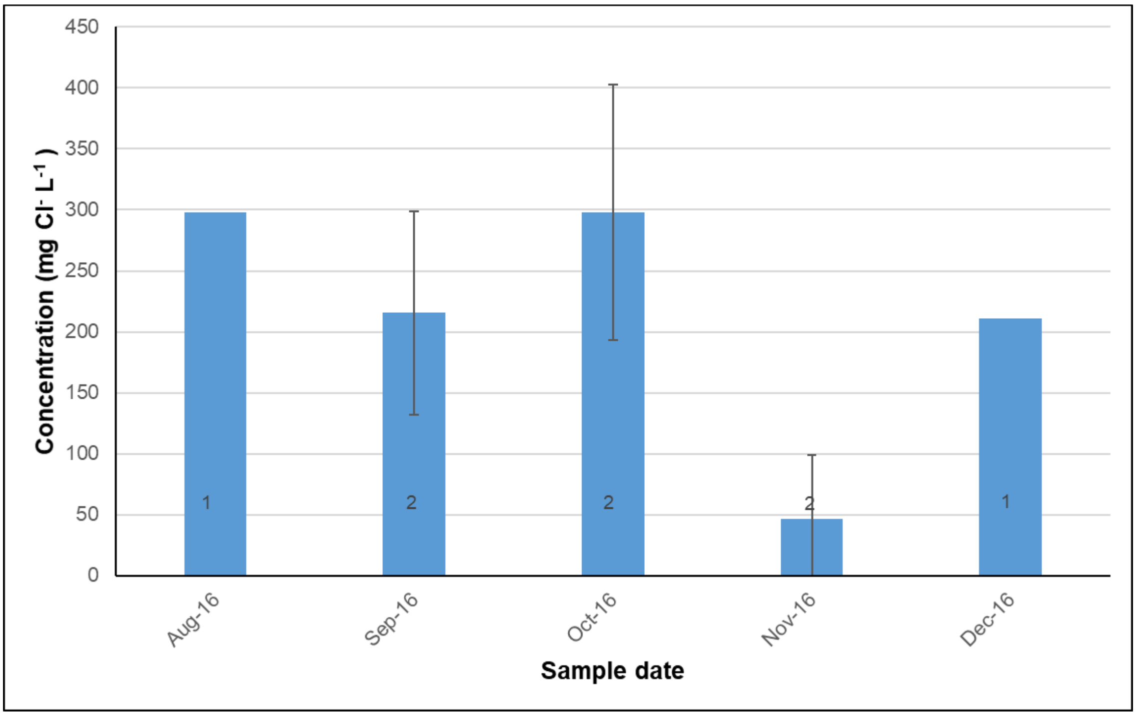


Figure 3.18 Concentration of chloride at St Clether Bridge. Error bars represent 2xSt. Dev. Number on bar = n.

At Two Bridges Inny (Figure 3.19), a similar pattern in concentration to St Clether Bridge is observed, with a stable concentration of chloride across the data set and a significant drop in November, bringing the mean close to that seen upstream of the outfall. This could be related to a greater flow in the channel at St Clether Bridge.

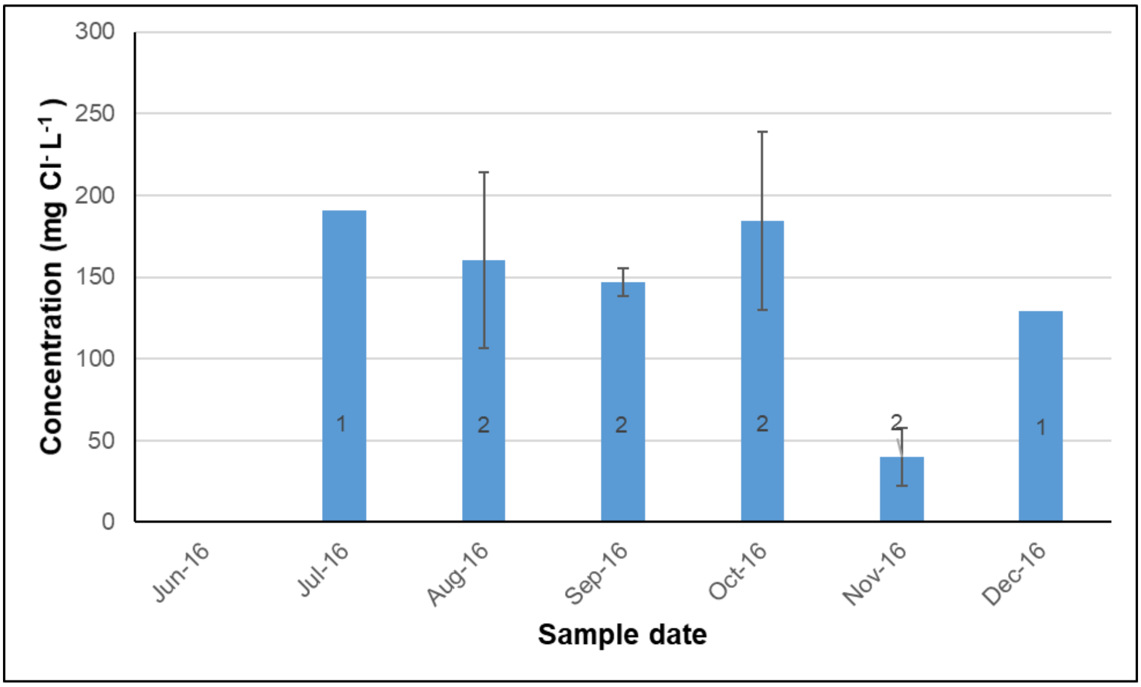


Figure 3.19 Concentration of chloride at Two Bridges, Inny. Error bars represent 2xSt. Dev. Number on bar = n.

3.8 Sodium

Across the 2000 – 2019 period, routine monitoring data for sodium concentrations were only available for 2011 and 2019 with 2011 data only available for Penpont Water (control channel) where mean concentration of 8.2 mg Na L^{-1} was recorded.

Upstream of the discharge point, mean concentrations of sodium in 2019 range from 29 mg L^{-1} to 46 mg L^{-1} (Figure 3.20), whilst post treatment, within the WwTW a concentration of 2070 mg L^{-1} was recorded.

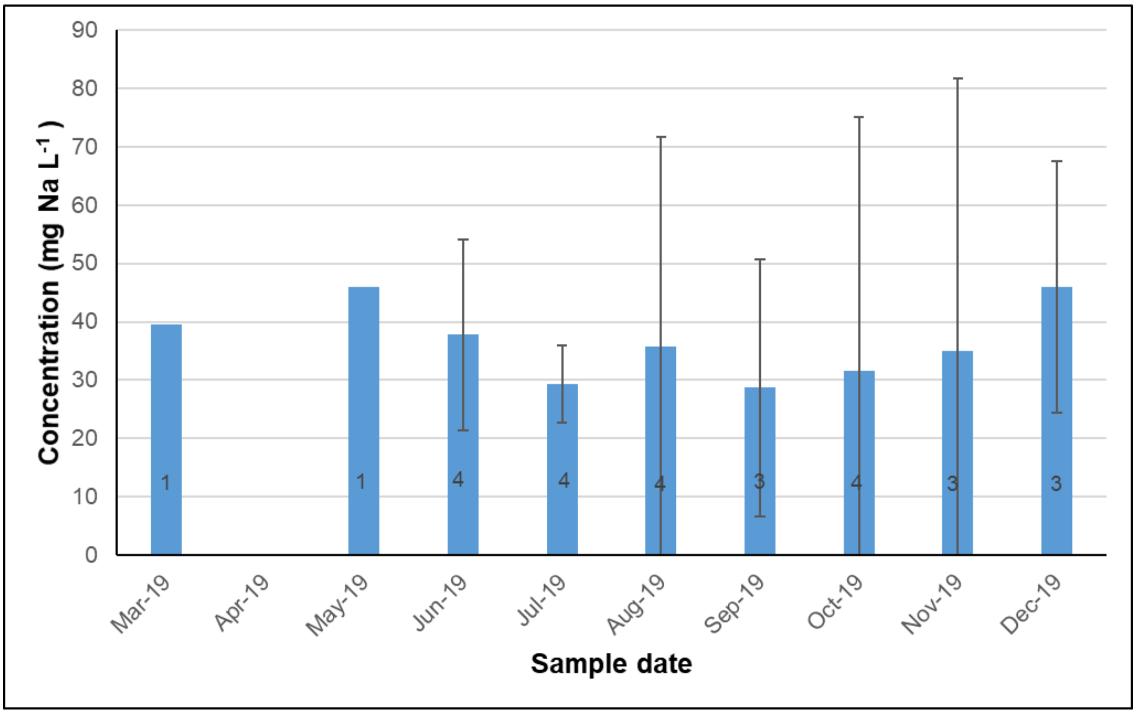


Figure 3.20 Concentration of sodium upstream of discharge point. Error bars represent 2xSt. Dev. Number on bar = n.

Data from 2019 (Figure 3.21) show the mean concentration from the outfall to be in the range 1900 mg L^{-1} to 3650 mg L^{-1}.

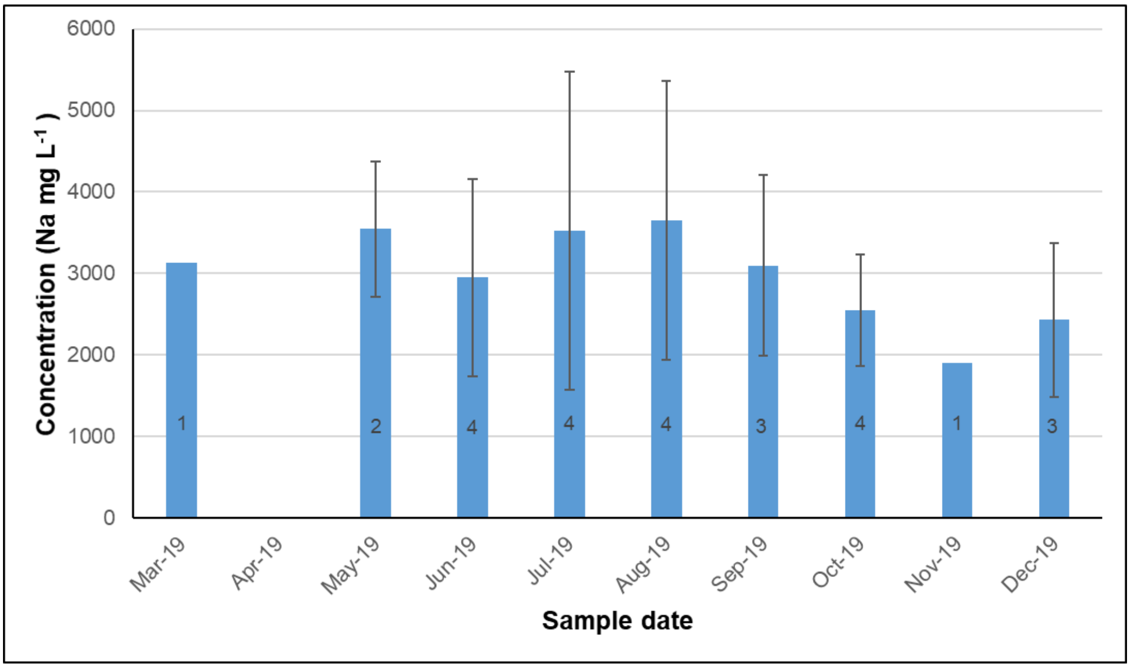


Figure 3.21 Concentration of sodium within the outfall discharge. Error bars represent 2xSt. Dev. Number on bar = n.

Downstream of the outfall, (Figure 3.22) mean concentrations across the period March to December were in the range 109 mg L^{-1} to 1280 mg L^{-1}, with high concentrations mirroring times of lower river flow.

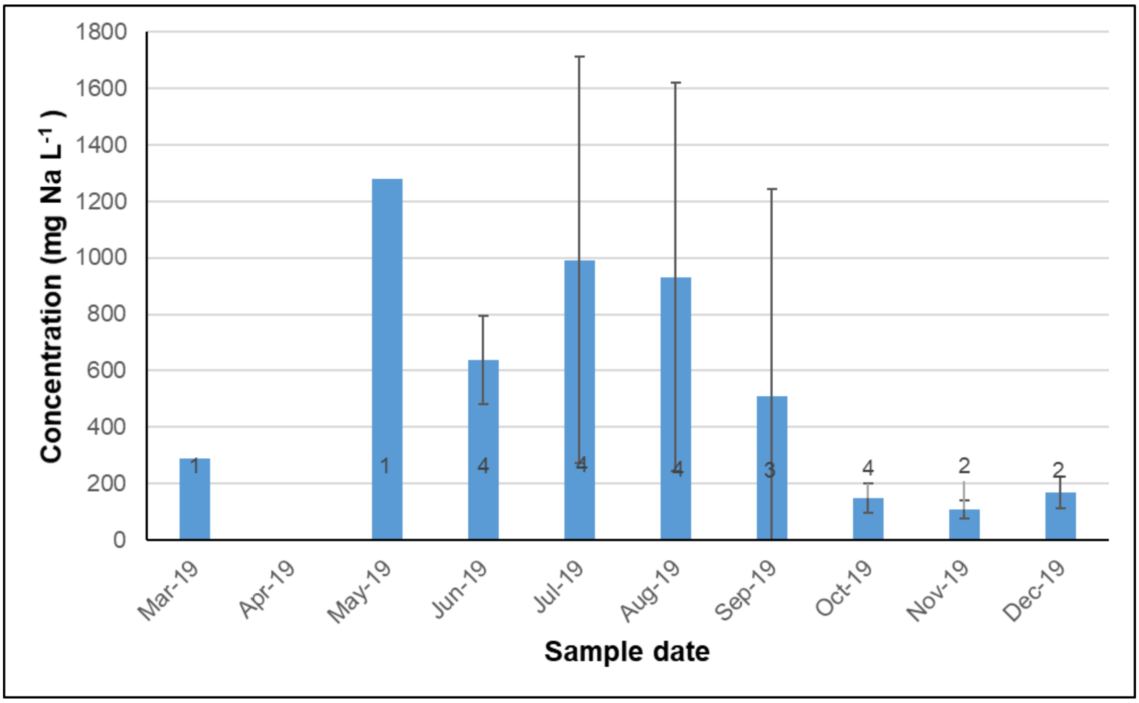


Figure 3.22 Concentration of sodium downstream of discharge point. Error bars represent 2xSt. Dev. Number on bar = n.

3.9 Potassium

Data for potassium, is available for some of the sites of interest between 2001 and 2006. Beyond that it is available for 2011, 2016 and 2019, although not as frequently or widespread as the earlier monitoring period. Figure 3.23 shows the mean concentration of potassium in the River Inny, upstream of the discharge point monthly for 2019. Within the WwTW, one data point for April 2019 measured a concentration of potassium of 548 mg L^{-1}.

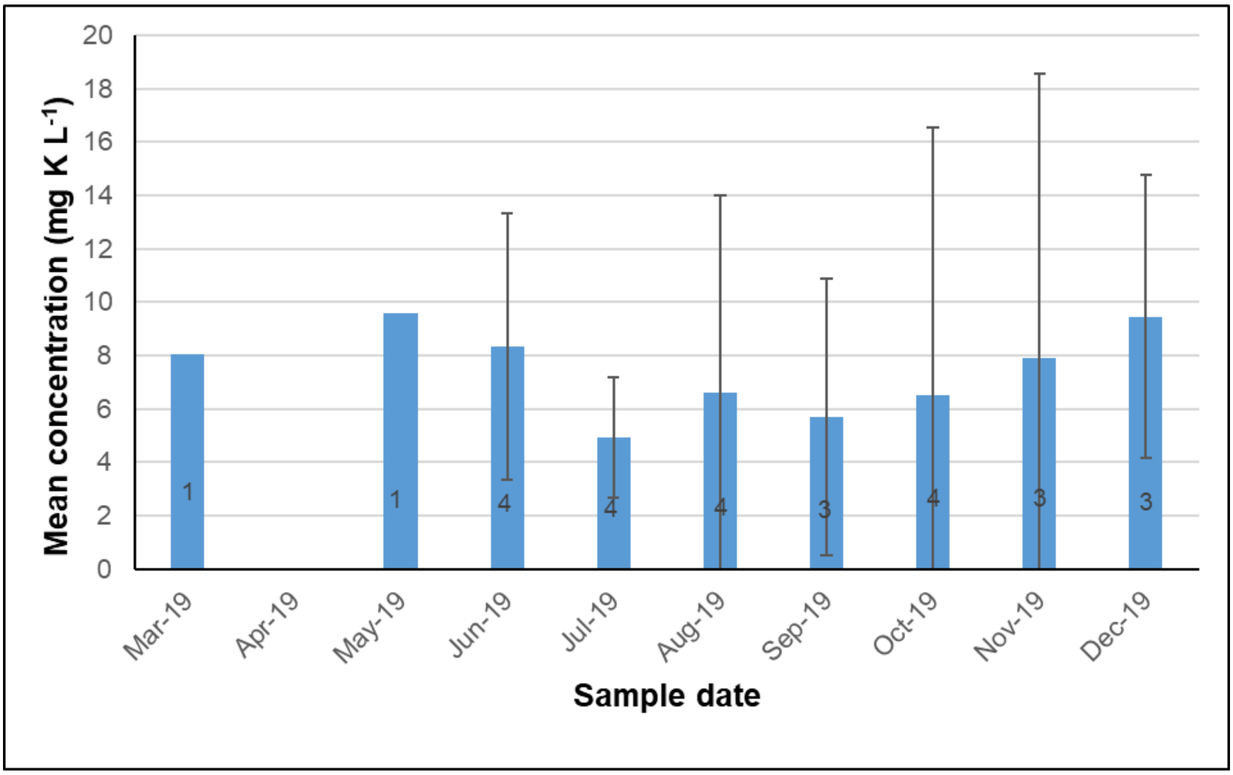


Figure 3.23 Concentration of potassium upstream of discharge point. Error bars represent 2xSt. Dev. Number on bar = n.

From the outfall (Figure 3.24), mean potassium concentrations range from 613 mg L^{-1} in December 2019 to 1023 mg L^{-1} in August 2019. Data was available for June 2016 and the period March 2019 to December 2019, but only routine monitoring episodes are reported here.

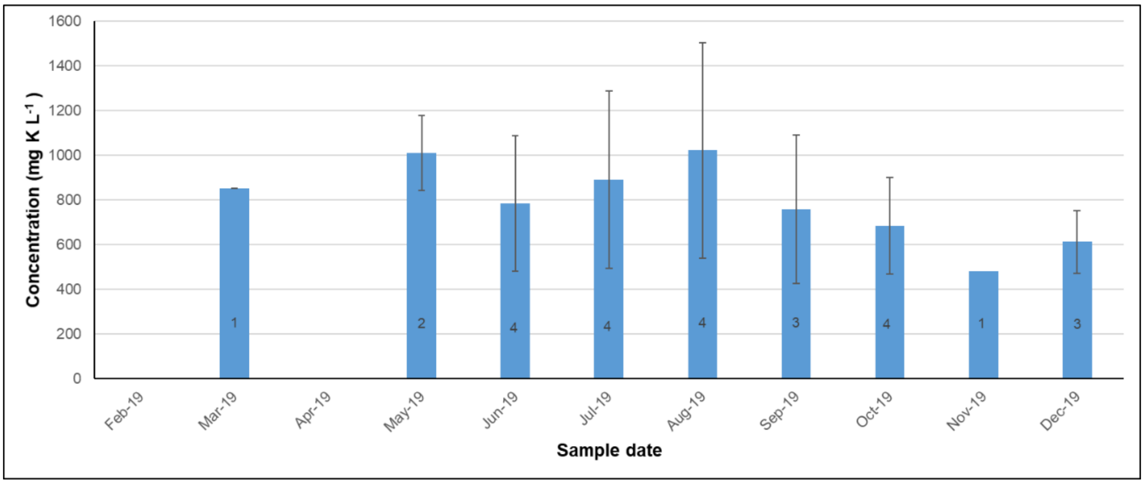


Figure 3.24 Concentration of potassium within outfall discharge. Error bars represent 2xSt. Dev. Number on bar = n.

Downstream of the outfall (Figure 3.25), data was only available for 2019. Considerable variation in mean concentration was seen across the nine month period that data is available for, with the range being 26 mg L^{-1} to 318 mg L^{-1}.

At St Clether Bridge, potassium was only measured for the start of the monitoring period, 2001 to 2006. Figure 3.26 shows a concentration range of 2.83 mg L^{-1} to 4.49 mg L^{-1}. Concentrations at this site are stable across the six year period of monitoring, reflecting a higher background flow and subsequent dilution.

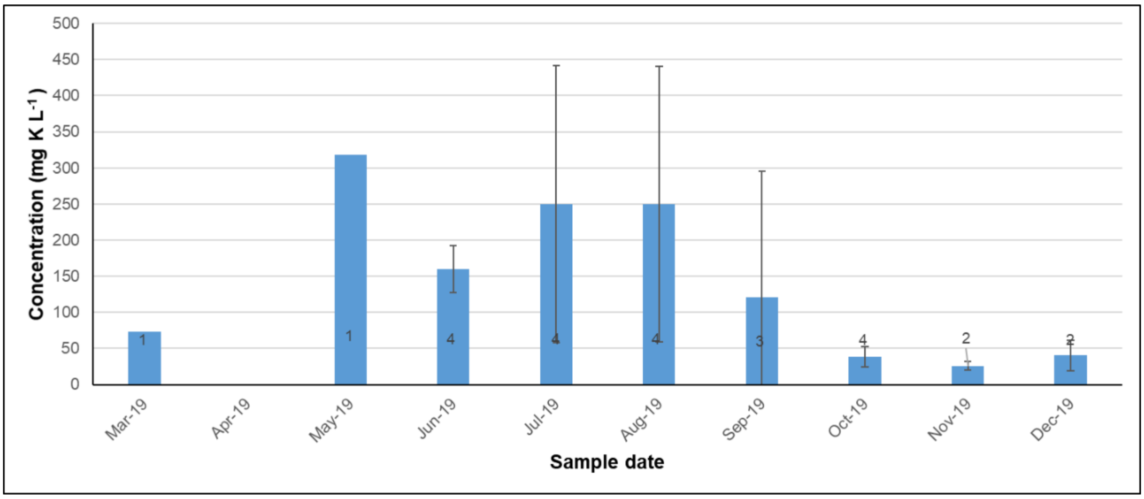


Figure 3.25 Concentration of potassium downstream of discharge point. Error bars represent 2xSt. Dev. Number on bar = n.

Like St Clether, 2B Inny only has data for 2001 to 2006 (Figure 3.26). Across the 6 year period, concentrations were stable with a range of 2.56 mg L^{-1} to 3.46 mg L^{-1}.

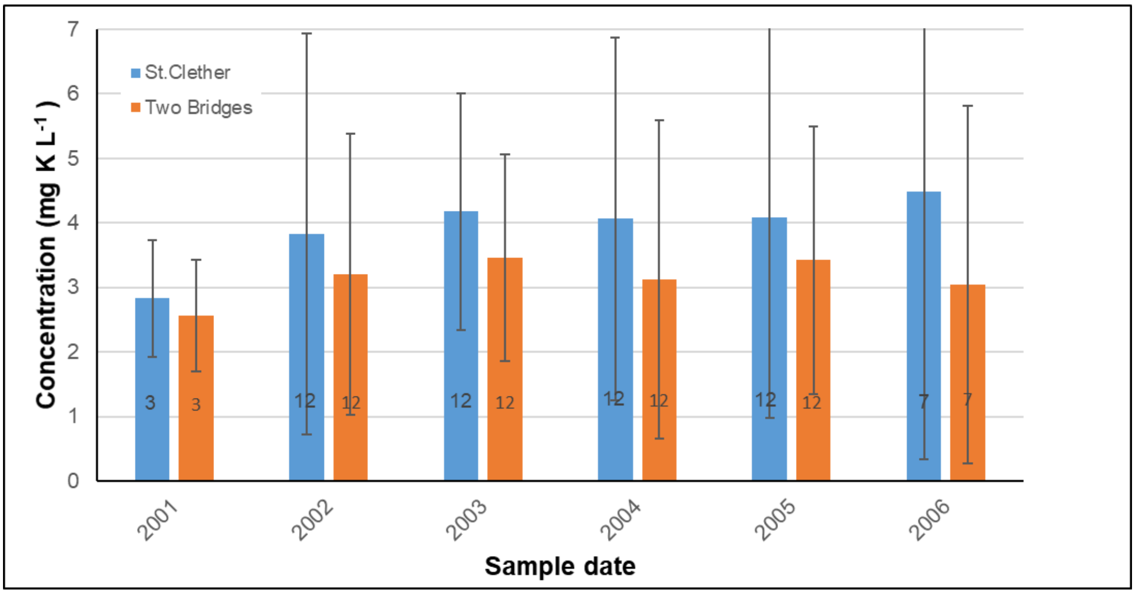


Figure 3.26 Concentration of potassium at St Clether Bridge (blue bars) and River Inny at Two Bridges (orange bars). Error bars represent 2xSt. Dev. Number on bar = n.

The mean data available for the Inny Tamar confluence site were all pollution incident data and show a range in concentration of 480 µg L^{-1} to 1100 µg L^{-1}. These concentrations, orders of magnitude higher than those measured at St Clether, are more comparable with the potassium concentration range found within the Saputo discharge. Similar to sodium, this illustrates another input is affecting water quality at this site, or errors in process and analysis are occurring.

3.10 Dissolved oxygen

Measurements for dissolved oxygen have taken place with greater consistency than chemical parameters. Data were available for both % saturated oxygen and dissolved oxygen (mg L^{-1}) Studying the concentrations upstream and downstream of the outfall, minimal difference is observed in the mean annual average and all samples were in excess of the EQS of 75%. Figure 3.27 shows a % saturated dissolved oxygen range of 96 to 100 upstream and 93 to 99 downstream of the outfall.

Post treatment within the outfall (n=24) (Figure 3.28), dissolved saturated oxygen concentrations are in the range 63 to 102 %. Currently, the dairy measures but is not permitted for dissolved oxygen.

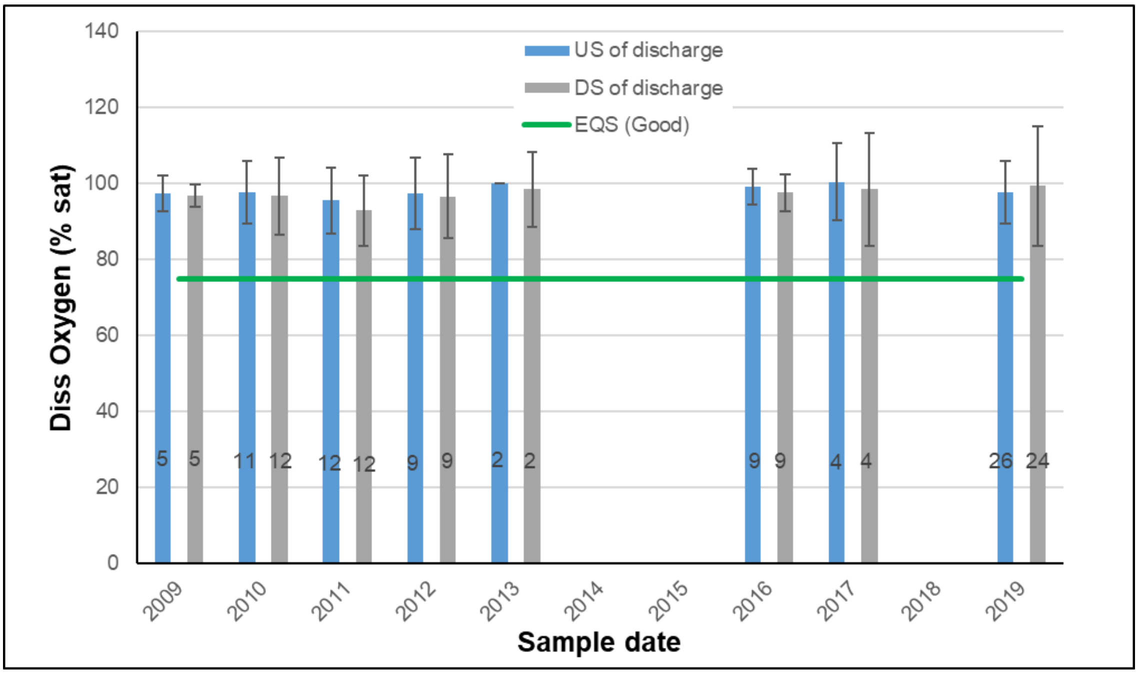


Figure 3.27 % Saturated dissolved oxygen upstream and downstream of discharge point. Error bars represent 2xSt. Dev. Number on bar = n. Green line represents 75% Dissolved Saturated Oxygen Environmental Quality Standard for 'Good'.

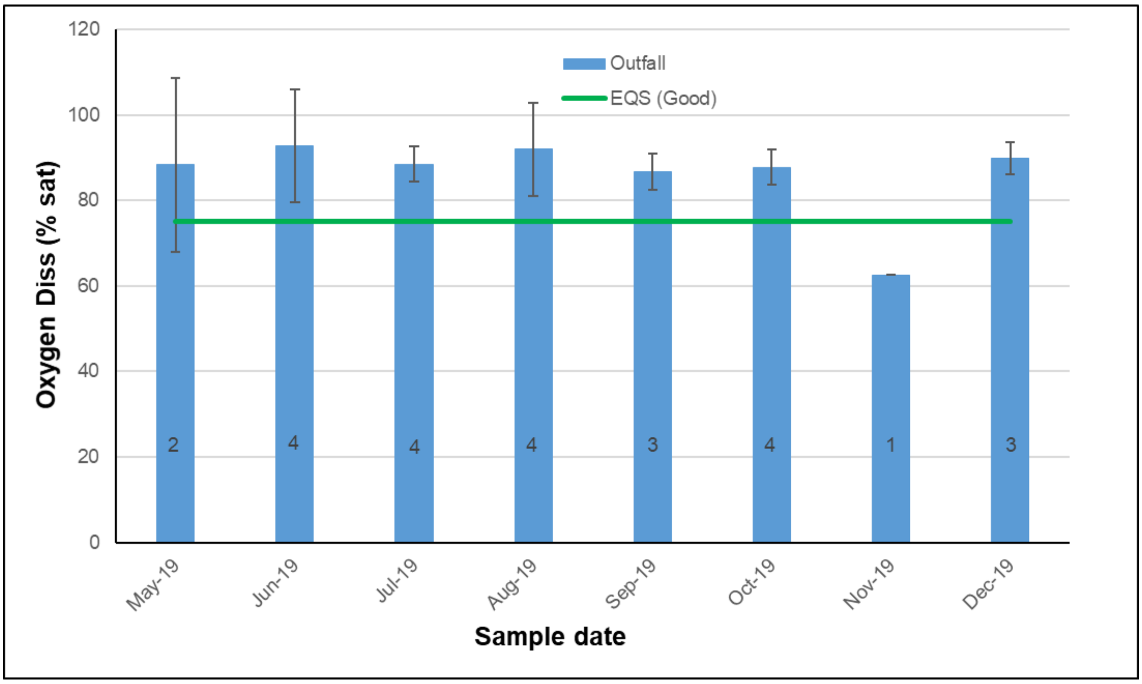


Figure 3.28 % Saturated dissolved oxygen post treatment, within effluent as it discharges to receiving waters. Error bars represent 2xSt. Dev. Number on bar = n. Green line represents 75% Dissolved Saturated Oxygen Environmental Quality Standard for 'Good' status in the receiving waters.

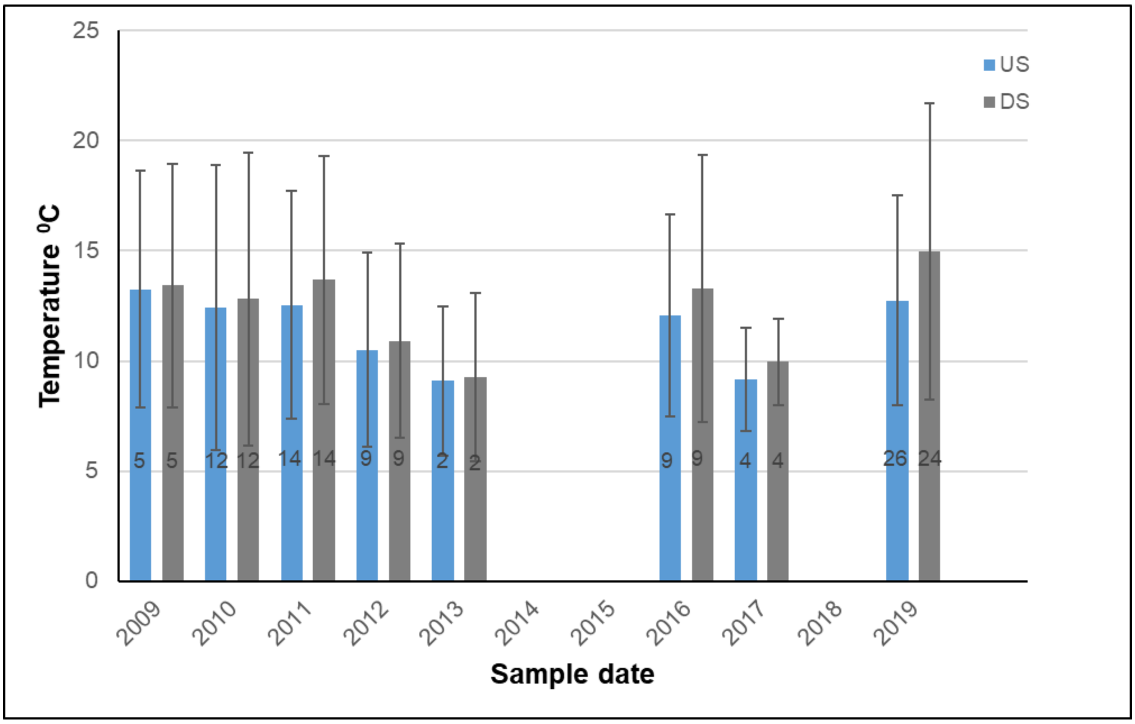
St Clether Bridge had a data set extending 2000 to 2019, excluding 2007 and 2008. % Saturated oxygen was consistent and above the EQS across the twenty year period of the historic data review. This location is used by the Environment Agency to determine the % saturated oxygen quality for the Upper Inny catchment. Downstream at 2B Inny, % saturated dissolved oxygen concentration exceeded the EQS of 75% in all of the 200 data points, being measured in the range 80 to 120%.

3.11 Temperature

Increased temperature within the water column can alter the conditions suitable for the growth of macrophytes and invertebrates. Temperature data from the EA were available for the period 2000 to 2018 at sites of interest to this study. Upstream of the discharge point (Figure 3.29 A), the annual mean temperature range between 2009 and 2019, excluding 2014 and 2015 was 6.80 to 18.5 ^{0}C. Downstream of the discharge the temperature range was 7.5 to 20.7 ^{0}C. Figure 3.29 B shows the water temperature upstream and downstream of the outfall for 2019, clearly illustrating the seasonal increase in temperature and how lower summer river flows allow an increased thermal impact of the discharge on the temperature of the downstream reach.

Post treatment, the effluent temperature has increased through the biological processes of treatment. Within the WwTW (Figure 3.30), the temperature range was 9.07 to 27.46 ^{0}C, whilst at the outfall it was 8.2 to 29.9 ^{0}C.

A



B

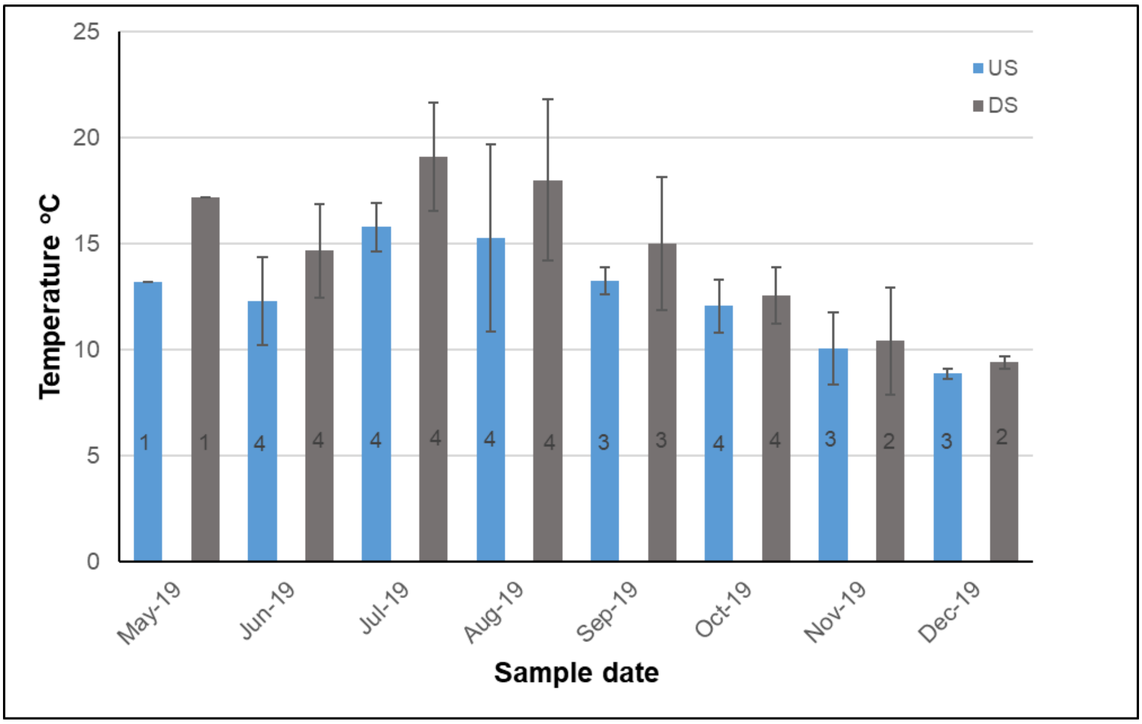


Figure 3.29 Water temperature upstream (US) and downstream (DS) of discharge point. A. Showing historic data by year, B. showing Environment Agency data for 2019. US measurements sampled 09:58 to 16:52, DS measurements sampled 09:38 – 17:13. Error bars represent 2xSt. Dev. Number on bar = n.

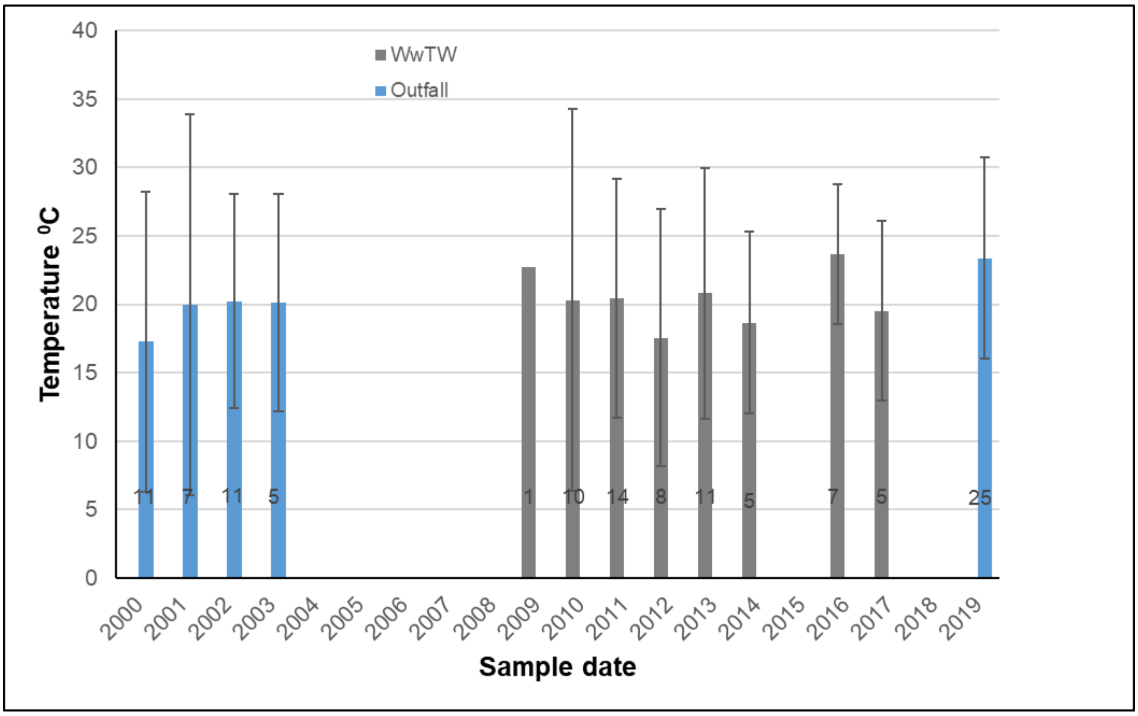


Figure 3.30 Water temperature post treatment at Davidstow WwTW and within outfall. Error bars represent 2xSt. Dev. Number on bar = n.

At St Clether Bridge, the annual temperature range was 4.4 to 17.49 ^{0}C. Moving downstream to Two Bridges Inny, the range is 3.6 to 17.84 ^{0}C.

3.12 Penpont Water at Two Bridges

Penpont Water joins the River Inny downstream of Two Bridges (Figure 2.2), below the 2B Inny (Figure 3.1) sample point. It is a river of similar land use, topography and geology as the River Inny, but without significant industrial input, hence acting as a ‘control’ channel for this investigation. Frequency of sampling across the historic review period was fairly consistent, with 12 sampling episodes per year in the period 2000 to 2015 at Penpont Water, excluding 2001 (n=8) and 2012 (n=14). 2016 Saw 8 sampling episodes and none were taken in the period 2017 to 2019. Data are displayed here (

Table **3.1**) with historic data for the Two Bridges River Inny site for comparison, to illustrate a local water body without influence from a dairy processing unit. T-tests were carried out to determine if there were any statistically significant differences in the mean concentrations at these two sites, comparing data that were measured on the same day. This reduced the period of dataset considerably (see Table 3.1, df-1 compared with n). With the exception of sodium (no data), iron (no data) and total phosphorus (not significant) all parameters showed statistically significant differences in the concentrations measured in the River Inny compared with Penpont Water.

Comparison of the orthophosphate concentration measured US of the Saputo discharge with Penpont Water at Two Bridges reveals a mean concentration of 0.09 versus 0.05 mg L^{-1}, measured across the 2000 – 2019 period where data was available. DS of the discharge the mean concentration across the monitoring period was 0.78 mg L^{-1} versus 0.43 mg L^{-1} at St Clether, where adequate mixing has occurred.

Mean total iron concentration measured US of the discharge was 299 ug L^{-1} (n=11), compared with DS 370 ug L^{-1} (n=9) and 729 ug L^{-1} (n=3) at Penpont Water where the individual Fe total results were 1940, 116 and 131 ug L^{-1}. These should be compared with the proposed EQS of 0.73 mg L^{-1} Fe total. A large variation in total iron concentrations has been seen on the River Inny associated with large flows and higher TSS. Based on the monitored data, there was not a noticeable impact on local waterways from total Fe associated with the Davidstow creamery.

Mean chloride measured upstream of the discharge was higher (51 mg L^{-1} in 2019 to 79 mg L^{-1} in 2016 than at Penpont Water (15.25 mg L^{-1}), with the DS mean 394 to 1420 mg L^{-1}. Both sodium and potassium follow this pattern, with US concentrations being higher than those measured at Penpont Water. These patterns will be looked at in the next chapter by comparison with data collected during fieldwork at the top of the catchment which is above any influence from the WwTW. Water temperature compares well between Upstream and Penpont Water (+1.02 ^{o}C) and St Clether and Penpont Water (+0.42 ^{o}C). % Saturated dissolved oxygen across the historic monitoring period US of the discharge was recorded as 97.6%, compared with 97.1% at St Clether and 96.76 % at Penpont Water, all above the EQS of 75%.

Table 3.1 Summary data for physico chemical measurements for Penpont Water and River Inny, 2000 – 2016 taken at Two Bridges. Environment Agency data from WIMS, interrogated using R. Statistical significance determined where data point exists for both sites on the same day using MS Excel. Green font = significant difference in parameter measured at the two sites vs red font, no significant difference.

	Penpont Water			Two Bridges Inny			
Parameter	Mean conc ($mg\ L^{-1}$) unless otherwise stated.	Standard Deviation	n	Mean conc ($mg\ L^{-1}$) unless otherwise stated.	Standard Deviation	n	Statistical Significance
Calcium	9.40	2.97	58	19.4	4.79	44	$t(43)=9.46$; $p=4.5x10^{-12}$
Chloride	15.3	0.76	8	138	61.26	10	$t(7)=5.07$; $p=0.001$
Conductivity (@25°C)	136 µs cm^{-1}	46.0	84	437 µs cm^{-1}	306	108	$t(56)=6.50$; $p=2.28x10^{-8}$
Dissolved oxygen, % saturation	96.8 %	4.28	196	97.0 %	4.37	198	$T(175)=2.48$; $p=0.014$
Iron, total	729 µg L^{-1}	1048	3	N/A	N/A	0	N/A
Iron, dissolved	54.6 µg L^{-1}	38.4	4	N/A	N/A	0	N/A
Magnesium	3.16	0.55	58	4.23	0.71	44	$t(43)=9.26$; $p=8.53x10^{-12}$
Orthophosphate	0.05	0.07	163	0.27	0.32	191	$T(135)=8.04$ $p=4.01x10^{-13}$
Potassium	1.63	0.41	61	3.23	1.05	58	$t(57)=10.80$; $p=2.09x10^{-15}$
pH	7.54	0.31	199	7.80	0.37	197	$t\ (170)=3.03$; $p=0.003$
Sodium	8.18	1.64	3	N/A	N/A	0	N/A
Temperature	11.1 °C	2.97	200	11.4	3.19	199	$T(180)=3.14$; $p=0.002$
Total phosphorus	0.05	0.04	30	0.51	0.49	10	$t\ (7)=2.29$; $p=0.056$
Total suspended solids	8.11	15.36	178	12.3	22.4	174	$T(170)=3.65$; $p=0.0003$

3.13 Discussion

The availability of historic water quality datasets allow the researcher to gain a baseline in water conditions and monitor how modifications to anthropogenic activities within a catchment can lead to alterations, both positive and negative in water quality. Environment Agency data included both routine monitoring data and that obtained from pollution investigations. The later was not included in this review as temporal trends were being investigated and concentrations from pollution incidences would bias data sets. Within the River Inny, water quality according to orthophosphate concentrations has seen significant improvement since 2011. This is most apparent from St Clether Bridge, downstream to Two Bridges. Increases in production capacity and modernisation of wastewater treatment at Saputo Dairy UK have led to a more stable discharge of phosphorus contaminated waste. Regulation by the Environment Agency to protect and enhance UK waterways places limits on how much phosphorus can be released within the treated discharge (1000 µg P L^{-1} (as Total P) Saputo UK at Davidstow). Permits are monitored for compliance and any significant alteration or modification to process can result in a review of the permit parameters, and a more restrictive set of discharge boundaries. Historic upstream to downstream difference in mean concentration of iron is less than 500 µg Fe L^{-1}, indicating a slight increase resulting from the outfall.

As a result of the whey demineralisation process, the concentration of chloride within the discharge rose substantially during the data review period and is seen from 2018 measurements onwards. Sodium concentrations, like chloride were also raised significantly below the outfall.

Temporal and spatial resolution of the historic potassium data was poor, resulting in difficulty drawing conclusions from the dataset. Pre 2006, the concentrations of potassium measured are of comparable concentrations to those upstream of the outfall measured through 2019 (4 – 8 mg K L^{-1}).

Dissolved oxygen concentrations within the River Inny are above the EQS (therefore compliant) for the duration of the available historic data. Water temperature upstream and downstream of the outfall show greater variation over the 2016 – 2019 period than the 2009 – 2013 period. Again, conclusions should be drawn with caution due to the inconsistencies in monitoring frequency. Monitoring period is an issue for the regulator in order to maintain a detailed picture of long term river health, balanced with the need to utilise limited resources.

Davidstow WwTW operates as a PE of approximately 15,500, with a permitted effluent flow of 2,600 m^3 day^{-1}. A comparison of its composition with the average composition of conventional predominantly domestic WwTWs is shown in Table 3.2. This has been produced from the historic Environment Agency data for Davidstow Creamery, data gathered from WwTW1 during this study and data generated in a UK water industry national Chemicals Investigation Programme (Gardner *et al*., 2012). 95%ile has been used to allow for direct comparison with the data from Gardner *et al*., (2012).

Table 3.2 Davidstow WwTW data from historic Environment Agency data (2000 to 2019), Davidstow WwTW data collected during study (Dec 2017 to Nov 2019), Conventional WwTW data reproduced from (Gardner *et al*., 2012)

Substance	Davidstow WwTW 95 Percentile (mg L^{-1})			Conventional WwTW 95 Percentile (mg L^{-1}) (n=162)
	Historic EA data	Data collected during study	Permitted	
Total Suspended solids	26.3 (n=70)	35.3 (n=21)	20	26
Ammonia (Ammoniacal Nitrogen as N)	5.05 (n=76)	N/A	5	17.3
BOD	4.82 (n=76)	N/A	5	19
COD	N/A	N/A		87.2
Total phosphorus	31.6 (n=20)	1.96 (n=23)	1	9.8
SRP	28.9 ('orthophosphate' so likely to be unfiltered, i.e.TRP) (n=64)	1.15 (n=23)		19
Sodium	2070 (n=1)	4697 (n=23)		188
Potassium	548 (n=1)	1497 (n=23)		27
Magnesium	21.3 (n=1)	87.0 (n=23)		25
Calcium	144 (n=1)	337 (n=23)		138
Total organic carbon	N/A	N/A		28
Dissolved organic carbon	4.21 (n=1)	N/A		24
Sulphate	1020 (n=1)	N/A		168
Chloride	5265 (n=20)	9618 (n=7)		272
pH	8.3 (n=66)	8.35 (n=24)	6-9	8.0

Of the 15 parameters that Gardner *et al*. (2012) measured, Environment Agency data were available for 13 of them for the Davidstow Creamery effluent, although for 6 of these parameters, there was only a single measurement in the period 2000 to 2019. Across the twenty year period, significant changes and modifications have occurred within the WwTW, so although data shown here for TSS and total phosphorus are above the permitted concentration, the permit does not apply across the entire 2000 to 2019 period as numerous amendments to details have been made. TSS concentrations are comparable with domestic WwTW although since the installation of new filtration equipment, the Davidstow WwTW will now show lower concentrations of total suspended solids. BOD and ammonia for Davidstow is below the permit at the 95 percentile and considerably lower than that measured by (Gardner *et al*., 2012). This illustrates a compositional difference between Davidstow's industrial effluent compared with a domestic WwTW whose effluent would be predominantly derived from human generated waste. Saputo operate under more stringent permits than 'domestic' WwTWs, although water companies are facing ever tighter permits. Total phosphorus and orthophosphate, sodium, potassium, sulphate and chloride are considerably higher in concentration in the Davidstow effluent than conventional WwTW owing to the specific process from which the waste is generated. These compounds are not removed in the WwTW process so enter receiving waters with an intention for dilution. As salts they will alter the conductivity of the receiving waters, particularly during times of low flow and this will have an effect on the river's biota. Current monitoring data (introduced and discussed in chapter 4), is presented here purely as a visual comparison with the historic data and illustrates significant decreases in concentrations of total phosphorus and soluble reactive phosphorus. These improvements occur alongside deterioration in concentrations of potassium, sodium and chloride which are significantly increased. These issues will be explored further in the next chapter through current observations of water quality.

4 Discharge related changes in water chemistry

4.1 Introduction

In this chapter, focus is made on water chemistry. Detail is provided on issues associated with the determination of phosphorus concentrations and the complexity of phosphorus physico-chemistry. Methodologies used for the water chemistry aspects of the study are introduced before summarising the physico-chemical data for the River Inny, collected throughout the study, November 2017 to November 2019. Field data can be found in Appendix 2. The work contained therein fulfils objective 2 of the study (Figure 1.1).

4.2 Determination of phosphorus concentrations

A principal goal of the EU Water Framework Directive (WFD: 2000/60/EC) is

"*to protect, enhance and restore all surface waters and groundwaters with the aim of* achieving Good Ecological Status (GES)" (European Union, 2000).

A significant factor leading to the failure of a surface water habitat to achieve good status is the nutrient loading. Concern over the impact of nutrients, particularly phosphorus, on rivers has increased since the publication of the EU Urban Waste Water Directive and subsequently the EU Water Framework Directive (Kelly, 1998). Of the major nutrients controlling plant growth, phosphorus is widely accepted as limiting for riverine environments (Reynolds & Davies, 2001; Mainstone & Parr 2002). However, point and diffuse source discharges usually result in concentrations of phosphorus that are not growth limiting but conversely lead to accelerated growth of undesirable phytoplankton and macrophytes (Jarvie *et al.*, 2018).

The current UK guidance sets a site-specific phosphorus EQS expressed as reactive phosphorus (RP) using a combination of altitude and alkalinity (Figure 4.1) to reflect different riverine typologies (UKTAG, 2014b). Assessments are based on natural alkalinity and not an anthropogenically altered value resulting from catchment water modification (Tappin *et al.*, 2018). Within surface waters, however, there exist numerous aquatic fractions of phosphorus (Figure 4.2) (Worsfold *et al.*, 2005), not all of which are immediately bioavailable. RP is considered bioavailable and is therefore in a suitable form for plant and algal growth within a watercourse.

a) *High/Good Standard* = $10^{((1.0497 \times \log_{10}(0.702) + 1.066) \times (\log_{10}(\text{reference Phosphorus}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))}$

b) *Good/Moderate Standard* = $10^{((1.0497 \times \log_{10}(0.532) + 1.066) \times (\log_{10}(\text{reference Phosphorus}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))}$

c) *Moderate/Poor Standard* = $10^{((1.0497 \times \log_{10}(0.356) + 1.066) \times (\log_{10}(\text{reference Phosphorus}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))}$

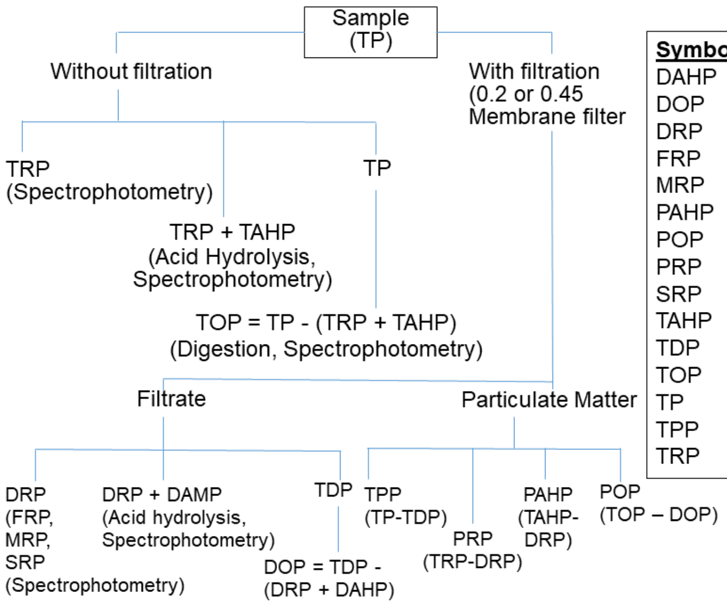
d) *Poor/Bad Standard* = $10^{((1.0497 \times \log_{10}(0.166) + 1.066) \times (\log_{10}(\text{reference Phosphorus}) - \log_{10}(3{,}500)) + \log_{10}(3{,}500))}$

where the value for reference phosphorus is calculated by the equation:

Reference phosphorus = $10^{(0.454 (\log_{10} \text{alk}) - 0.0018 (\text{altitude}) + 0.476)}$

Figure 4.1 Equations used for the calculation of the EQS for each WFD class (High/Good, Good/Moderate. Moderate/Poor and Poor/Bad), expressed as μg L^{-1} reactive phosphorus (UKTAG, 2014b)**.**

Historically, riverine RP concentrations have been determined by colorimetry, using the established phosphomolybdenum blue method; (HMSO, 1992; UKTAG, 2013; Nagul *et al.*, 2015) which is quick, simple, cheap, sensitive and not prone to interferences from typical riverine matrices (Baken *et al.*, 2014).



Symbol	Name
DAHP	Dissolved acid hydrolysable phosphorus
DOP	Dissolved organic phosphorus
DRP	Dissolved reactive phosphorus
FRP	Filterable reactive phosphorus
MRP	Molybdate reactive phosphorus
PAHP	Particulate acid hydrolysable phosphorus
POP	Particulate organic phosphorus
PRP	Particulate reactive phosphorus
SRP	Soluble reactive phosphorus
TAHP	Total acid hydrolysable phosphorus
TDP	Total dissolved phosphorus
TOP	Total organic phosphorus
TP	Total phosphorus
TPP	Total particulate phosphorus
TRP	Total reactive phosphorus

Figure 4.2 Operationally defined aquatic P fractions (adapted from Worsfold *et al*., 2005)

Although the method is clear and reliable, sample pre-treatment and the nomenclature of the reported concentrations is often imprecise. Soluble reactive phosphorus (SRP) or dissolved reactive phosphorus (DRP) is a clear definition and has the pre-requisite of filtration of the sample prior to analysis, normally through a 0.45 µm membrane (UKTAG, 2013b). SRP is widely accepted as the most readily bioavailable fraction of phosphorus present in any given sample (McKelvie *et al.*, 1995; Reynolds & Davies, 2001; Anthony *et al.*, 2007). Several authors (e.g. Haygarth *et al.*, 1997; Lapworth *et al.*, 2013) point out that colloidal inputs can impact on both SRP and TRP concentration, depending on the size of the colloids, i.e. <>0.45 µm, the accepted cut off between total and dissolved RP. However, much recent documentation expresses phosphorus concentrations using other terminology including molybdate reactive phosphorus (MRP), 'orthophosphate' (Mainstone *et al.*, 1996), and RP, which fails to specify clearly how the sample should be treated prior to determination. The term MRP can give rise to ambiguity (Jarvie *et al.*, 2002) as it may refer to filtered samples, where MRP is equivalent to SRP measurements, or even unfiltered samples, where MRP is equivalent to SRP plus a fraction of particulate phosphorus which is reactive to the phosphomolybdenum blue method reagents. Jarvie *et al.*, (2002), note that MRP determined on unfiltered samples is routinely referred to as 'Orthophosphate as P' by the Environment Agency (Anthony *et al.*, 2007) in England and Wales.

It has been observed that measured concentrations of phosphorus in surface waters do not always correspond closely with indicators of ecological quality (UKWIR, 2017). This is unsurprising when the Trophic Diatom Index used to calculate diatom ecological health has been developed using Environment Agency 'orthophosphate' data implying a lack of filtration based on the published Environment Agency's methodologies (Kelly & Whitton, 1995) as a proxy for nutrient enrichment.

A further example of this confusion arises from more recent guidance regarding measuring phosphorus under the WFD. It advises that, where necessary, and to ensure accuracy of the method, samples be filtered using a filter not less than 0.45 µm pore size to remove gross particulate matter (UKTAG, 2013b). However, there is no definition of specific mass or concentration of "gross particulate matter'. Furthermore, other recent documentation generated to support WFD environmental quality standard setting procedures states, for example: "*Most analyses by UK agencies are of molybdate reactive phosphorus in unfiltered samples* ***from which large particles have been allowed to settle*** *and referred to here as "reactive phosphorus". In practice, the difference between RP and SRP is usually minor*" (UKTAG, 2013; UKTAG, 2014).

Most of the water quality data reported for phosphorus in the UK has used the assumption that the difference between RP and SRP is usually minor and therefore unfiltered samples have been analysed, potentially after settling for particularly turbid samples. A 2016 comparison between filtered and unfiltered samples (Environment

Agency, 2016) was undertaken, in which the relationship between unfiltered samples, allowed to settle and determined by the molybdenum blue method, henceforth denoted Total Reactive Phosphorus (TRP), and SRP (labelled as filtered P) appears to be 1:1 (Environment Agency, 2016) (Figure 4.3). However, closer examination of the lower portion of the graph at the range of phosphorus concentrations of interest in UK rivers (and typically world-wide) which is ≤100 µg P L^{-1}, shows a significant amount of scatter in the data with SRP concentrations predominantly falling below the 1:1 line.

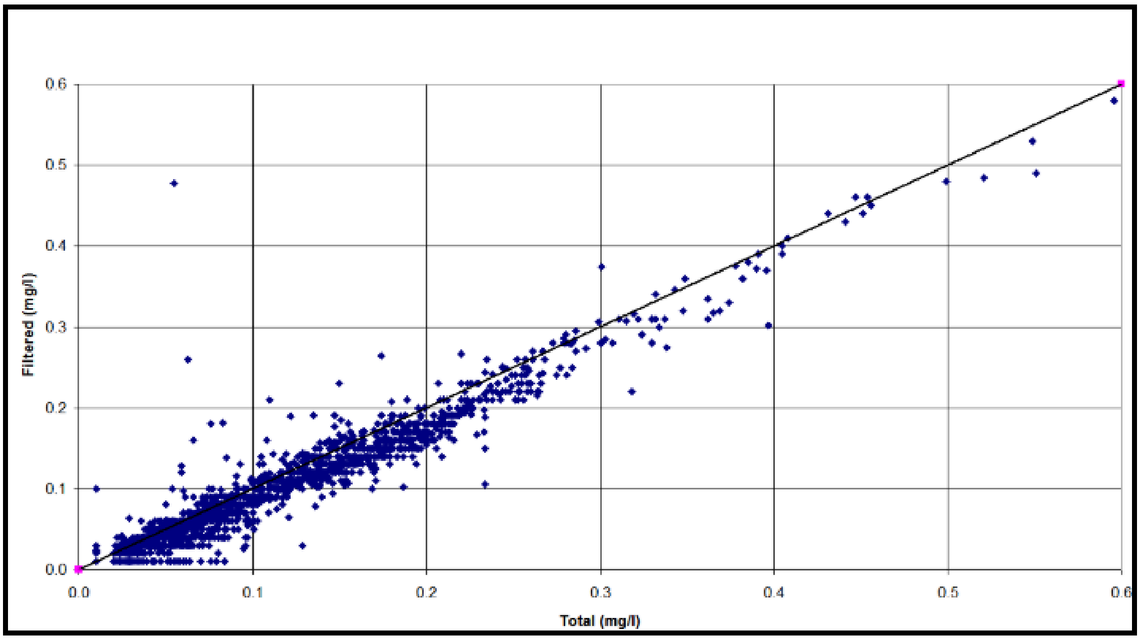


Figure 4.3 Comparison of total and filtered orthophosphate (Environment Agency, 2016).

Further examination of the premise that SRP dominates riverine phosphorus speciation shows that the conclusion was based on a constrained dataset, from rivers mainly sampled from the south and east of England, predominantly high alkalinity and low altitude catchments (Environment Agency, 2016).

This raises the question as to what are the main factors controlling the form of phosphorus within the riverine environment. From a physico-chemical point of view, the difference between RP and SRP will be driven by ambient water quality factors that impact on (a) the reactivity of phosphorus species to the molybdate chemistry and (b) the formation of colloidal/particulate species which may or may not pass through a 0.45 µm membrane. Figure 4.4 shows the complexity of phosphorus biogeochemistry within flowing water. In a freshwater system, SRP will undergo sorption processes in the presence of suspended solids, leading to adsorption onto particle surfaces or desorption depending on the ambient concentrations within each matrix. SRP can also be adsorbed or incorporated into colloids such as Fe and Al oxyhydroxides (Withers & Jarvie, 2008; Baken *et al.*, 2014) (Figure 4.4) a process utilised within the wastewater treatment works (WwTW) industry to reduce phosphorus concentrations within effluent to meet discharge permit conditions.

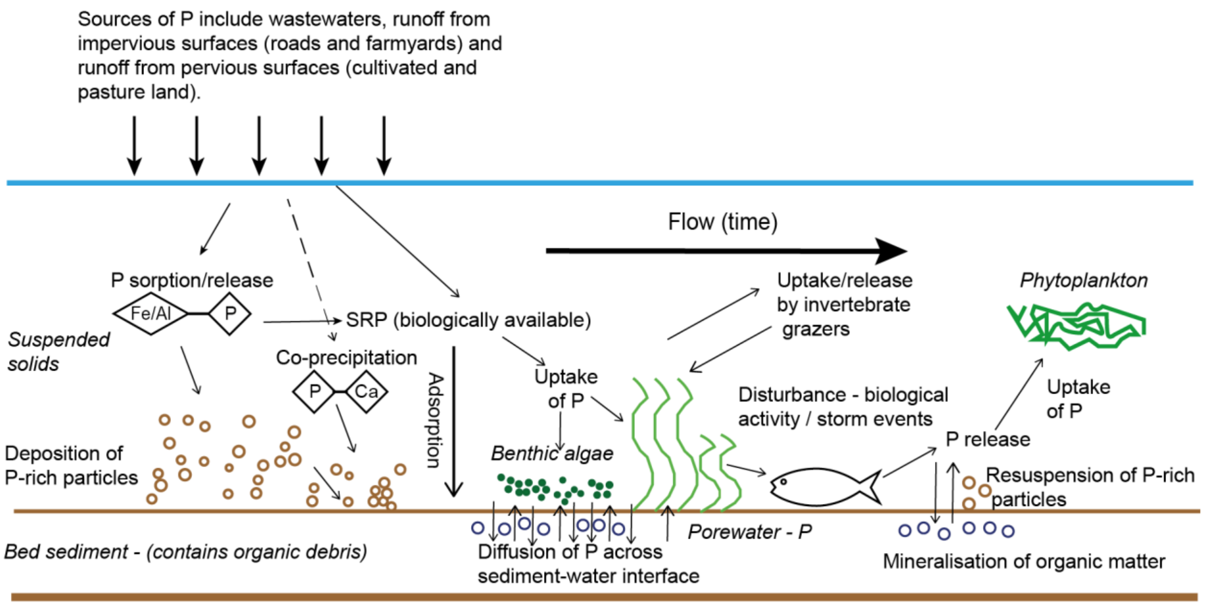


Figure 4.4 Conceptualised diagram of in-stream processes influencing P concentrations in flowing waters (reproduced with permission from Withers & Jarvie 2008).

Particulate phosphorus (PP) is defined as that fraction which is retained by filtration using a 0.45 µm membrane. PP may comprise biological material (animal, plant, bacterial), weathering products (mineral), inorganic precipitates and organic precipitates, as well as phosphorus associated with aggregates through metal binding or adsorbed to the surface of clay and mineral particles (McKelvie *et al.*, 1995). Deposition of sewage-derived particulates enriched with P, particularly during an extended period of low summer baseflows, may provide localised bed-sediment hotspots and later act as a source of SRP. From an ecological standpoint, there is uncertainty over the degree of bioavailability associated with PP or molybdate 'unreactive' species which may pass through a 0.45 μm membrane. These phosphorus fractions within a water column may be utilized by algae and bacteria after hydrolysis by extracellular enzymes. These enzymes are usually only exuded under conditions of bioavailable P deficiency (McKelvie *et al.*, 1995). Hence, some particulate phosphorus can become bioavailable either via natural partitioning or biological processes.

There has been, and will continue to be, substantial investment in reducing phosphorus loads entering waterbodies across Europe and beyond; via reduced agricultural loss from farms and fields and investment in new technology within WwTW. In order to ensure that the most scientifically robust guidance is provided, it is essential to fully examine the variety of phosphorus forms that occur throughout a range of geographical and physico-chemical conditions within riverine waterbodies, thereby allowing regulators to provide clear instructions on the pre-treatment of samples to ensure consistency and clarity of outcomes.

4.3 Sampling and analysis for phosphorus

Sample site names and codes are shown in Figure 4.5 together with distances from the top of the catchment. Table 4.1 provides a reference point to link the following charts with sample site names. Sample sites descriptions can be seen in Chapter 2, section 2.1 (also Figure 2.2 andFigure 2.3), together with a schematic of the sample sites showing whether they have been impacted by the dairy unit discharge (Figure 3.1).

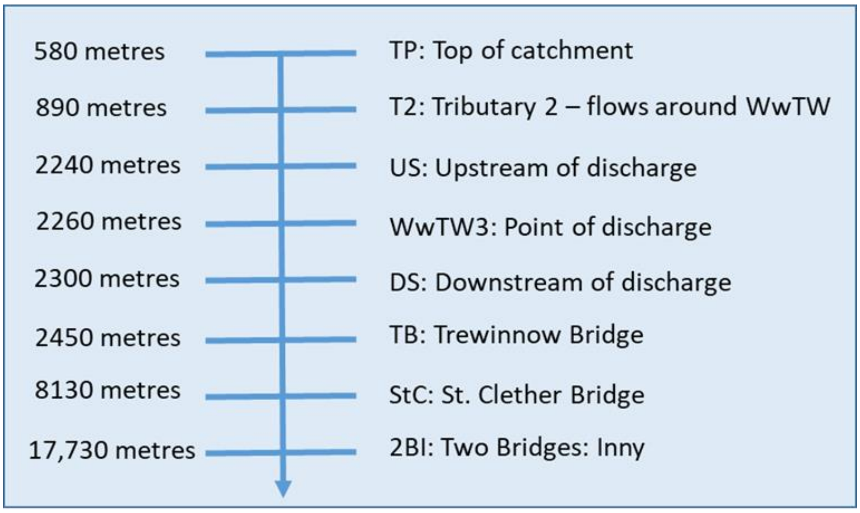


Figure 4.5 Schematic of River Inny, showing distance from top of catchment to end of monitoring reach

Table 4.1 Site abbreviations and names

Site reference	Site name	Notes
TP	Top of catchment	Upper sample point on River Inny
T2	Tributary running around WwTW	Classed as tributary of the River Inny
US	Upstream of discharge	Main river body
WwTW1	Post treatment effluent	Sampled from within Wastewater treatment works, post treatment
WwTW2	Post treatment effluent – composite sample	As above but from composite auto sampler.
WwTW3	Discharge to River Inny	Collected from outfall into the River Inny
DS	Downstream of discharge	Main river body, downstream of discharge
T1	Tributary 1	Joins main channel below DS site
TB	Trewinnow Bridge	Main river body, considered end of mixing zone
StC	St. Clether Bridge	Main river body
2BPP	Two Bridges Penpont	Large tributary of similar geology to River Inny
2BI	Two Bridges Inny	Main river body. End of field study area

4.4 Methodology for water chemistry

There is a lack of clarity over the species measured and methodology used for sample collection and processing when studying phosphorus (Goddard *et al*., 2020). Chapter 3 has reviewed reactive phosphorus defined as orthophosphate and refers to the species reported throughout that section i.e. orthophosphate. In this study, samples are analysed for principal species, namely soluble reactive phosphorus (SRP), total reactive phosphorus (TRP), total soluble phosphorus (TSP) and total phosphorus (TP) on a monthly basis. Water samples have been collected from the selected sites together with five field blanks each produced using high purity water. A water sample was collected from the site in a clean measuring jug during low flow conditions or bucket. The sample was agitated before being sub-sampled for the separate tests.

Samples were collected in sterile or acid rinsed 15 mL centrifuge tubes. Tubes had been soaked in 10% HCl for at least 24 hours before being rinsed 4 times in deionised water and once in high purity water.

Tubes were rinsed with filtered or unfiltered sample as appropriate, before triplicate 12.5 mL samples for SRP were filtered into the tubes on site using 0.45 µm cellulose acetate filters and syringes, precleaned in 2% HCl and rinsed twice with high purity water. Triplicate 12.5 mL samples for TRP were collected into the tubes on site using the clean syringe. Triplicate 9 mL samples for TSP were filtered into the tubes on site using 0.45 µm non-sterile hydrophilic SFCA membrane filters, supplied by Cole Parmer and syringes, precleaned in 2% HCl and rinsed twice with high purity water. Triplicate 9 mL samples for TP were collected into the tubes on site using the clean syringe. The 9 mL samples were all spiked with 1 mL Primar-Plus Trace analysis grade Nitric acid s.g. 1.42 (70%), supplied by Fisher Scientific (Lot no.1287386). Samples collected for the total and total soluble forms of phosphorus were used for measuring other elements by ICP-MS and ICP-OES. During summer sampling episodes, samples were kept in a cool box.

4.4.1 Reactive phosphorus

Samples collected for SRP and TRP analysis were tested within 24 hours, following the molybdenum blue method (Murphy & Riley, 1962) cited in (HMSO, 1992). using EnviroMAT Ground water, high level concentrate (ES-H), lot number S121012 supplied by QMX Ltd, x 100 dilution = 248 µg P L^{-1} and / or EnviroMAT Drinking Water, Low (EP-L) lot number S150123029 supplied by QMX Ltd, CRM x 100 dilution = 261 µg P L^{-1} , were used as Certified Reference Materials. Both certified materials were used as the arsenic concentration with in the ES-H interfered with the molybdenum blue reaction, thereby giving an incorrect phosphorus concentration.

In order to undertake the molybdenum blue method, the following reagents were made up:

1) Ascorbic acid

- Dissolve 2.5 g of ascorbic acid, $C_6H_8O_6$, in 12.5 mL of high purity water. Add 12.5 mL 25% sulphuric acid solution. The diluted acid solution is made up from 250 mL concentrated sulphuric acid added to 750 mL of distilled water, allowed to cool then made up to 1 L. The ascorbic acid solution should be stored in an amber lab glass bottle and refrigerated. A new batch of ascorbic acid was made up before each analysis.

2) Mixed Reagent P

- Dissolve 12.5 g of ammonium heptamolybdate tetrahydrate, $(NH_4)_6Mo_7O_{24}.4H_2O$ in 125 mL high purity water.
- Dissolve 0.5 g of potassium antimony tartrate, $K(SbO)C_4H_4O_6$ (with/without ½ H_2O) in 20 mL high purity water.
- Add molybdate solution to 350 mL of 25% sulphuric acid solution, stirring continuously. Add the tartrate solution and mix well. Store the solution in a lab glass bottle. The mixed reagent is stable for several months.

A working standard of 10 mg P L^{-1} was made up using 0.5 mL of 1000 mg P L^{-1} in a 50 mL volumetric flask made up with high purity water to 50 mL Calibration standards were set up as described in Table 4.2

Table 4.2 Calibration standards for Soluble reactive phosphorus and Total reactive phosphorus analysis

Volume of working standard	Concentration of final standard (µg P L^{-1})
39 µL of 10 mg P L^{-1}	**31.3 µg P L^{-1}**
78 µl of 10 mg P L^{-1}	**62.5 µg P L^{-1}**
156 µl of 10 mg P L^{-1}	**125 µg P L^{-1}**
313 µl of 10 mg P L^{-1}	**250 µg P L^{-1}**
625 µl of 10 mg P L^{-1}	**500 µg P L^{-1}**
1250 µl of 10 mg P L^{-1}	**1000 µg P L^{-1}**

All samples of reactive phosphorus (SRP and TRP) and the calibration solutions were prepared for analysis by the addition of 0.25 mL of ascorbic acid to each 12.5 mL sample. 0.25 mL of the mixed reagent was added to the solution which was mixed and allowed to develop for 10 minutes. Samples were decanted into a 4 cm cuvette and measured for absorbency using a Cecil CE1010 colorimeter at 710 nm. Measurements were undertaken within 30 minutes of the reagents being added to the samples.

To maintain quality assurance and ensure analytical quality control, blanks for each batch of analysis were taken, together with filter blanks for each batch of filtrations. For each analysis batch, external certified reference materials (CRM) were included with each set of samples.ES-H, lot number S121012 supplied by QMX Ltd, x 100 dilution = 248 µg P L^{-1} and or EP-L, lot number S150123029 supplied by QMX Ltd,CRM x 1000 dilution = 26.1 µg P L^{-1} . Analysis using two CRMs was adopted as the ESH contained a high concentration of phosphorus but also contained arsenic so experienced interference, where as the EP-L contained a low concentration of phosphorus but was not certified.

4.4.2 Determination of total soluble and total phosphorus

Samples collected for total phosphorus and total soluble phosphorus were refrigerated below 4 ^{0}C. Prior to analysis, the samples were placed in a water bath with the caps loosened and heated to 95 ^{0}C to ensure acid digestion of phosphorus was complete.

Samples were analysed for total phosphorus, total soluble phosphorus and iron using Thermo Fisher Scientific Inductively Coupled Plasma Mass Spectrometer (ICP-MS) X Series 11 or Themo Fisher Scientific iCAP RQ, depending on availability. During the analysis, concentrations of aluminium, vanadium, molybdenum, cobalt, nickel, copper, arsenic, selenium, cadmium and lead were measured to complement the dataset later if required.

Known calibration standards for ICP-MS analysis were made up according to Figure 4.6. A standard solution of phosphorus together with a multi element standard solution were used to make standards for calibration.

All standards were diluted with 10% nitric acid diluted as required from 70% nitric acid supplied by Fisher, diluted with high purity water, to ensure comparable matrices with the samples.

100 mg P L^{-1} stock solution was produced by taking 0.25 mL of P standard (10,000 mg P L^{-1}) and made up to 25 mL with 10% $HN0_3$ (Figure 4.6). From this and the LK multi-element 100 mg P L^{-1} stock, a 1000 µg L^{-1} mixed P and LK intermediate standard was produced. This was diluted to give the concentrations of calibration standards across the range 10 to 300 µg L^{-1} (Table 4.3).

Table 4.3 Calibration standards and their concentrations used during ICP-MS analysis.

Standard	Concentration µg L^{-1}
1	10
2	40
3	100
4	200
5	300

Samples were spiked with 100 µl of 1000 µg Ir / In L^{-1} for use as an internal standard to give a final concentration of 10 µg Ir / In L^{-1}. ES-H and or EP-L certified reference material was measured with each analytical run.

Each 25 mL volumetric flask of standard was spiked with 250 µl of 1000 µg Ir / In L^{-1} internal standard to give a final internal standard concentration in standards and samples of 10 µg Ir / In L^{-1}.

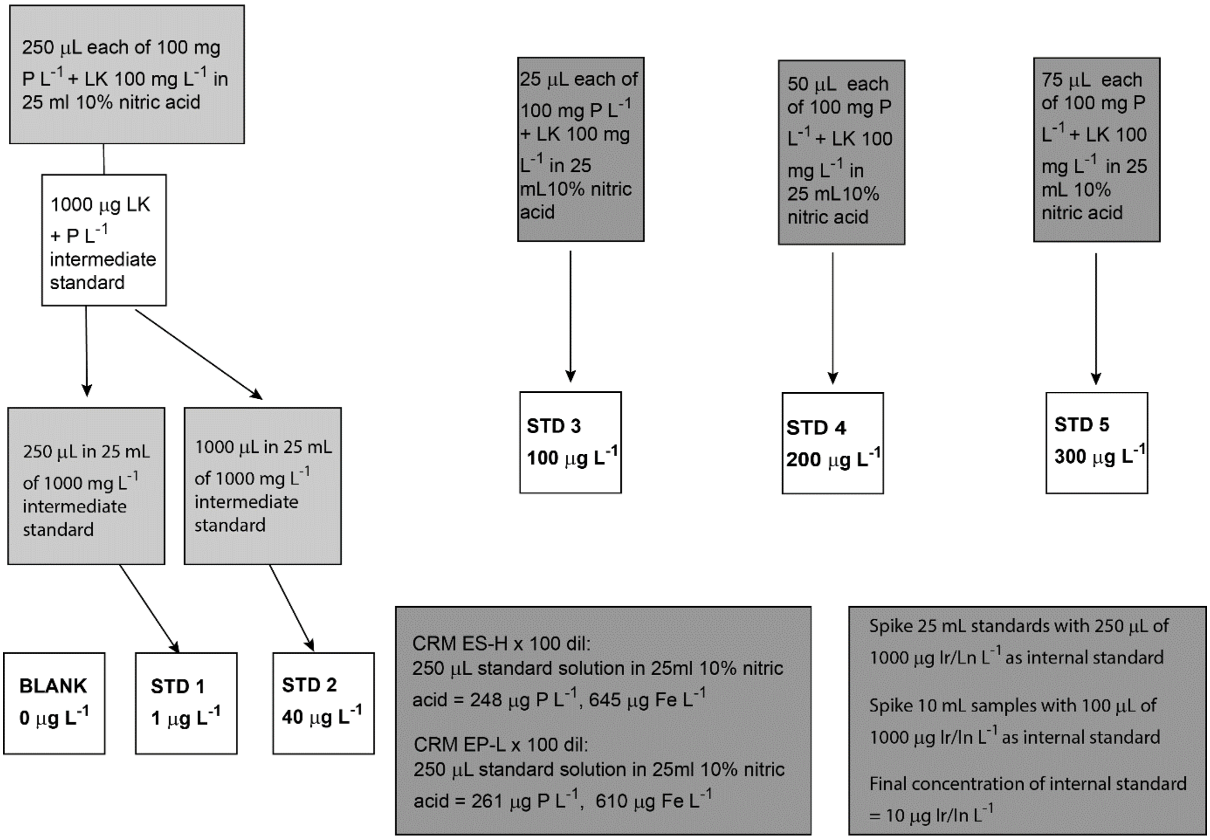


Figure 4.6 Procedure for making up calibration standards for ICP-MS

At this point, it should be reiterated that Saputo has a permit to discharge related to total phosphorus. The WFD standard is reporting water quality against reactive phosphorus (total). The following sections will discuss the concentrations of P species found spatially within the study catchment then look at those directly related to the WwTW.

4.4.3 Determination of other elements

Concentration of iron was determined as above by ICP-MS from the samples collected for TP and TSP analysis. After ICP-MS analysis, samples were measured as filtered and total for calcium, magnesium, potassium, silicon and sodium concentrations using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) iCAP 7400 ICP-OES, supplied by Thermo Fisher Scientific. ES-H and / or EP-L certified reference materials were tested with each set of samples as a reference for calcium, magnesium and potassium and sodium. No certified reference material was available for silicon.

Standard solutions described in Table 4.4 were used to make known calibration standards in the range 1 mg L^{-1} to 400 mg L^{-1} according to Figure 4.7, for the analysis. All standards were made up with 10% nitric acid to ensure comparable matrices with the samples.

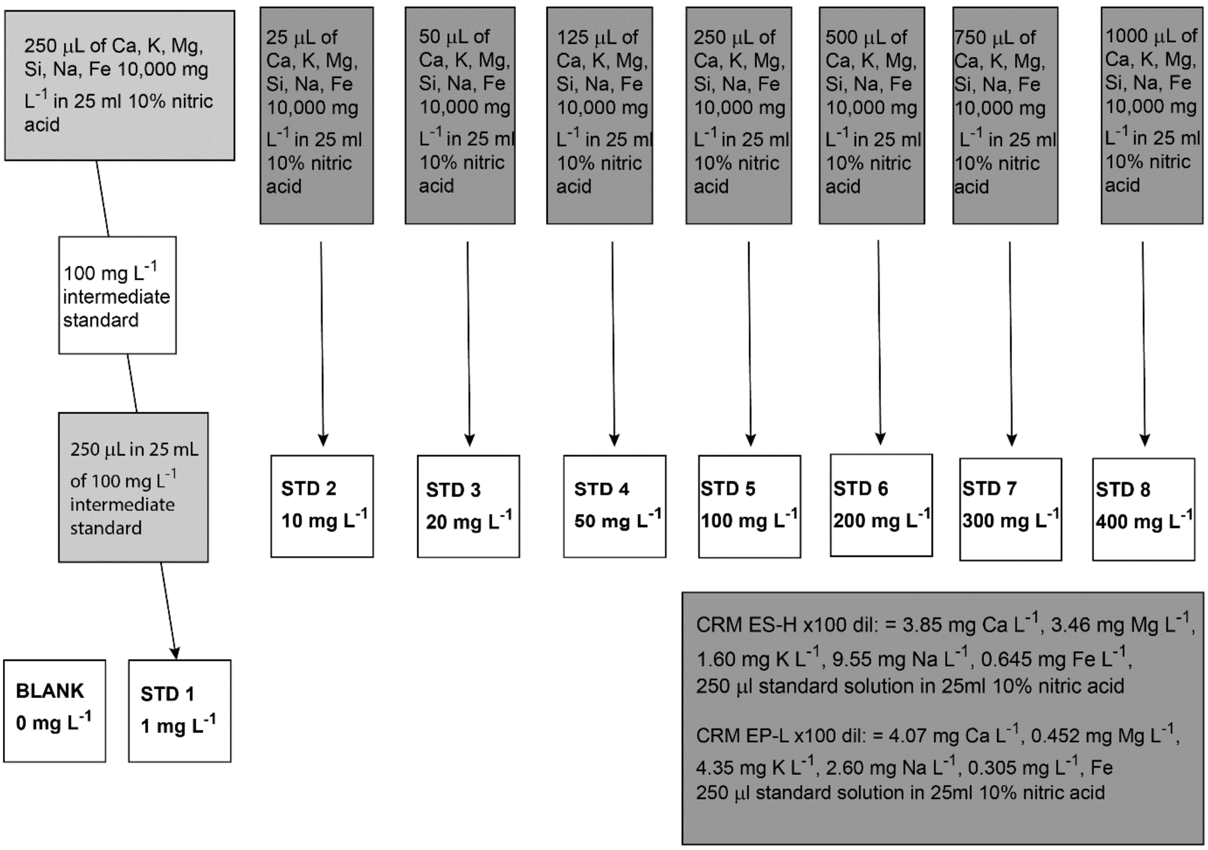


Figure 4.7 Procedure for making up calibration standards for ICP-OES

Table 4.4 Calibration standards and their concentrations used during ICP-OES analysis.

Standard	Concentration mg L^{-1}
1	1
2	10
3	20
4	50
5	100
6	200
7	300
8	400

Chloride concentrations were determined by ion chromatography. Two 50 mL centrifuge tubes of water samples were collected from each site for chloride analysis. On return to the laboratory, the samples were filtered through 47 mm Whatman GF/C Glass microfibre filters and refrigerated. Samples were diluted to bring conductivity to below 800 µs cm^{-1} in order to reduce the likelihood of analysis peaks merging.

Calibration standards were made up from 10,000 mg L^{-1} stock solutions across a range of 0.1 to 100 mg L^{-1}, according to Table 4.5. ES-H and EP-L were used as a certified reference materials with 3M KCl diluted to 1, 10 and 50 mg KCl L^{-1} and 0.06M NaCl diluted to 5 mg NaCl L^{-1} used as internal reference standards.

Table 4.5 Range of calibration standards used for ion chromatography

Standard	Concentration mg L^{-1}
1	0.1
2	1
3	2.5
4	5
5	10
6	20
7	50
8	100

Samples were decanted into 5 mL Dionex As-DV Autosampler PolyVials, supplied by Life Technologies Limited, capped and added to the Dionex AS-DV autosampler carousel. Samples were run using a Thermo Scientific Dionex aquion system with triplicate injections from each vial, and analysed by Dionex Ion Pac AS23 25 µl loop for the ions and Dionex Ion Pac CS12A 5 µl loop for the cations. Both systems were run using a suppressor. Each injection had a 25 minute leach and three injections were performed from each vial.

4.5 Water chemistry results for phosphorus

4.5.1 SRP

SRP at the top of the catchment (TP) was usually measured well below the 'Moderate' EQS (87 µg P L^{-1}); one erroneous reading of 350 µg P L^{-1} (Figure 4.8) was recorded however the mean value was 43 with the median 22 µg P L^{-1}.The EQS for 'Good' for this site is 28 µg P L^{-1} (reactive phosphorus). At the site above the Saputo discharge (US), measurements were more consistent, with a mean concentration of 33, median of 26 and a 'Good' EQS of 30 µg P L^{-1}. Water chemistry results can be seen in Appendix 4.

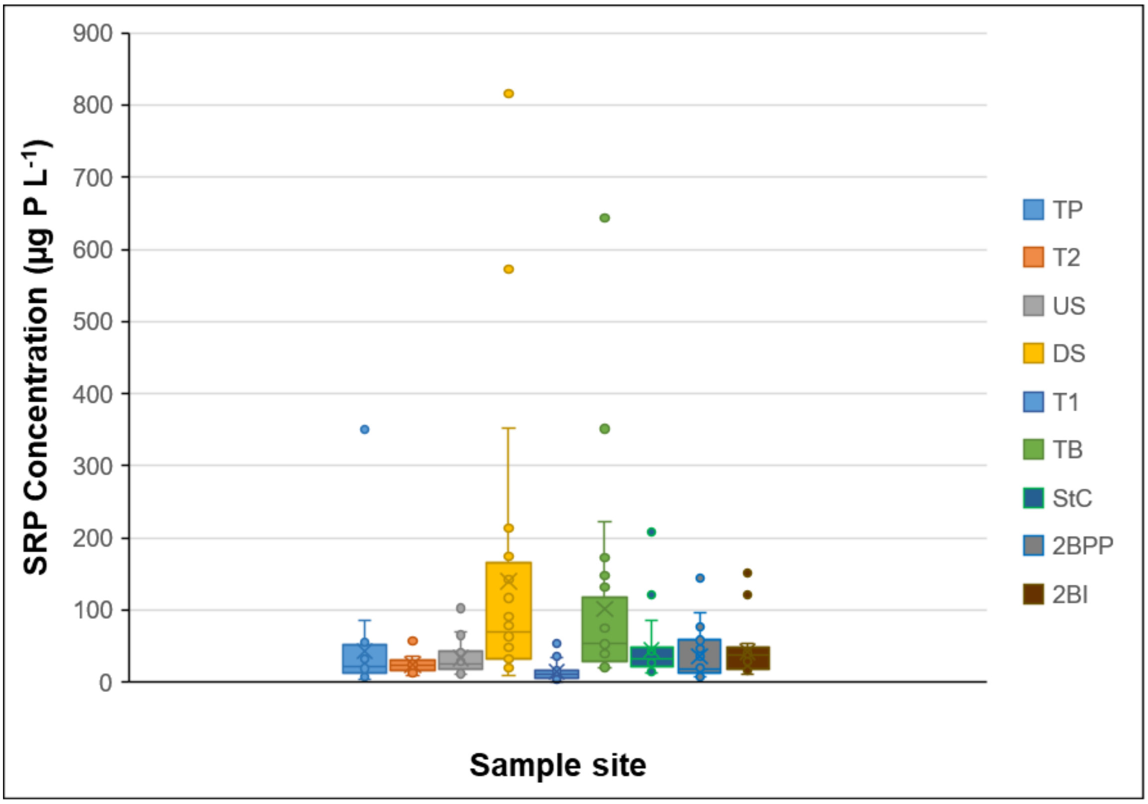


Figure 4.8 Soluble reactive phosphorus concentrations for River Inny sample sites Autumn 2017 – Autumn 2019, excluding wastewater treatment works. Chart shows mean and median values of Soluble reactive phosphorus at each sample site for the duration of the study period (n=24).

Downstream of the outfall (DS) and at Trewinnow Bridge (TB) SRP concentrations were significantly increased, with a mean SRP of 140 and 102 µg P L^{-1} and median of 69 and 54 µg P L^{-1}, respectively, and 'Good' EQS for the sites of 41 and 28 µg P L^{-1} respectively. At St Clether Bridge (StC), some 5.6 km further downstream, SRP was measured at a mean of 46 and median of 33 µg P L^{-1}, where the 'Good' EQS has been set at 42 µg P L^{-1}.

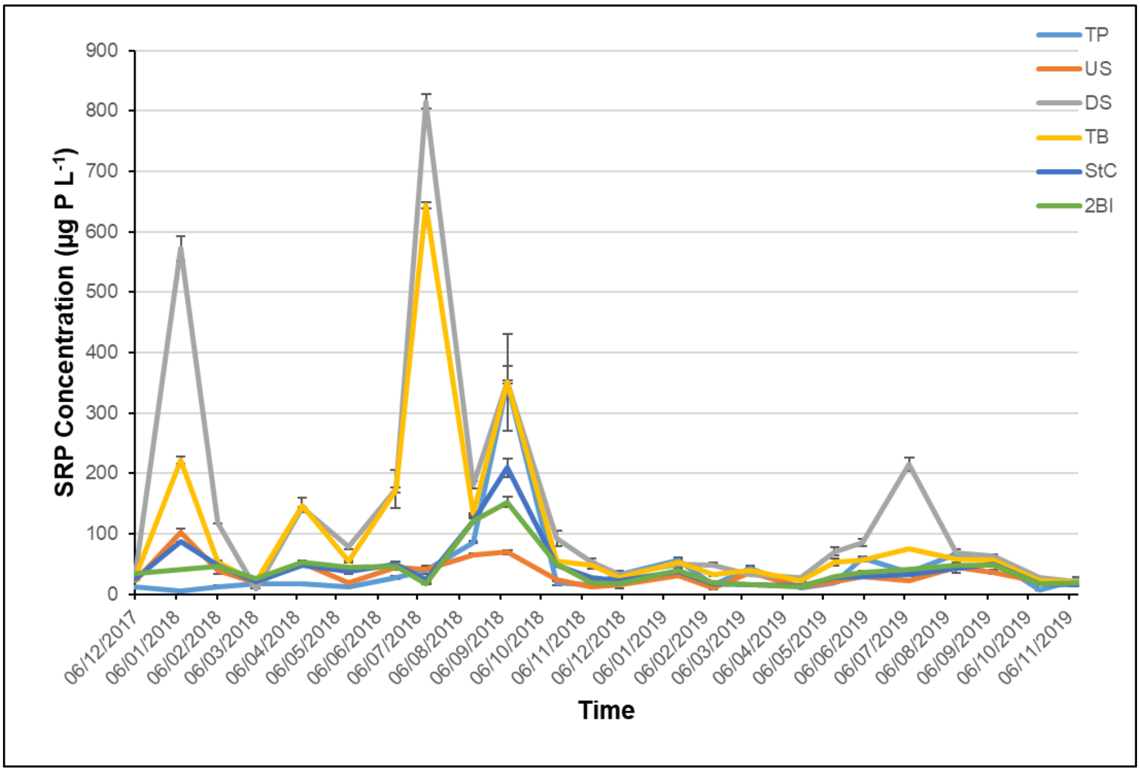


Figure 4.9 Soluble reactive phosphorus concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

In Figure 4.9, the centre of the graph shows a summer peak in SRP at the downstream and Trewinnow Bridge sites. August 2018 coincided with an incident at the wastewater treatment works, resulting in P concentrations increasing considerably. Following this incident, the concentrations have remained consistently lower, with the exception of July 2019. Low summer river flows have shown to impact on the concentrations within the river due to the lower dilution factor.

4.5.2 TRP

Comparable with concentrations of SRP, TRP for the three sample sites above the outfall, showed mean concentrations below 100 µg P L^{-1}. Median concentrations of TRP were 33-34 µg P L^{-1} (Figure 4.10). Downstream of the outfall the mean was 171 and median 93 µg P L^{-1} and at Trewinnow Bridge, a mean of 124 and median of 71 µg P L^{-1}. At St Clether, the concentrations were similar to upstream levels, measuring a mean of 52 and median of 37 µg P L^{-1}.

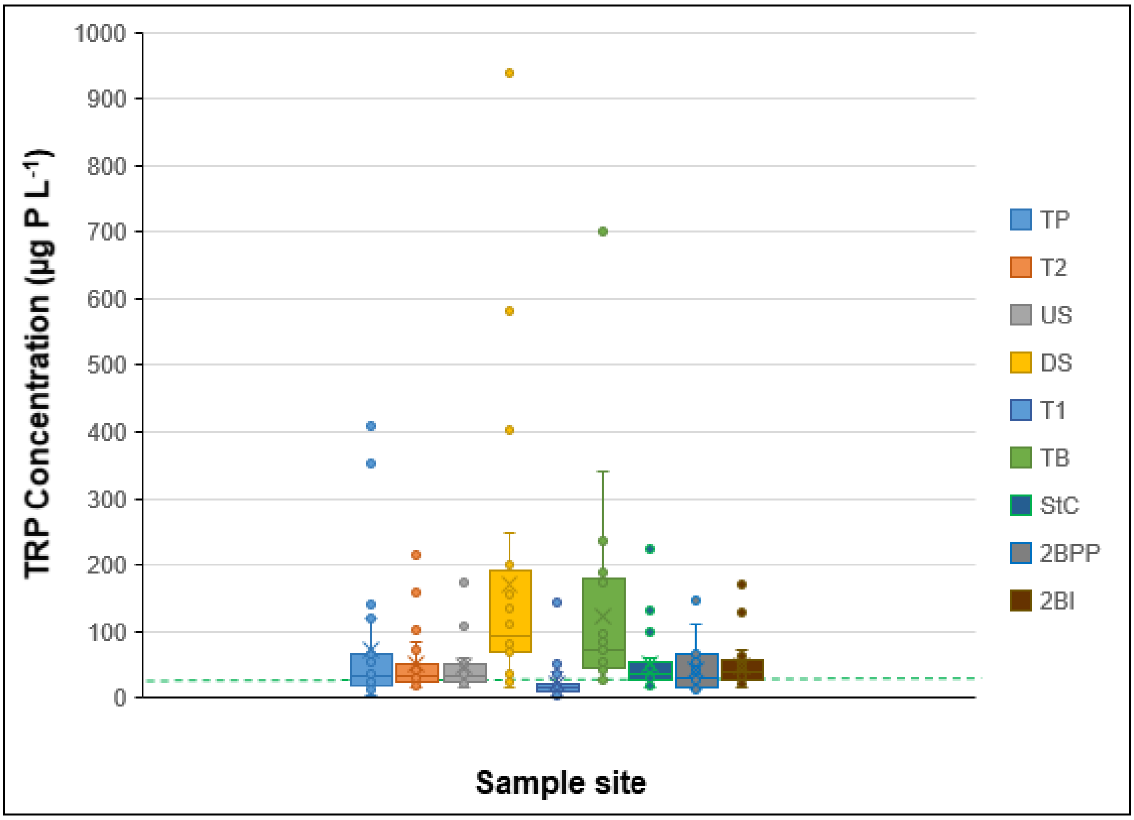


Figure 4.10 Total reactive phosphorus concentrations for River Inny sample sites, excluding wastewater treatment works. Chart shows mean and median values of Total reactive phosphorus at each sample site for the duration of the study period (n=24). Green dashed line represents EQS 'Good' for Reactive phosphorus at site Trewinnow Bridge.

Looking at the temporal data for TRP (Figure 4.11), a similar pattern to the SRP (Figure 4.9) chart is seen. Again, lower concentrations of TRP are seen after the installation of the new filtration system, although a TRP peak at the TP site may have impacted downstream measurements.

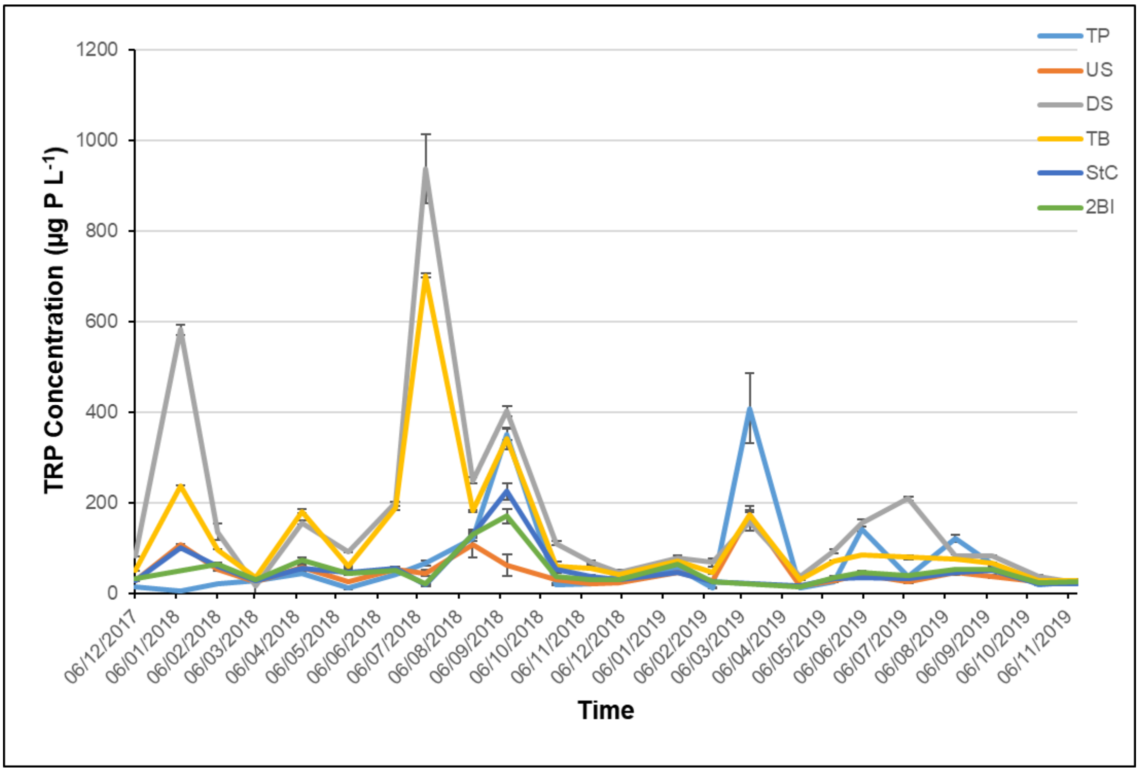


Figure 4.11 Total reactive phosphorus concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

4.5.3 TSP

TSP concentrations show a similar pattern (Figure 4.12) to SRP regarding the shape and spread of the data, but with overall higher concentrations – the TP site has a mean of 76 and median of 52 µg P L^{-1} and US a mean of 77 and median of 63 µg P L^{-1}. DS and TB, the mean TSP concentration is increased to 270 and 178 µg P L^{-1}, before dropping back to a mean concentration of 97 at StC and 92 µg P L^{-1} at 2BI, where the median concentrations are 86 and 66 µg P L^{-1} respectively. The closer values of mean and median concentrations suggest less variation than is experienced immediately downstream of the discharge point. This indicates consistency in the temporal concentration of TSP.

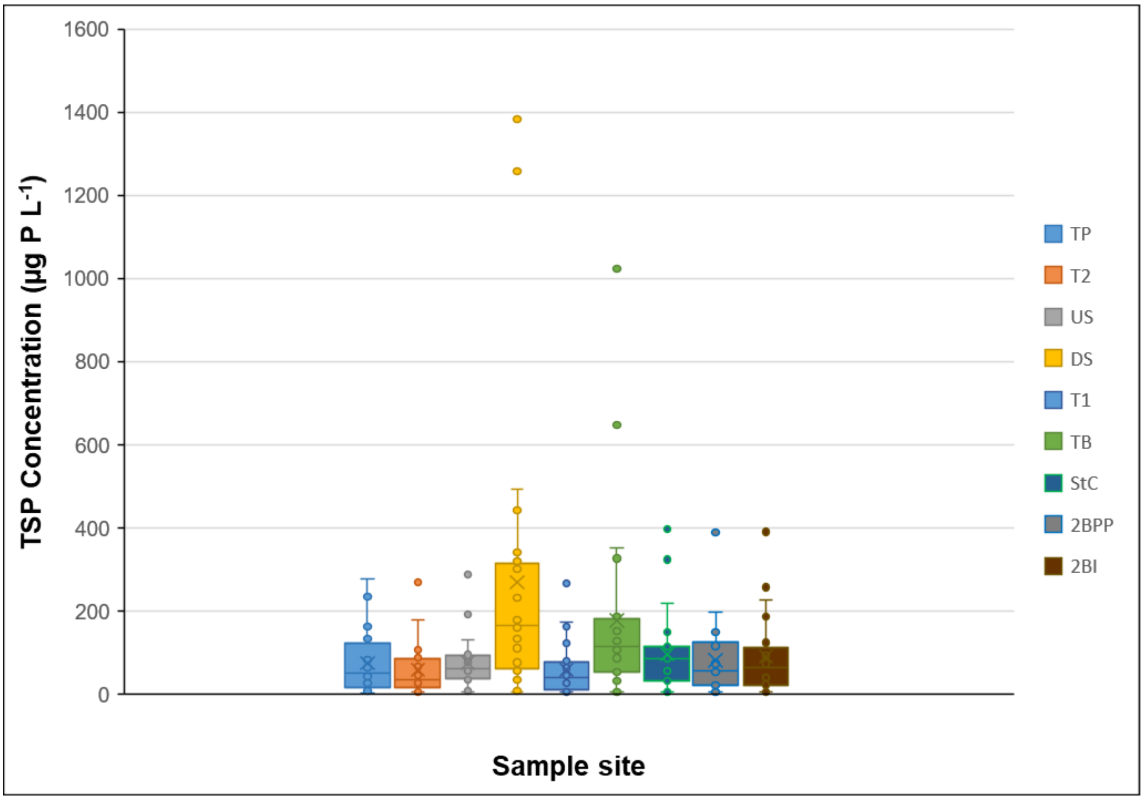


Figure 4.12 Total soluble phosphorus concentrations for River Inny sample sites, excluding wastewater treatment works. Chart shows mean and median values of Total Soluble Phosphorus at each sample site for the duration of the study period (n=24).

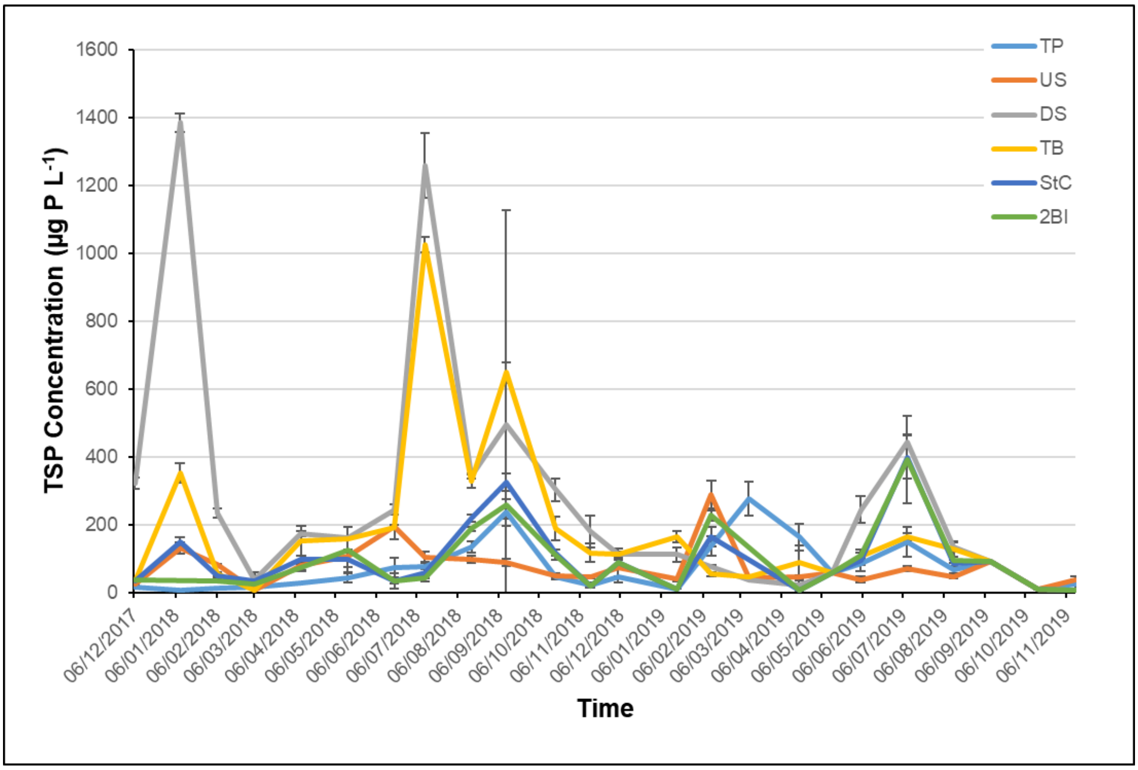


Figure 4.13 Total soluble phosphorus concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

Temporally, most of the mean TSP concentrations are ≤400 µg P L^{-1} (Figure 4.13). Again, lower summer flows can be seen to result in higher concentrations. The concentration for September 2018 shows a higher mean value at TB than DS, however, this is not significant owing to the high variation in the replicate samples associated with TB. In an attempt to explain the higher concentrations of TSP at TB than DS in September 2018, it was hypothesised that the concentration of P within the effluent might vary throughout the day and the switch in patterns of higher to lower concentrations between DS and TB lower has occurred due to sampling times. Mcginnity (2019), investigated the temporal variation of SRP within the Saputo treated effluent. Further analysis of this data showed a significant difference in daily concentrations of SRP (F=(4,25)5.669, *p=0.002*) and TRP (F=(4,25)4.169, *p=0.010*), but no significant difference in concentrations of TSP and TP on the five days that hourly (n=6) sampling took place.

Higher peaks in concentration occurred at DS and TB in January 2018 and July 2018 and in July 2019 at DS and 2BI. No explanation can be offered for the January 2018 peak, however, the July 2018 observation occurred immediately prior to a pollution incident associated with the discharge as a result of complications within the treatment works. An explanation for the higher peak in July 2019 could not be determined. Low summer flows were occurring, but the mean river depth at DS in May to July remained stable at 0.1m.

4.5.4 TP

At the uppermost sampling point (TP), the mean concentration of TP was 134 µg P L^{-1} (Figure 4.14) with a median concentration of 71 µg P L^{-1}. Excluding DS and TB, all sites exhibit mean concentrations of TP <200 µg P L^{-1}. DS experienced a mean value of 333 µg P L^{-1} and TB of 241 µg P L^{-1}. 2BI at the furthest extent of the study area had a mean of 119 and median of 110 µg P L^{-1}; a difference in mean value of 40 µg P L^{-1} compared to the US measurement.

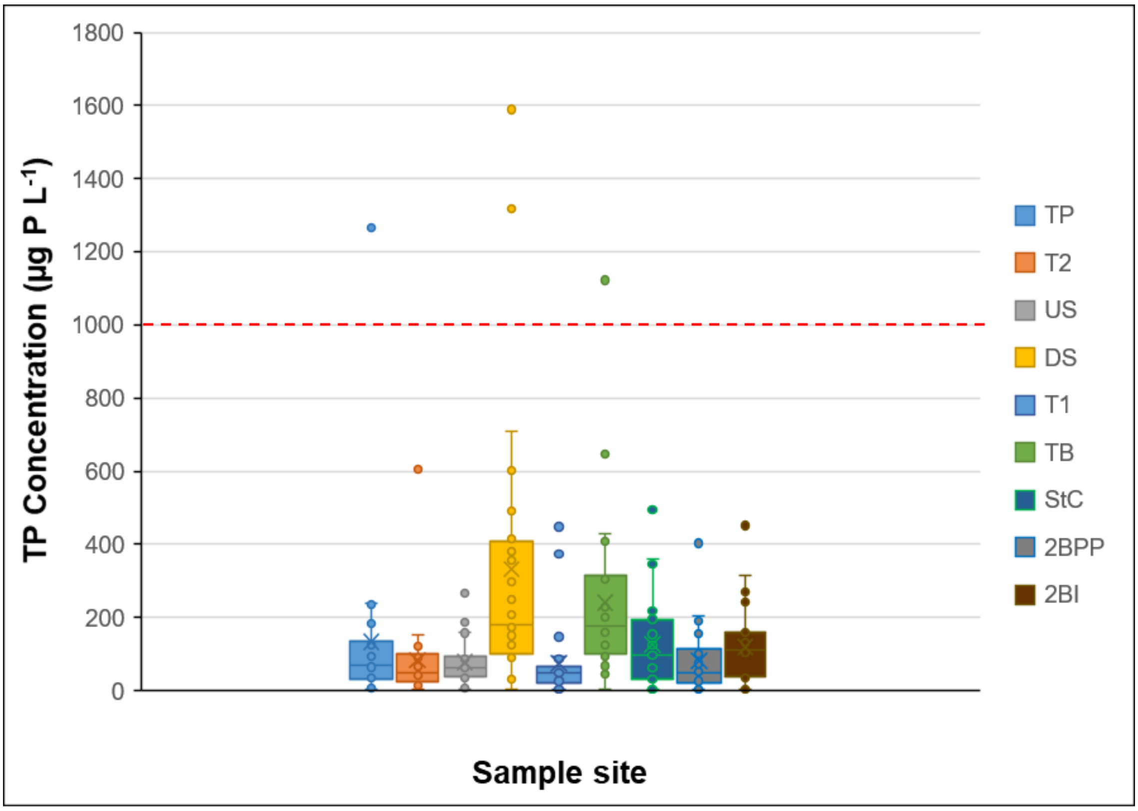


Figure 4.14 Total phosphorus concentrations for River Inny sample sites, excluding wastewater treatment works. Chart shows mean and median values of Total reactive phosphorus at each sample site for the duration of the study period (n=24). Red dash line represents 1 mg P L^{-1} annual average permit.

The high peak of P at the TP site (Figure 4.15) could be explained by springtime addition of phosphate fertiliser to grazing land. Although not mirrored in the SRP or TSP data, there is a similar peak in the TRP data.

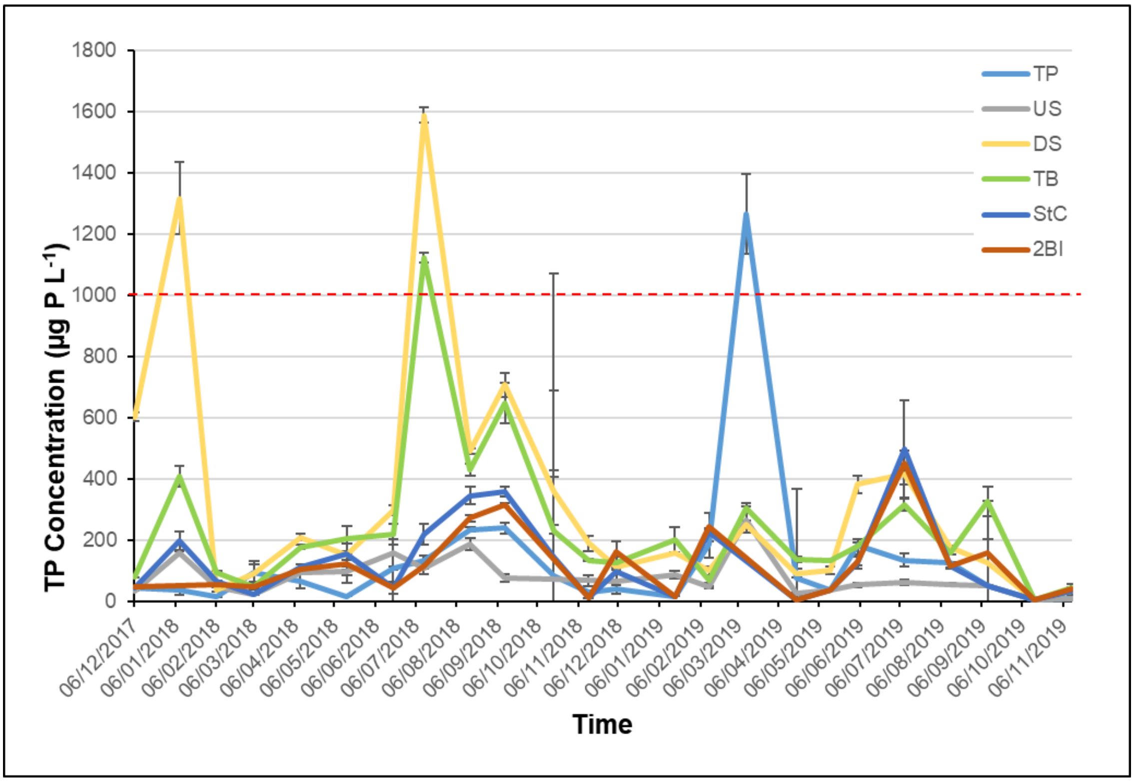


Figure 4.15 Total phosphorus concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev. Red dash line represents 1 mg P L^{-1} permit held by Saputo

Post treatment within the WwTW, sample WwTW1 is collected as a spot sample before the treated effluent enters the pipe that leads to the discharge point (WwTW3) and receiving waters of the River Inny. WwTW2 is a composite sample, auto-collected from the point of WwTW1 at a predetermined rate and stored within a collection vessel and analysed as required for permit compliances. WwTW3 is collected at the end of the discharge pipe as it fall to the receiving waters of the River Inny. Differences in composition and physical characteristics of these samples occur for several reasons:

1. differing composition within the flow at WwTW1
2. effect of dilution within storage container for WwTW2
3. continued chemical processes occurring in WwTW2 and the pipe to WwTW3

Saputo has an agreed discharge consent issued by the Environment Agency of 1 mg P L^{-1}, as total phosphorus (absolute). Figure 4.16 shows the average concentrations of phosphorus measured from the WwTW sample sites across the study period. WwTW1 showed a mean SRP concentration (solid bars) of 383 µg P L^{-1}, with a median value of 307 µg P L^{-1}. WwTW2, showed a mean of 362 and median of 133 µg P L^{-1} and WwTW3 showed a mean SRP concentration of 460 and median 388 µg P L^{-1}.

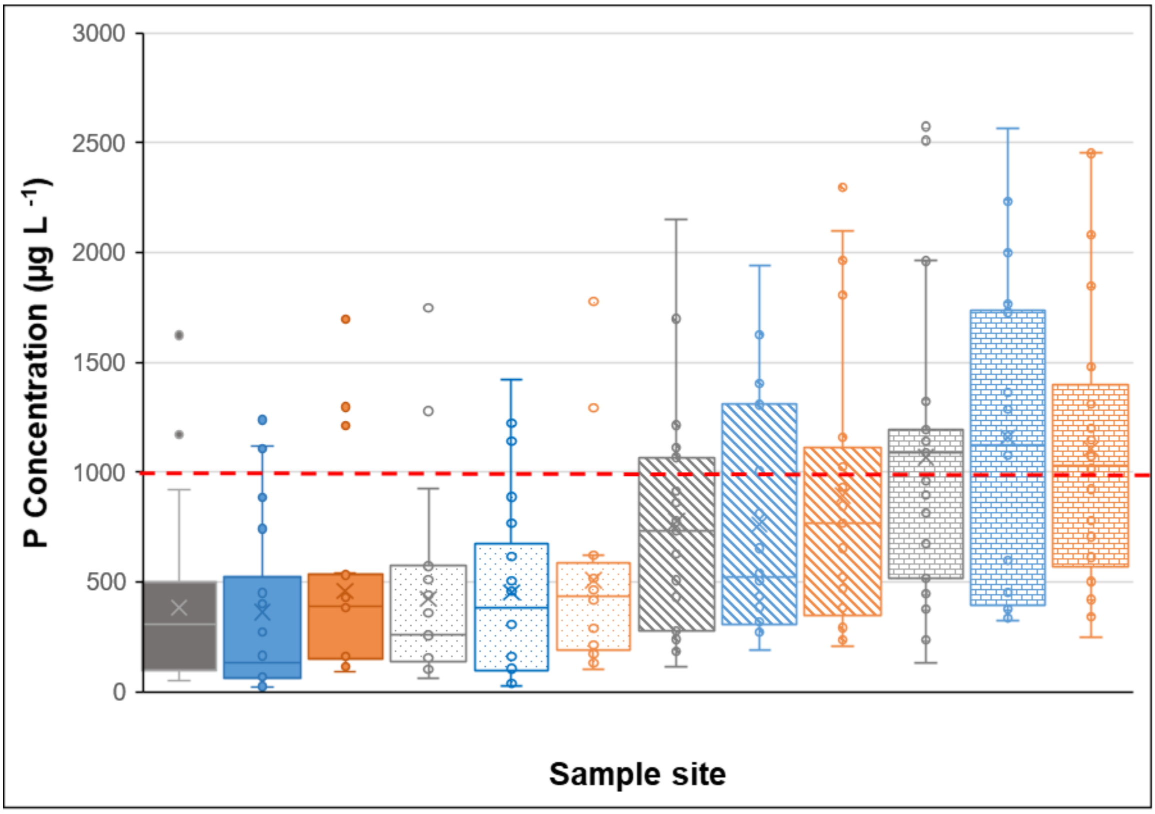


Figure 4.16 Phosphorus speciation at the WwTW, Autumn 2017 – Autumn 2019. WwTW1=grey, WwTW2=blue, WwTW3 = orange. Soluble reactive phosphorus=solid fill, Total reactive phosphorus=spotted fill, Total soluble phosphorus=diagonal line fill, Total phosphorus=brick fill. Current permit of 1 mg P L^{-1} (Total phosphorus, absolute) represented by red horizontal dashed line. WwTW1 post treatment, WwTW2 composite sample, WwTW3 effluent entering the River Inny. Chart shows mean and median values of Soluble reactive phosphorus at each sample site for the duration of the study period (n=24)

The mean TRP (spotted fill) concentrations measured in the effluent were 423, 454 and 508 µg P L^{-1} for WwTW1, 2 and 3 respectively, whilst median measurements were 258, 385 and 434 µg P L^{-1}. Mean concentrations of TSP (diagonal fill) from WwTW1, 2 and 3 were 777, 762 and 895 µg P L^{-1}, respectively and median concentrations were 734, 523 and 768 µg P L^{-1}. TP concentration (brick fill) measured at the compliance point (WwTW2), showed a mean of 1159 µg P L^{-1} and median of 1126. There is less variation at WwTW1 and WwTW3, with mean concentrations of 1070 and 1107 and median concentrations of 1088 and 1029 µg P L^{-1} respectively.

Plotting the SRP concentrations from WwTW1, 2 and 3 together against time (Figure 4.17), shows significant variation before and after February 2019 ($t(8)=3.42$, df =8, $p=0.009$). Within the WwTW, new cylinder filtration equipment was installed in February 2019 and its impact can be clearly seen.

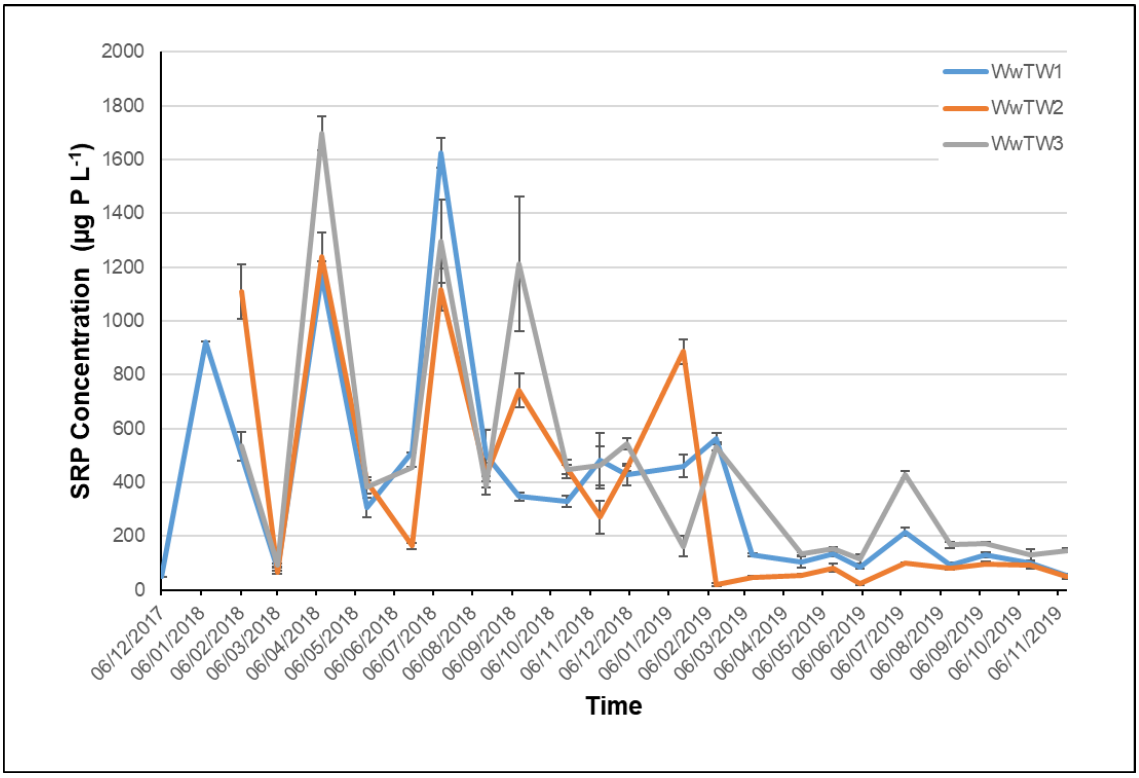


Figure 4.17 Temporal change in Soluble reactive phosphorus concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

A similar downward trend is observed in the TRP concentration (Figure 4.18), the TSP concentration (Figure 4.19) and the Total P concentration (Figure 4.20) within the effluent is observed, particularly around the upgrade of the filtration equipment. This illustrates an element of continual improvement in phosphorus management from within the WwTW.

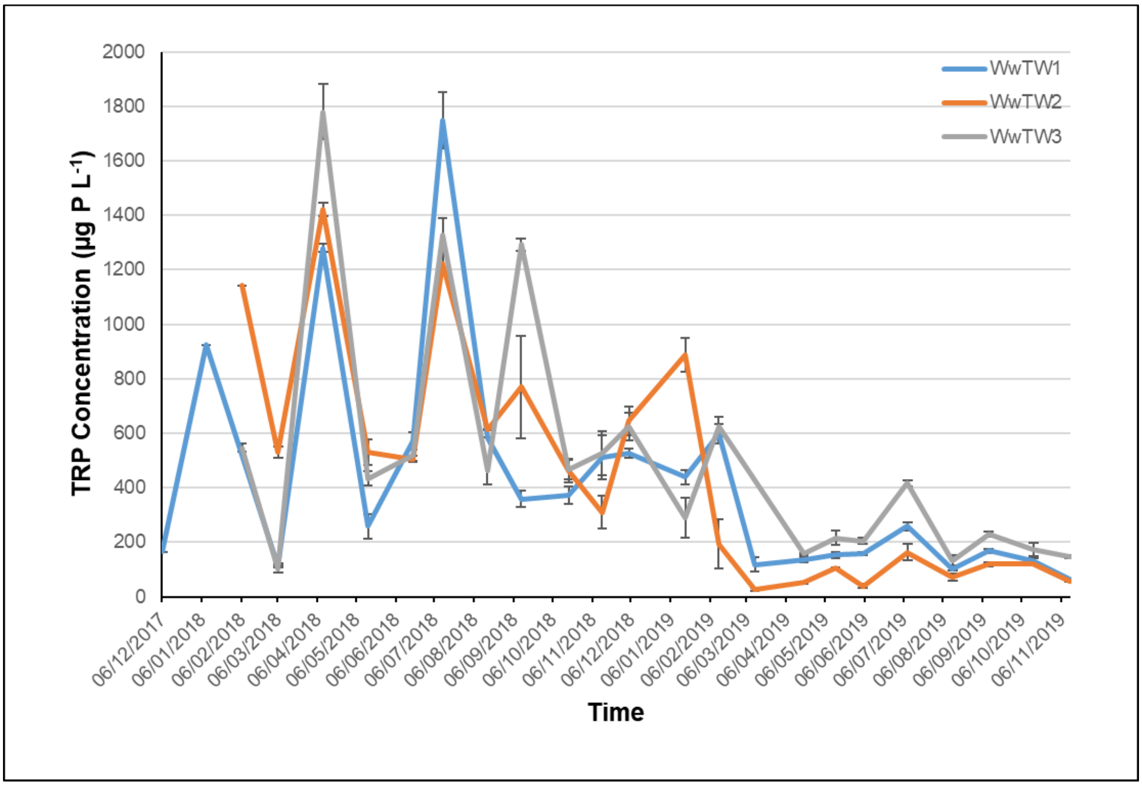


Figure 4.18 Temporal change in Total reactive phosphorus concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

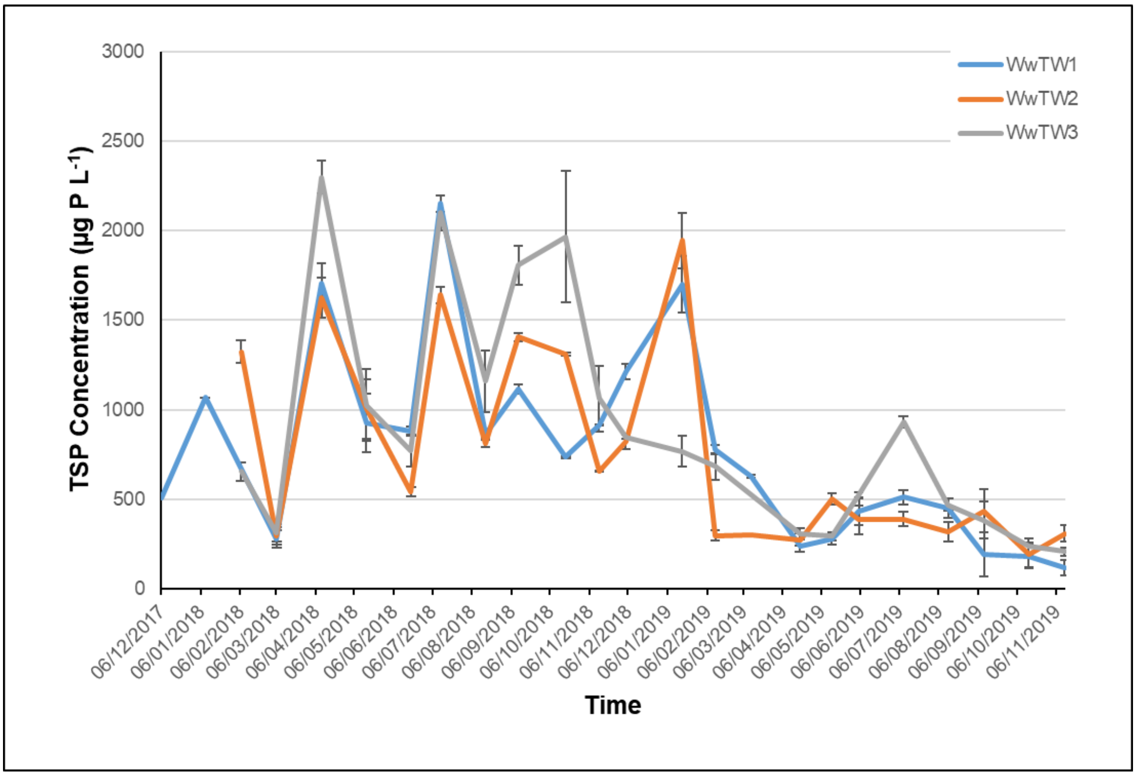


Figure 4.19 Temporal change in Total soluble phosphorus concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

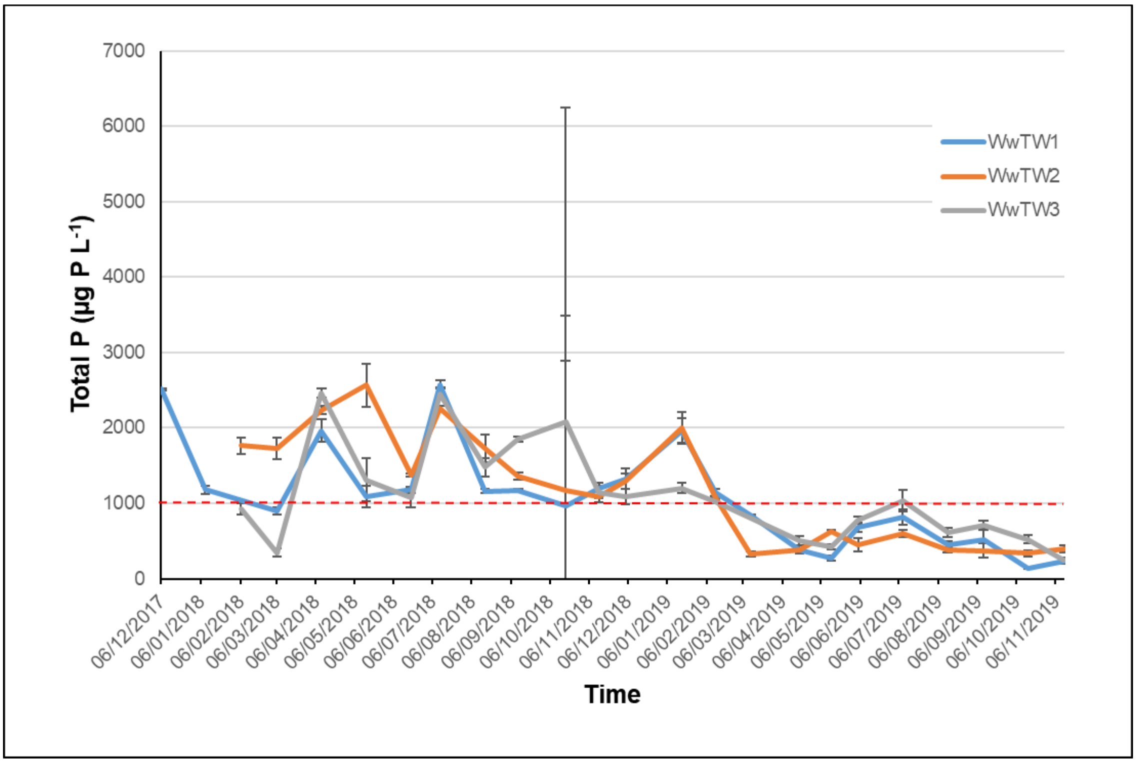


Figure 4.20 Temporal change in Total phosphorus concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

4.6 Iron

Water samples analysed for iron were those collected and analysed for TSP and TP. Sample preparation was the same as that for TSP and TP samples and analysis took place at the same time as the P analysis, using Thermo Fisher Scientific Inductively Coupled Plasma Mass Spectrometer (ICP-MS) X Series 11 or Themo Fisher Scientific iCAP RQ, depending on availability. Iron has been measured as filtered iron and total iron. Each form will be reported separately.

4.6.1 Filtered iron

At the top of the catchment, sampling took place at an elevation of 256 m AOD. Filtered iron was measured as a mean concentration of 110 µg Fe L^{-1}, with a median concentration of 23 µg Fe L^{-1} (Figure 4.21). The tributary that feeds into the Inny before the upstream site, T2 showed a mean concentration of 111 but a median of 93 µg Fe L^{-1}. T2 flows across boggy ground and iron rich precipitation coloured standing water.

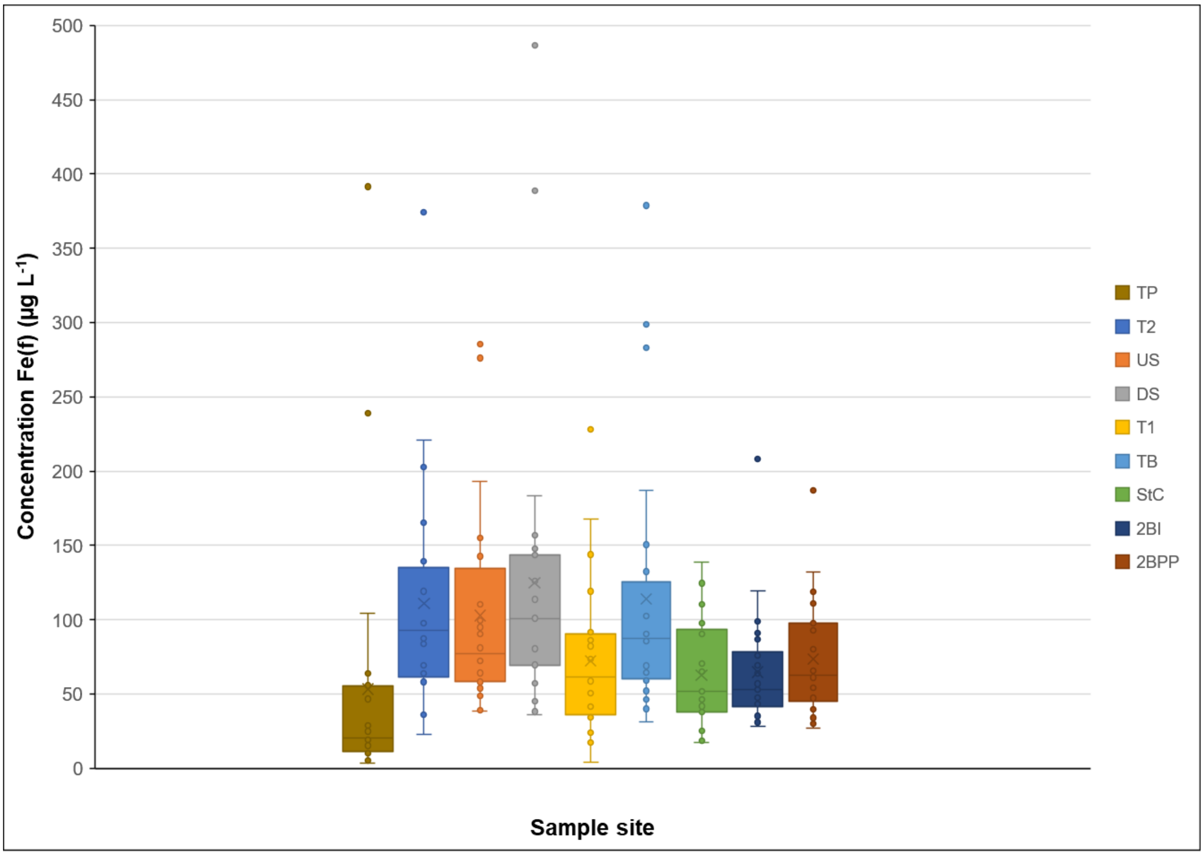


Figure 4.21 Fe (filtered) concentrations for River Inny sample sites, excluding wastewater treatment works. Chart shows mean and median values of iron at each sample site for the duration of the study period (n=24). Data clipped at 500 µg Fe L^{-1}.

Upstream of the outfall measured a mean concentration of 103 µg Fe L^{-1}, with a median of 77. Downstream of the outfall the concentration increased to 125 µg Fe L^{-1}, with a median of 101. The tributary (T1) below this site showed a mean of 72 µg Fe L^{-1}, which would have contributed to the diluted concentration at TB of 114 µg Fe L^{-1} (median 88). At St. Clether Bridge, the concentration has fallen back to baseline levels and was measured at a mean of 63 µg Fe L^{-1}, median of 52. Minimal change is observed at Two Bridges Inny, where a mean of 65 and median of 53 is observed. Compared to Two Bridges Penpont Water, which flows over similar geology and land use, except for the dairy processing unit, and filtered iron is measured as a mean of 73 µg Fe L^{-1} and median of 64.

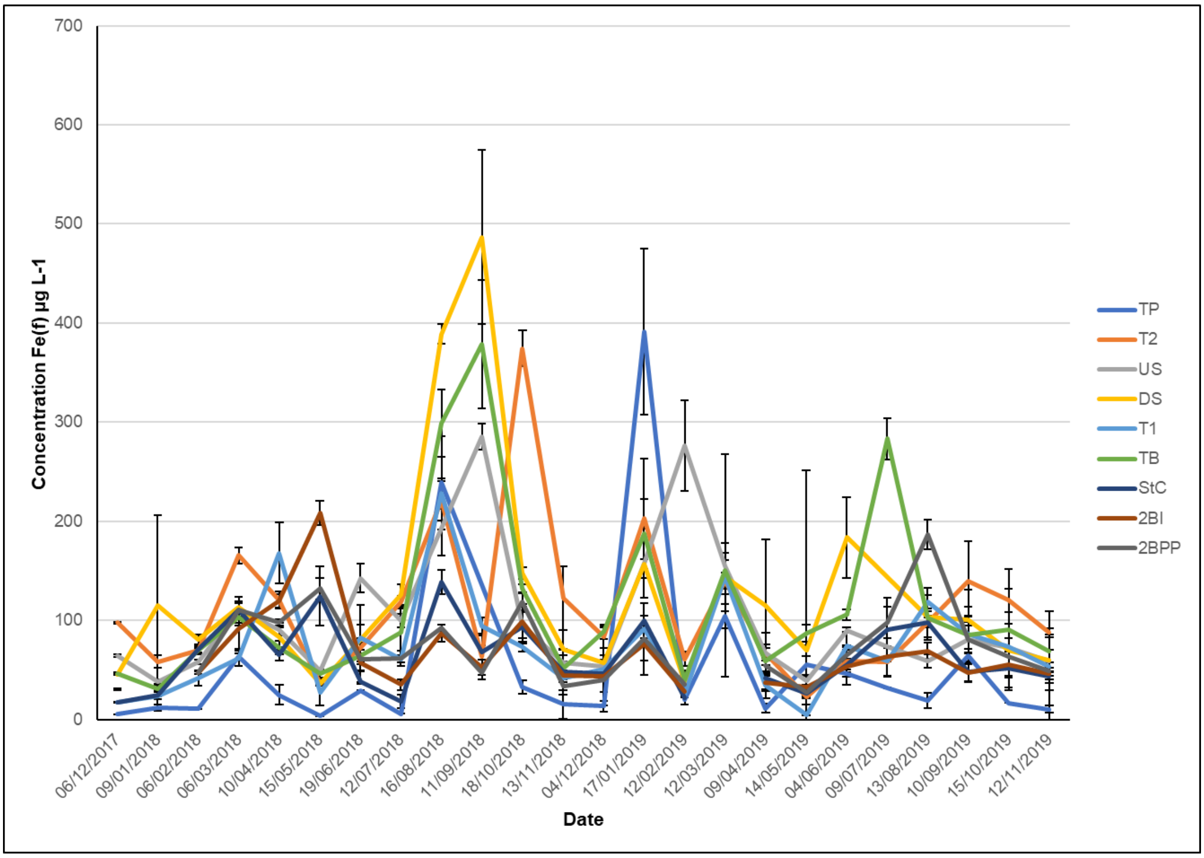


Figure 4.22 Fe filtered concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

Figure 4.22 illustrates the mean concentration of all sample sites across the sampling period to allow comparison of filtered iron within tributaries of the River Inny as well as the main river body. With the exception of two peaks at TP (1425 µg Fe L^{-1}) and DS (4426 µg Fe L^{-1}) filtered iron showed little variation by sample date across the sampling regime.

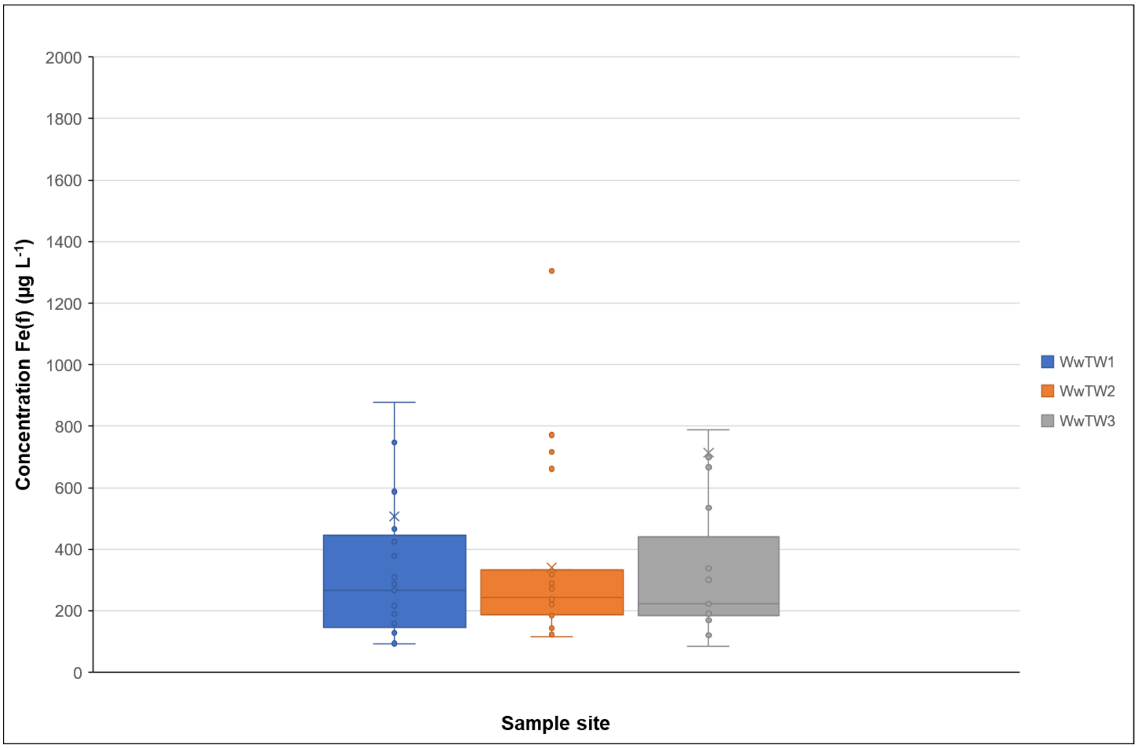


Figure 4.23 Fe (filtered) concentrations for WwTW samples. WwTW1 post treatment, WwTW2 composite sample, WwTW3 effluent entering the River Inny. Chart shows mean and median values of iron at each sample site for the duration of the study period (n=24).

Mean concentrations of filtered iron in the effluent samples (Figure 4.23) were measured at 517, 341 and 714 µg Fe L^{-1} for sites WwTW1, 2 and 3 respectively. The median concentrations were 267, 242 and 222 µg Fe L^{-1}. Raised iron levels would be expected in these samples due to the addition of ferric chloride to precipitate out phosphorus. Temporal behaviour of filtered iron in the WwTW samples is shown in Figure 4.24. Of the 24 sampling episodes that took place, just four exceed 1000 µg Fe L^{-1}. The majority of samples measured <800 µg Fe L^{-1}.

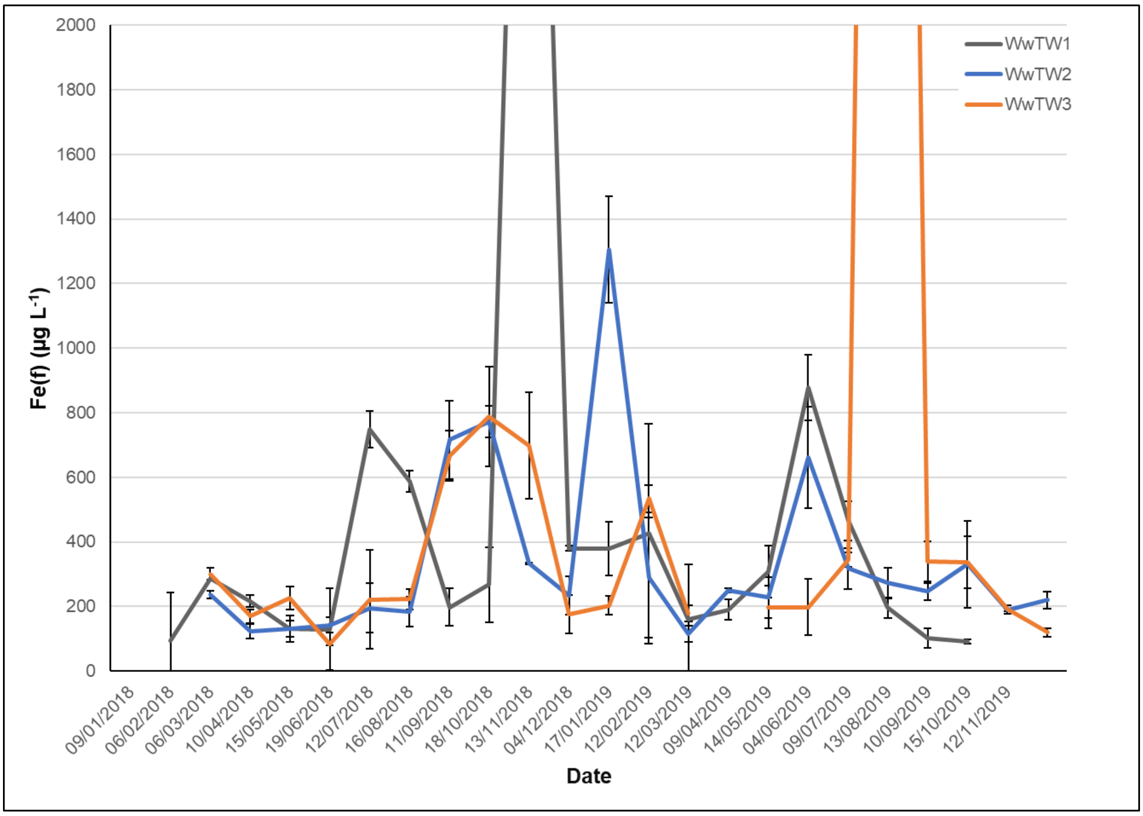


Figure 4.24 Temporal change in filtered iron concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev. Data clipped at 2000 µg Fe L1. WwTW1 peaks at 4399 µg Fe L^{-1}, WwTW3 peaks at 8794 µg Fe L^{-1}.

4.6.2 Total iron

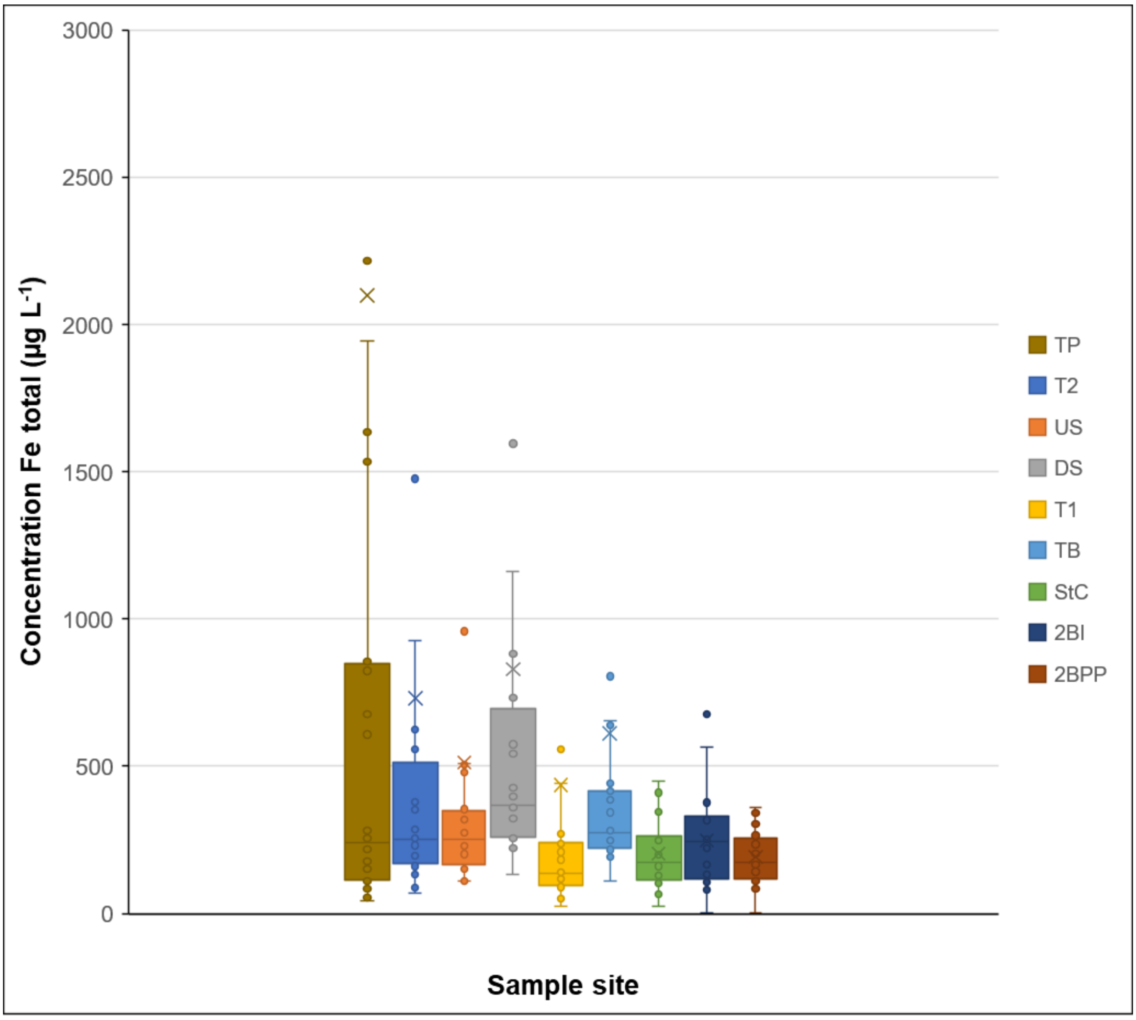


Figure 4.25 Total Fe concentrations for River Inny sample sites, excluding wastewater treatment works. Chart shows mean and median values of iron at each sample site for the duration of the study period (n=24). Concentration clipped at 3000 µg Fe L^{-1} total iron.

Outliers within the measurements for total iron included values between 5000 and 10,000 µg Fe L^{-1} and a peak value at TP of >35,000 µg Fe L^{-1}. As a result TP, showed a mean concentration (Figure 4.25) of 2100 µg Fe L^{-1} total iron, compared to a median concentration of 240 µg Fe L^{-1}. T2, which flows around the WwTW showed a mean of 730 and a median concentration of 253 µg Fe L^{-1} total iron. Upstream of the discharge measured a mean of 512 and median of 252 µg Fe L^{-1} total iron, whilst downstream, the mean was 830 and the median 367 µg Fe L^{-1} total iron. Tributary T1 measured a mean of 436 and median of 138 µg Fe L^{-1} total iron and at TB, a mean of 612 and median of 273 was recorded. At St Clether Bridge the mean concentration of total iron was 203 µg Fe L^{-1} total iron and median concentration of 175, whilst at 2BI the mean was 248 and the median 245 µg Fe L^{-1} total iron. By comparison, Two Bridges Penpont Water showed a mean concentration of 192 and a median of 172 µg Fe L^{-1} total iron.

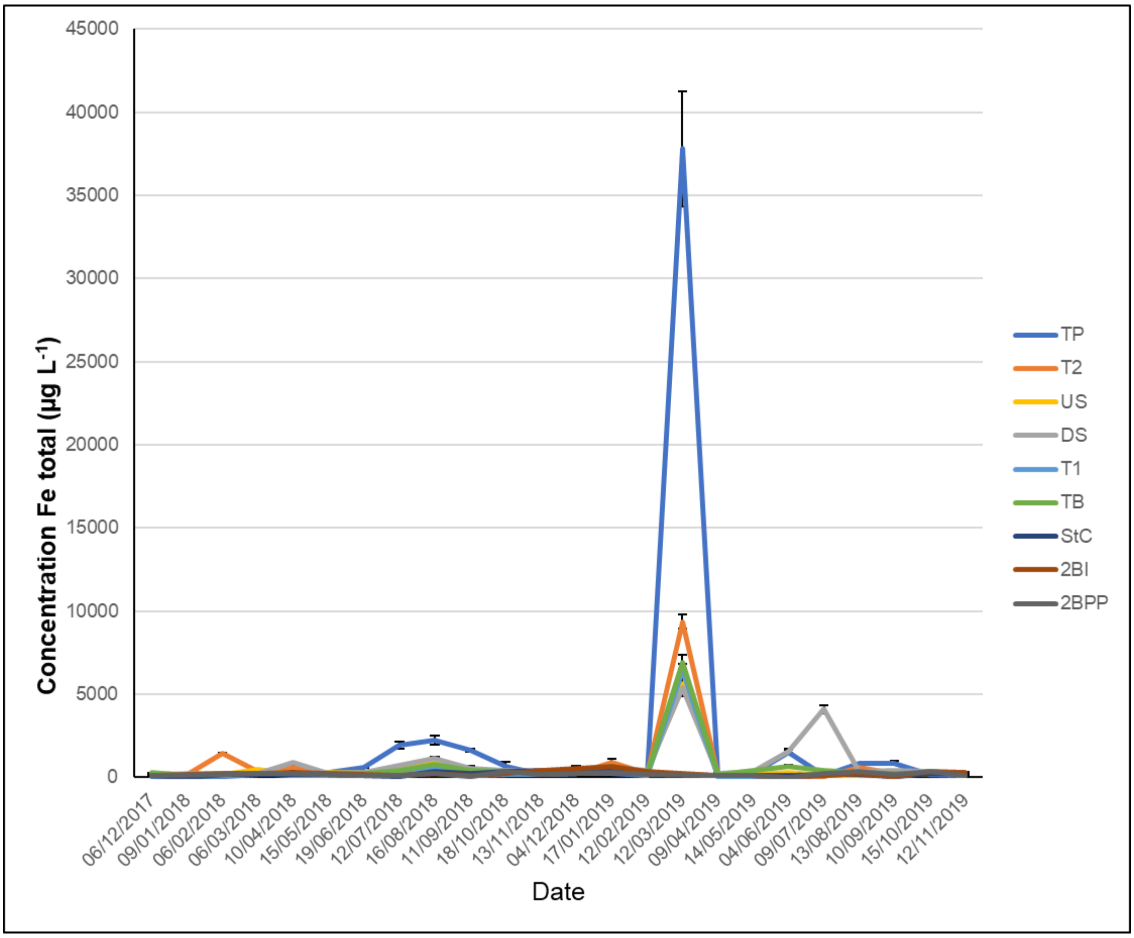


Figure 4.26 Total Fe concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

Again, several outliers mask the detail of total iron concentrations within the chart (Figure 4.26). The March 2019 sample was collected at a time of high flow and total suspended solids which would contain a higher concentration of Fe.

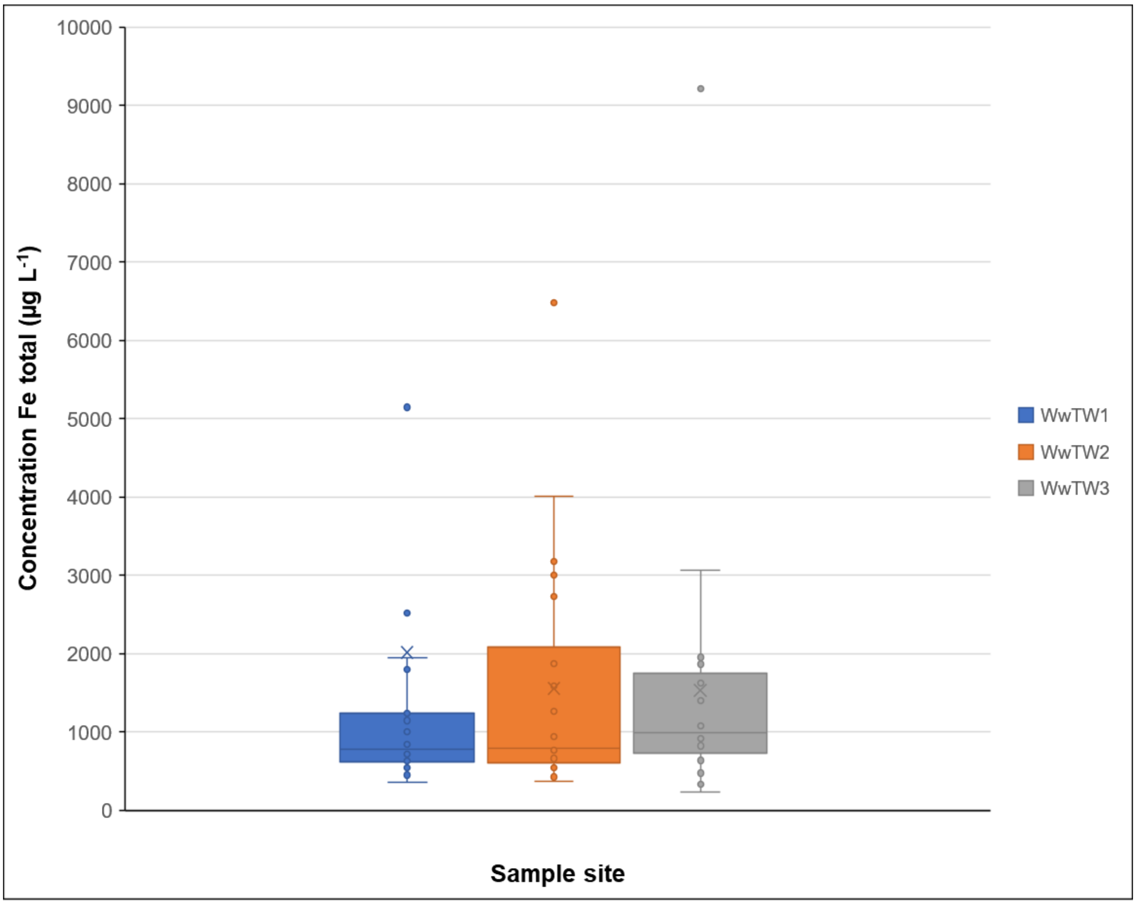


Figure 4.27 Total Fe concentrations for WwTW samples. WwTW1 post treatment, WwTW2 composite sample, WwTW3 effluent entering the River Inny. Chart shows mean and median values of iron at each sample site for the duration of the study period (n=24).Data clipped at 20,000µg Fe L^{-1}.

WwTW1 measured a mean concentration of 2012 µg Fe L^{-1} total iron (Figure 4.27) and median of 775 µg Fe L^{-1} total iron. WwTW2 and 3 measured mean concentrations at 1553 and 1528 µg Fe L^{-1} total iron, with median concentrations of 793 and 988 µg Fe L^{-1} total iron respectively.

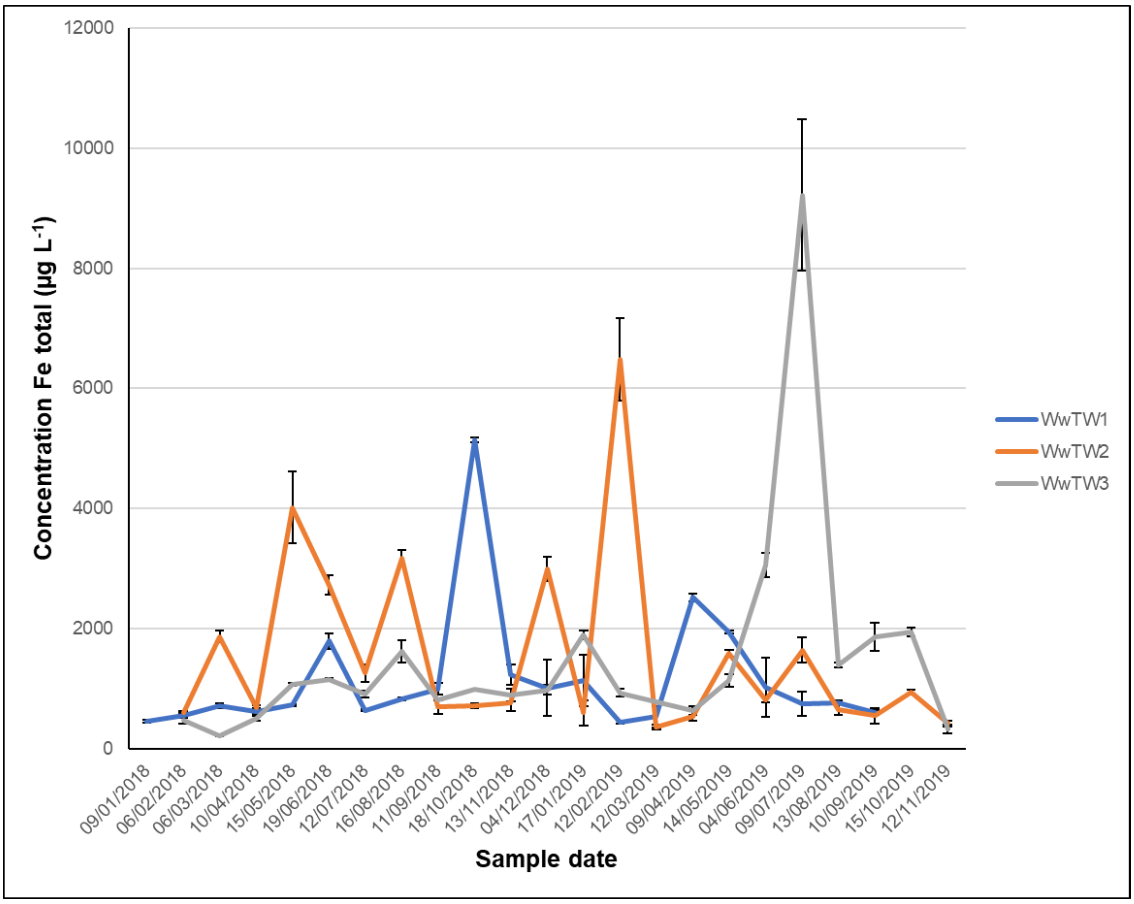


Figure 4.28 Temporal change in total iron concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

Unlike the trends for phosphorus associated with WwTW1, 2 and 3, there is a general increase in the concentration of total iron from the WwTW3 sample across the study period (Figure 4.28). The trends for both WwTW1 and 2 show a steady decline, so the increase in 3 is possibly due to the continued reaction between ferric chloride and reactive phosphorus depositing Fe (III) within the discharge pipe which is later resuspended in the flow before the outfall. Data from Saputo show the mean daily Fe total concentration of the effluent to be 580 µg Fe L^{-1} total iron, across the period 1 May 2020 to 16 July 2020, with median concentration of 452 and minimum and maximum concentrations of 178 and 2520 µg Fe L^{-1} total iron.

4.7 Chloride

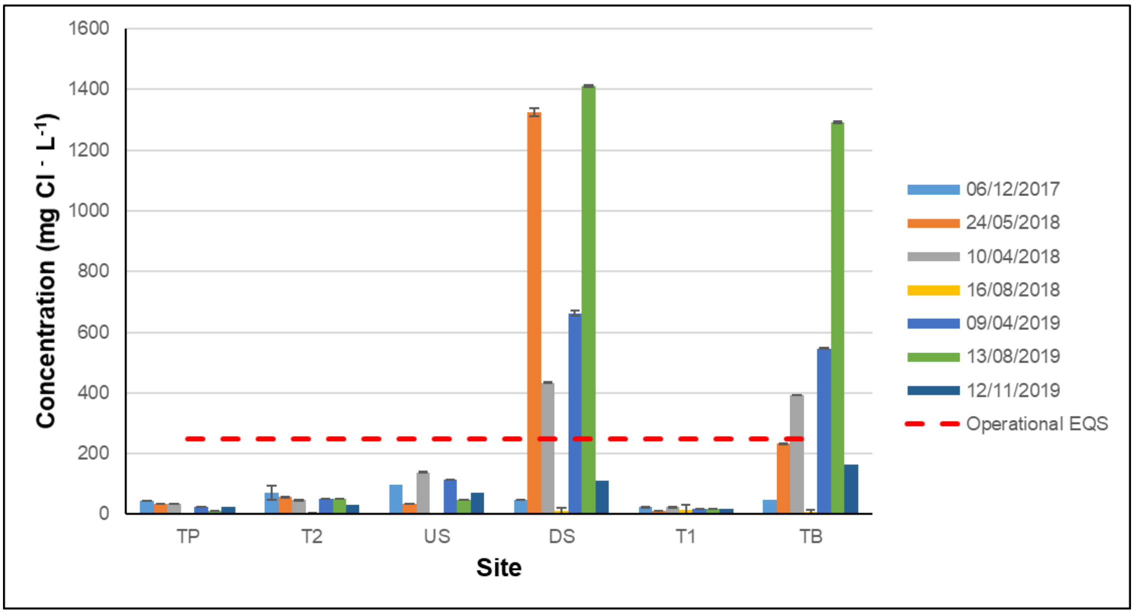


Figure 4.29 Mean chloride concentrations from top of catchment to end of study reach (n=7), with operational EQS of 250mg CL^- L^{-1} illustrated as red dashed line. Error bars represent 2xStDev.

Samples were analysed for chloride on 7 occasions (Figure 4.29). Mean concentrations of chloride within the River Inny, outside of influence from the dairy are consistently low (TP = 31 mg Cl^- L^{-1}, T2 = 51 mg Cl^- L^{-1}, US = 77 mg Cl^- L^{-1}, T1 = 27 mg Cl^- L^{-1} and 2BPP = 22 mg Cl^- L^{-1}). Downstream of the discharge a mean concentration of 708 mg Cl^- L^{-1} was measured (Figure 4.30), followed by 542 mg Cl^- L^{-1} at TB, 296 mg Cl^- L^{-1} at StC and 285 mg Cl^- L^{-1} at 2BI.

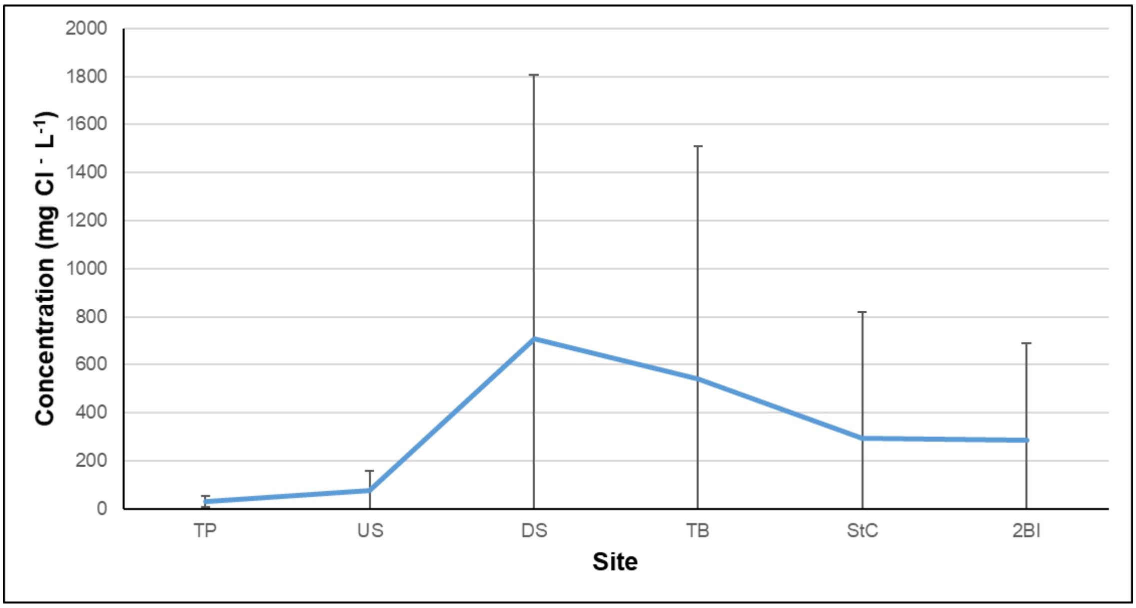


Figure 4.30 Mean chloride concentrations from top of catchment to end of study reach for the River Inny sites. Error bars represent 2xStDev.

4.8 Associated water chemistry

Unless stated, results discussed are for filtered samples only as minimal difference occurred between the dissolved and total phases.

4.8.1 Calcium

The mean concentration at TP was 11 mg L^{-1} (Figure 4.31) with a median of 13 mg L^{-1}. T2 was slightly higher with a mean of 17 and median of 15 mg L^{-1}. Upstream of the discharge, the mean was 19 and the median 20 mg L^{-1}. Downstream of the discharge, the mean was raised slightly to 32 and the median to 26 mg L^{-1}. The tributary T1 showed a mean and median of 14 mg L^{-1}. At TB the mean had dropped slightly to 30 with a median of 28 mg L^{-1}. At St Clether Bridge, the mean and median dropped further to 22 mg L^{-1} and at 2BI, the mean was 23 mg L^{-1} with a median of 22.

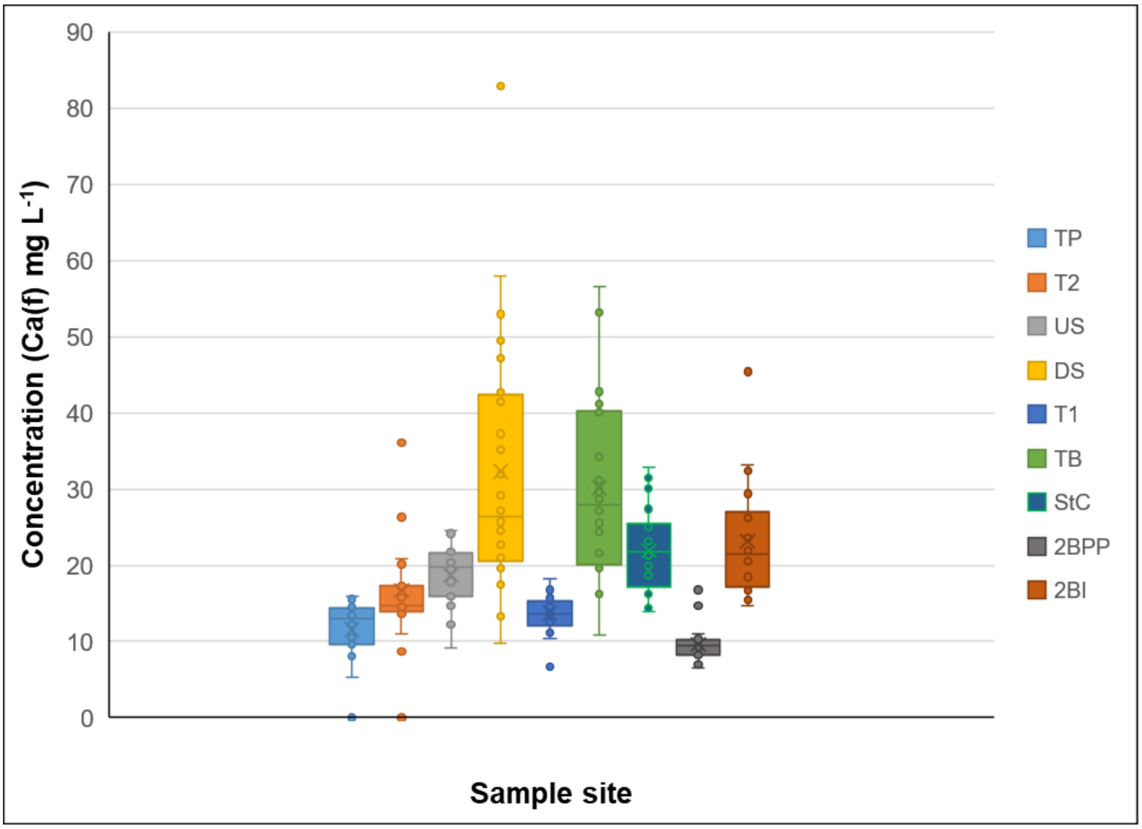


Figure 4.31 Calcium (filtered) concentrations for River Inny sample sites, excluding WwTW sites. Chart shows mean and median concentrations of calcium at each sample site for the duration of the study period (n=24).

Temporally (Figure 4.32), the concentrations varied through the year, with peak concentrations mirroring times of low river flow (Figure 7.2). This was more evident at sites DS and TB than at StC and 2BI, where the flow was significantly more.

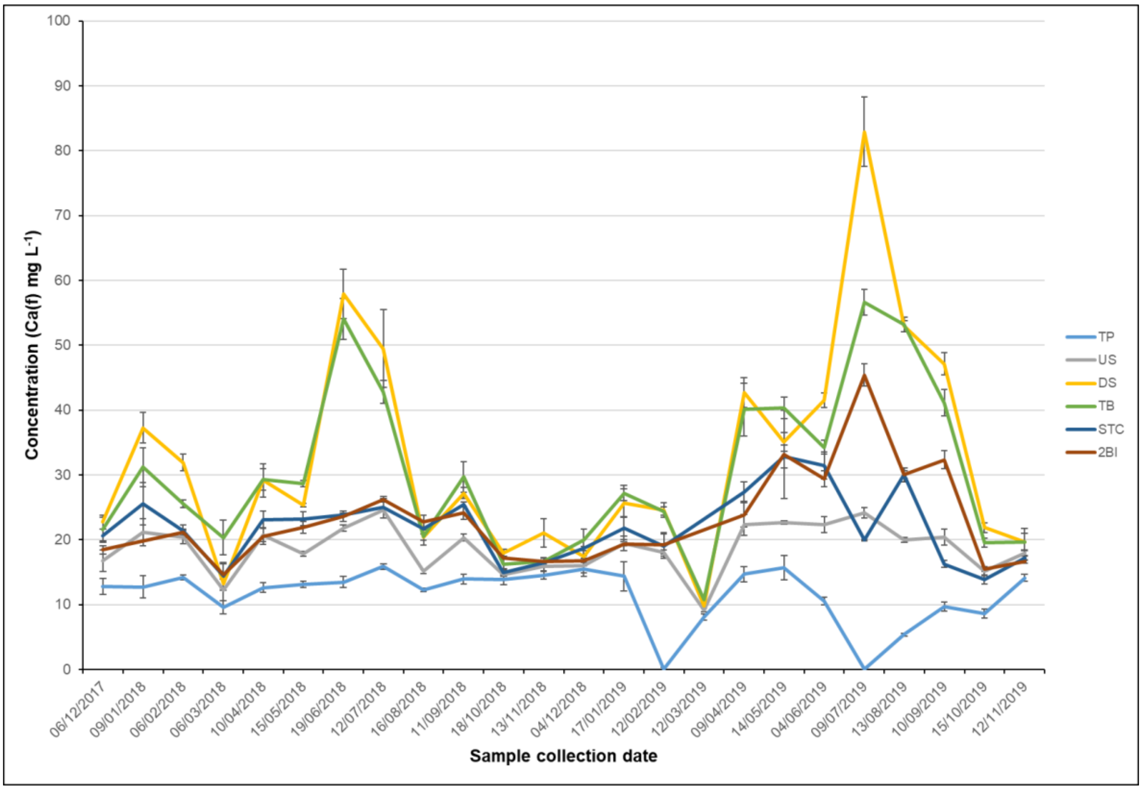


Figure 4.32 Calcium concentrations for monitored sites monthly, excluding WwTW sites, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

Samples from the WwTW measured for calcium are shown in Figure 4.33. WwTW1 showed a mean concentration of calcium of 163 mg L^{-1} with a median of 109. WwTW2 showed a mean of 113 mg L^{-1} with a median of 118, whilst WwTW3 showed a mean of 118 mg L^{-1} and a median of 119 mg L^{-1}.

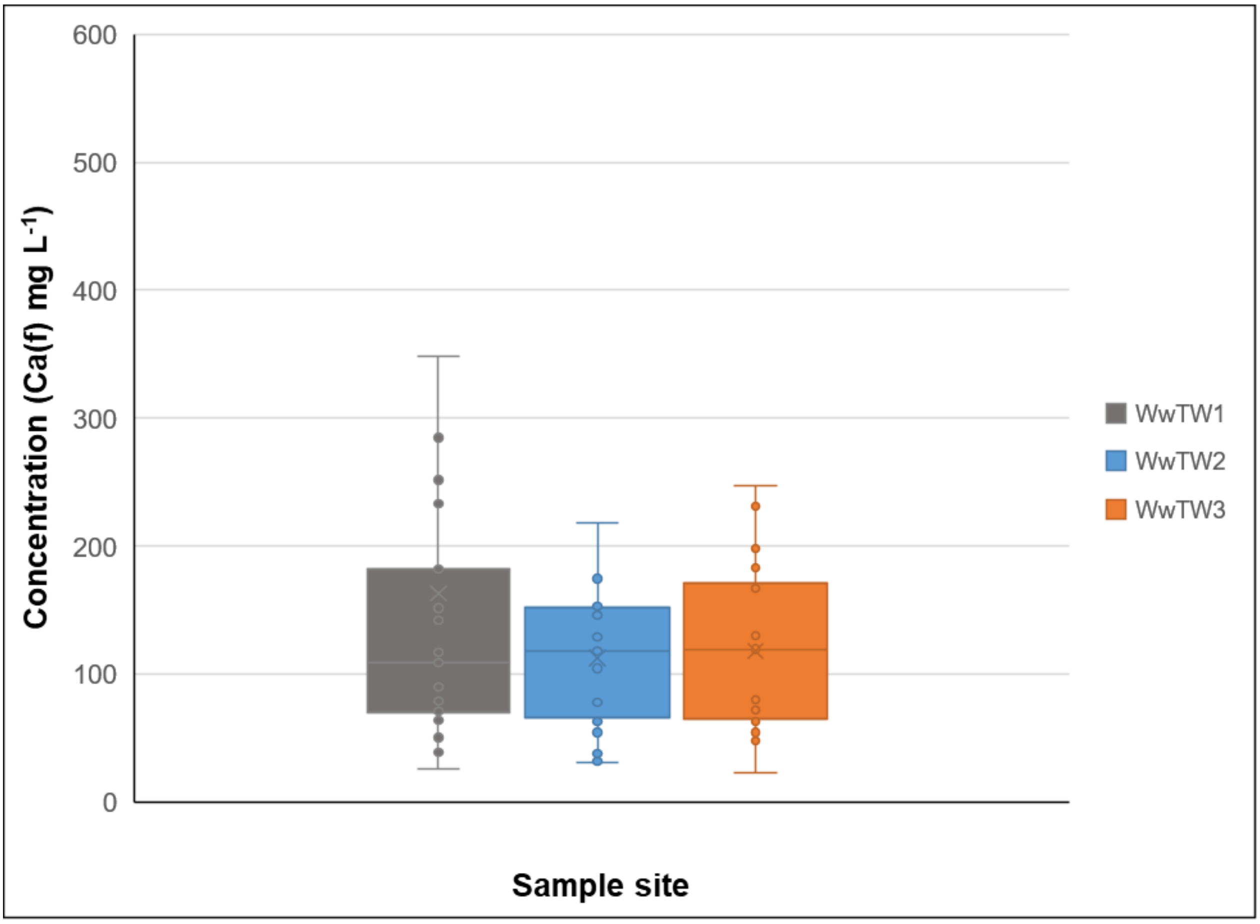


Figure 4.33 Calcium concentrations for WwTW samples. WwTW1 post treatment, WwTW2 composite sample, WwTW3 effluent entering the River Inny. Chart shows mean and median concentrations for each sample site for the duration of the study period (n=24) Data clipped at 600 mg Ca L^{-1}.

Across the study period (Figure 4.34), concentrations showed similarity from all three WwTW samples, although where variation occurred, it was usually with the WwTW1 sample.

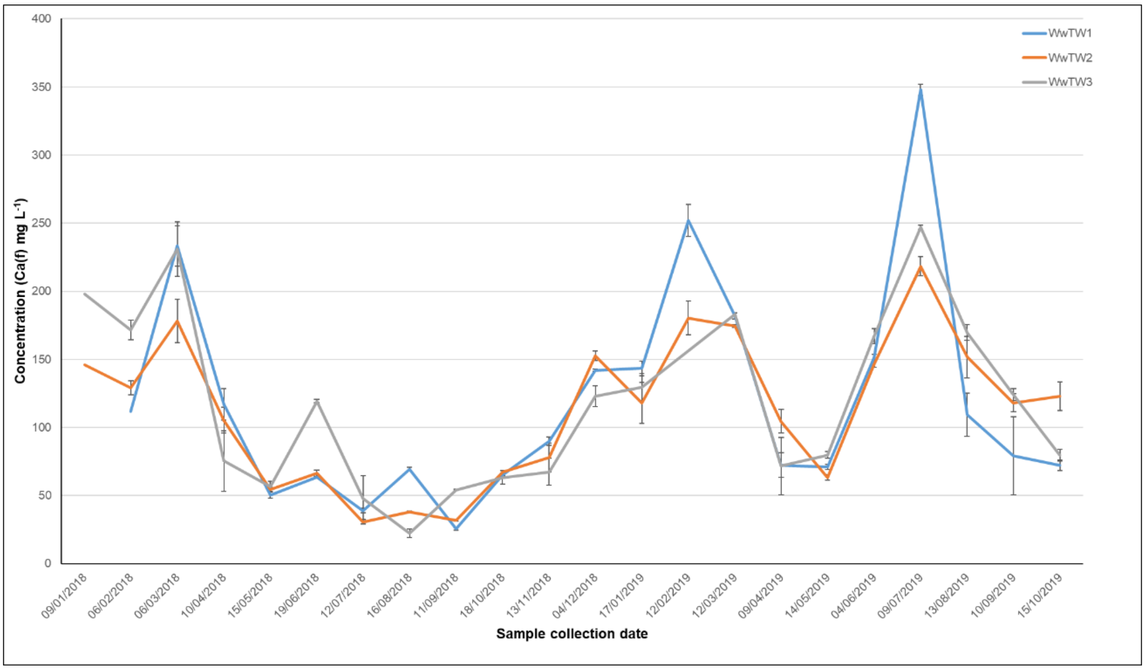


Figure 4.34 Temporal change in calcium concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

4.8.2 Sodium

The mean and median concentration of sodium at TP across the sampling period was 14 mg L^{-1} (Figure 4.35). T2, flowing around the WwTW showed higher concentrations with a mean of 56 and median of 28 mg L^{-1}. US showed a mean concentration of 40 and median of 38 mg L^{-1}. DS and influence from the discharge is observed with a mean concentration of sodium of 508 mg L^{-1} and a median of 387. By comparison, T1, similar to TP has a mean concentration of 11 and a median of 14 mg L^{-1}. At TB, this has dropped to a mean of 437 and median of 281 mg L^{-1}. StC still has a high concentration of sodium compared with the US measure, with a mean of 177 and median of 109 mg L^{-1}. At 2BI, the mean concentration is 163 and the median 116 mg L^{-1}, compared with 2BPP where both the mean and median are 11 mg L^{-1}.

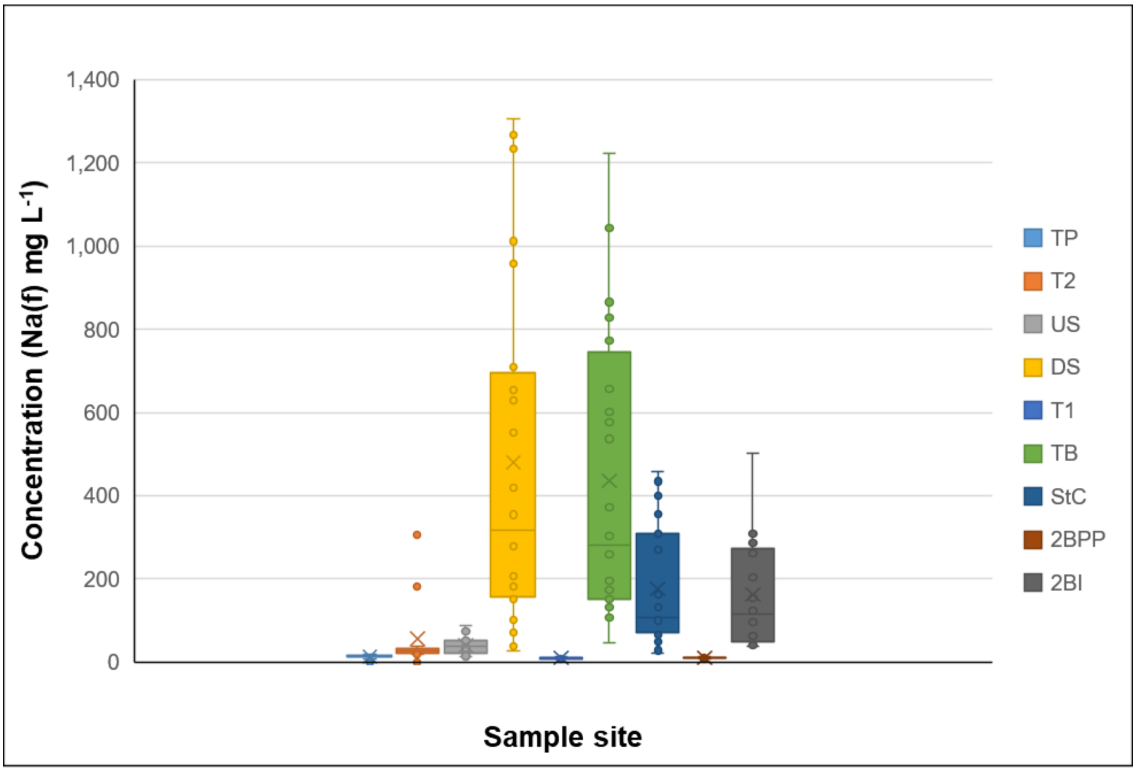


Figure 4.35 Sodium concentrations for River Inny sample sites, excluding WwTW sites. Chart shows mean and median concentrations of sodium at each sample site for the duration of the study period (n=24).

Across the study period, the same pattern (Figure 4.36) of peaks and troughs in concentration associated with low and high river flow are observed that were seen with calcium (Figure 4.32), although with sodium they are more pronounced.

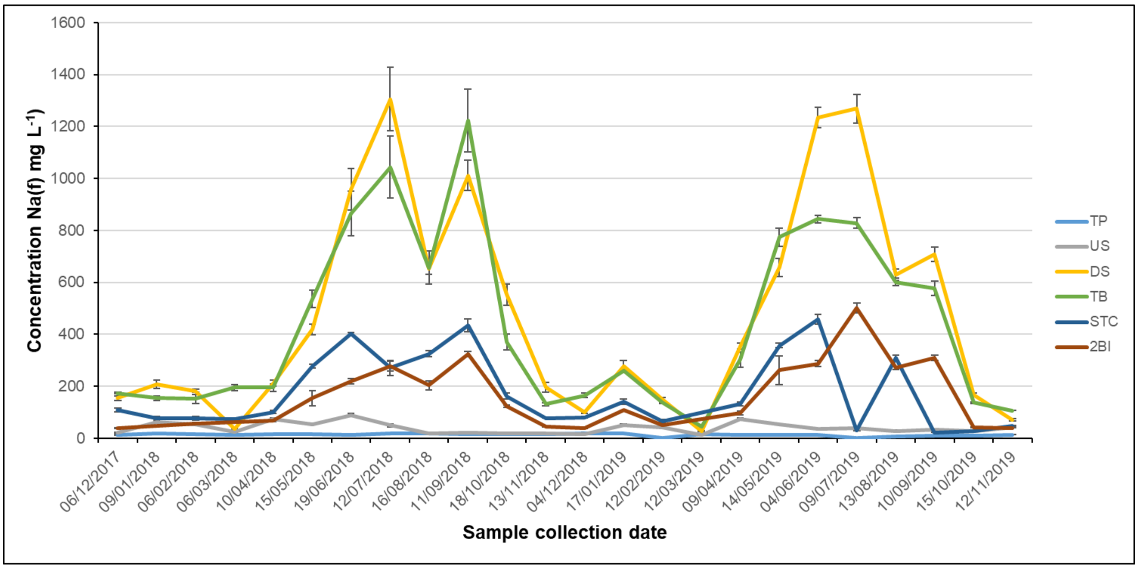


Figure 4.36 Sodium concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

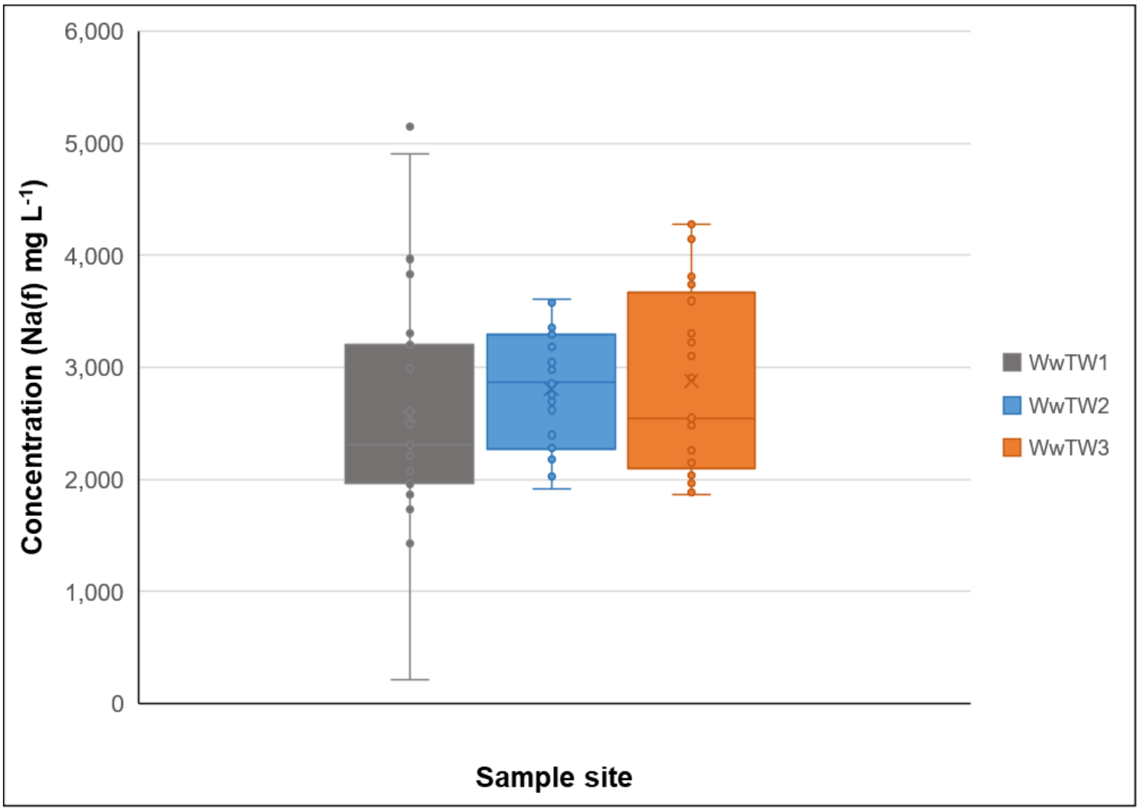


Figure 4.37 Sodium concentrations for WwTW samples. WwTW1 post treatment, WwTW2 composite sample, WwTW3 effluent entering the River Inny. Chart shows mean and median concentrations for each sample site for the duration of the study period (n=24).

The mean concentration of sodium for WwTW1 was 2563 mg L^{-1} (Figure 4.37), with a median of 2305. WwTW2 measured a mean concentration of 2804 mg L^{-1} with a median of 2869 and WwTW3 measured a mean concentration of 2875 mg L^{-1}, with a median of 2547.

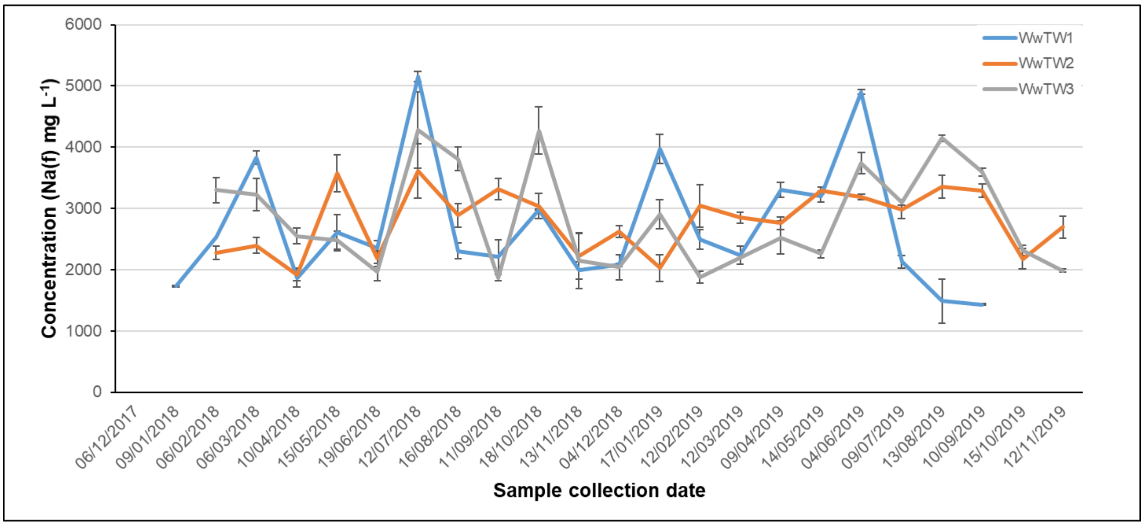


Figure 4.38 Temporal change in sodium concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

Across the study period, there is little consistency in the concentration of sodium within the treated effluent (Figure 4.38), with WwTW1 showing a quartile range in concentrations of 1117 mg L^{-1}, WwTW2 a range of 1027 mg L^{-1} and WwTW3 a range of 1446 mg L^{-1}.

4.8.3 Potassium

At TP and T1, both the mean and median concentration of potassium was 2 mg L^{-1} (Figure 4.39). T2 showed a mean of 13 and median of 5 mg L^{-1}. At US the mean concentration was 9 mg L^{-1}, with a median of 8 mg L^{-1}. At DS, a substantial increase in potassium is noted, with a mean concentration of 136 and a median of 91 mg L^{-1}. TB sees a mean of 121 and median of 80 mg L^{-1}, whilst StC has a mean of 49 and a median of 25 mg L^{-1}. At 2BI, the mean concentration was 46 mg L^{-1}, with a median of 30 mg L^{-1}. The measurements from 2BPP are comparable with TP and T1, having a mean and median of just 2 mg L^{-1}.

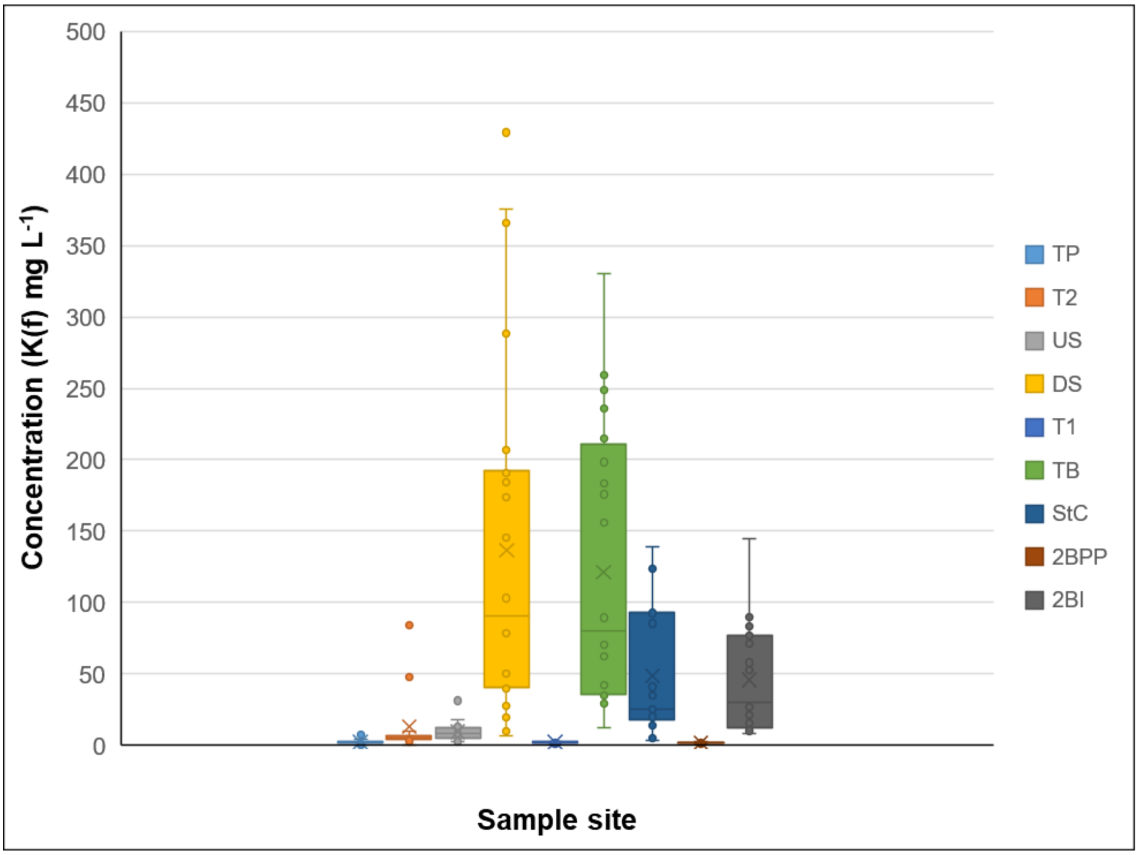


Figure 4.39 Potassium concentrations for River Inny sample sites, excluding wastewater treatment works. Chart shows mean and median concentrations of potassium at each sample site for the duration of the study period (n=24).

Once again the pattern of potassium peaks and troughs (Figure 4.40) aligns with the dilution from low and high seasonal river flows (Comber *et al.*, 2020), with significant dilution between TB and StC.

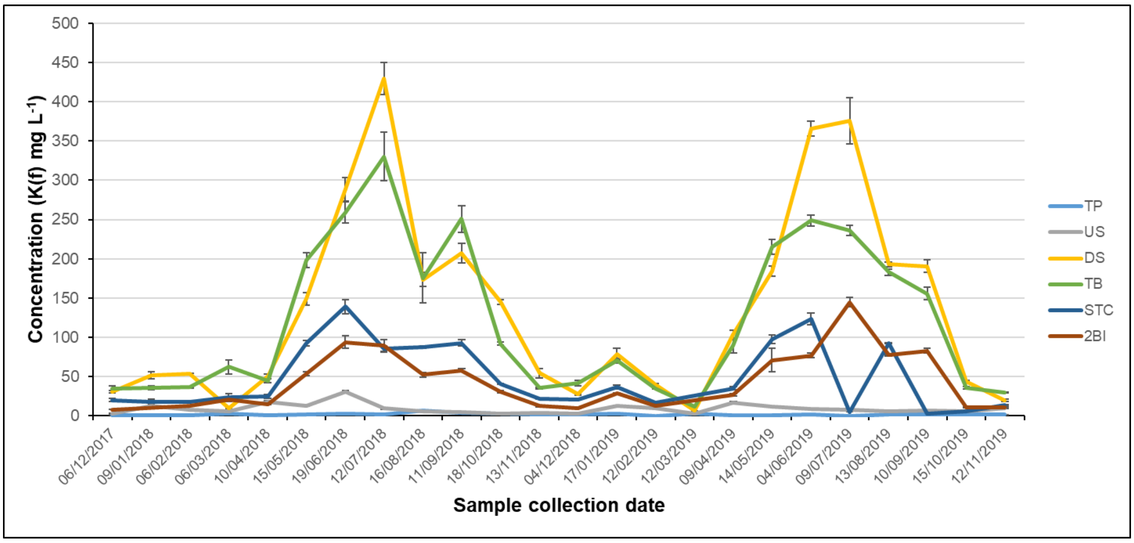


Figure 4.40 Potassium concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

With regard to the WwTW samples (Figure 4.41), WwTW1 showed a mean potassium concentration of 889 mg L^{-1}, with a median of 722. WwTW2 showed a mean of 817 and median of 803, whilst WwTW3 showed a mean of 832 and a median of 831 mg L^{-1}.

Looking at consistency in concentration of potassium across the study period (Figure 4.42), WwTW1 gave a range in concentration of 364 mg L^{-1}, WwTW2 gave a range of 200 mg L^{-1} and WwTW3 gave a range of 358 mg L^{-1}.

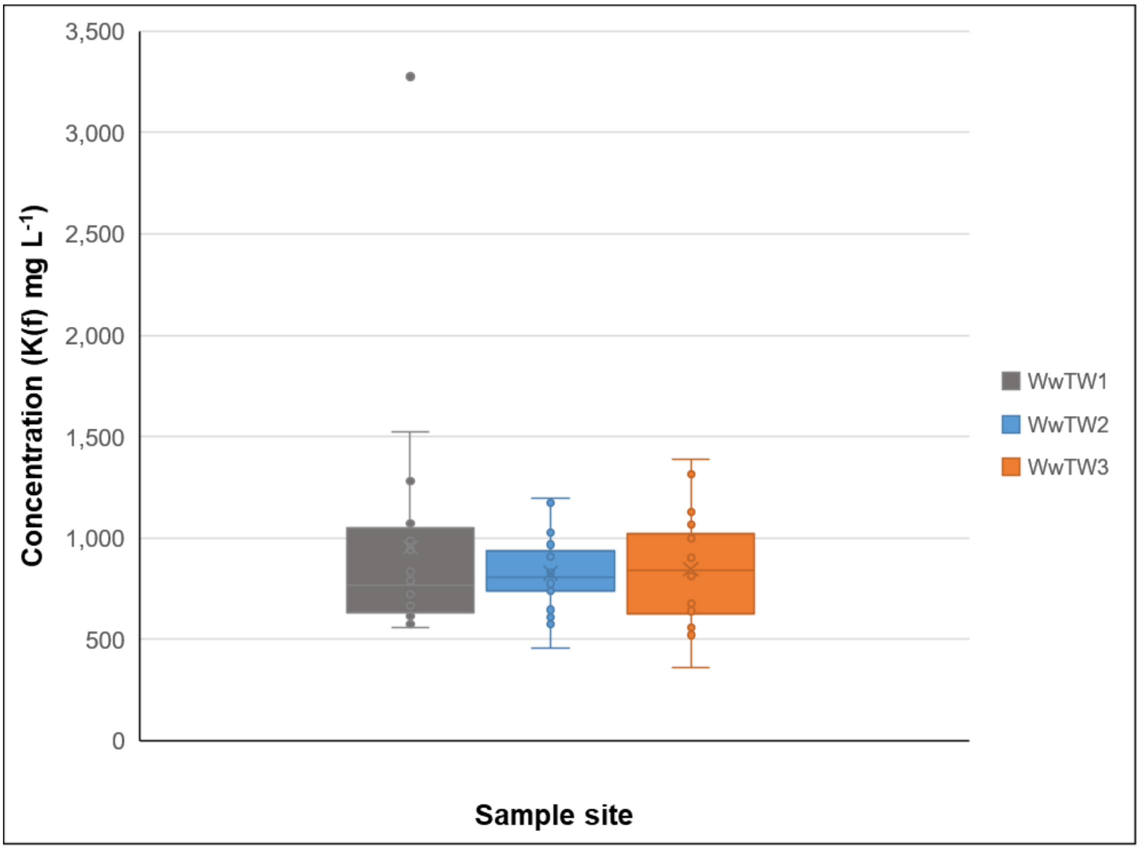


Figure 4.41 Potassium concentrations for WwTW samples. WwTW1 post treatment, WwTW2 composite sample, WwTW3 effluent entering the River Inny. Chart shows mean and median concentrations for each sample site for the duration of the study period (n=24).

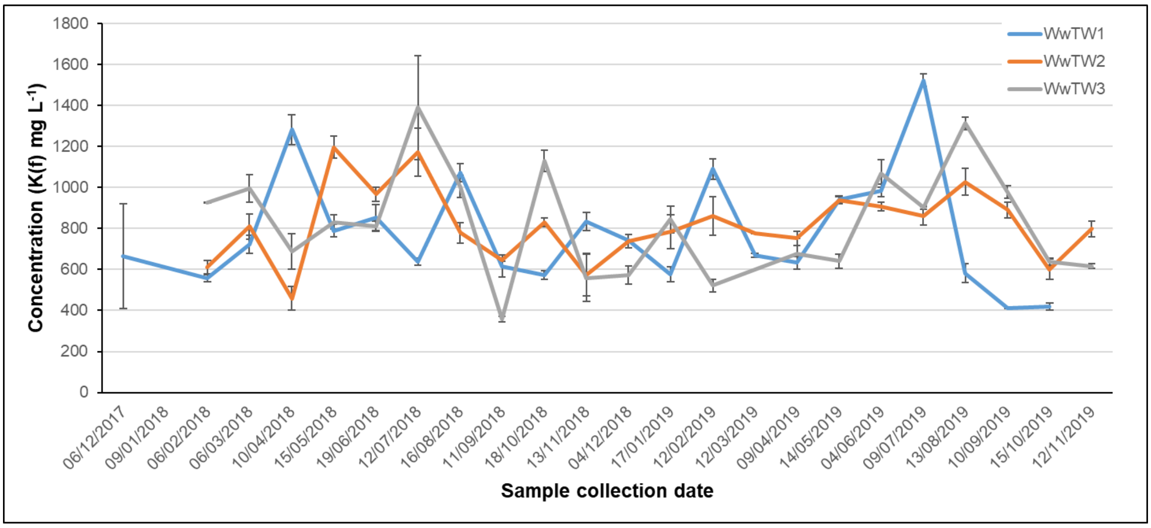


Figure 4.42 Temporal change in potassium concentration within the WwTW effluent across the study period. Error bars represent ± 2x St. Dev.

4.8.4 Silicon

The mean concentrations of silicon within the river samples showed little change between upstream and downstream samples, with all sample mean values falling in a range 2.1 to 2.5 mg Si L^{-1}. Mean Si within the outfall was measured at 3.6 mg L^{-1}. No significant patterns in temporal concentrations were observed.

4.8.5 Magnesium

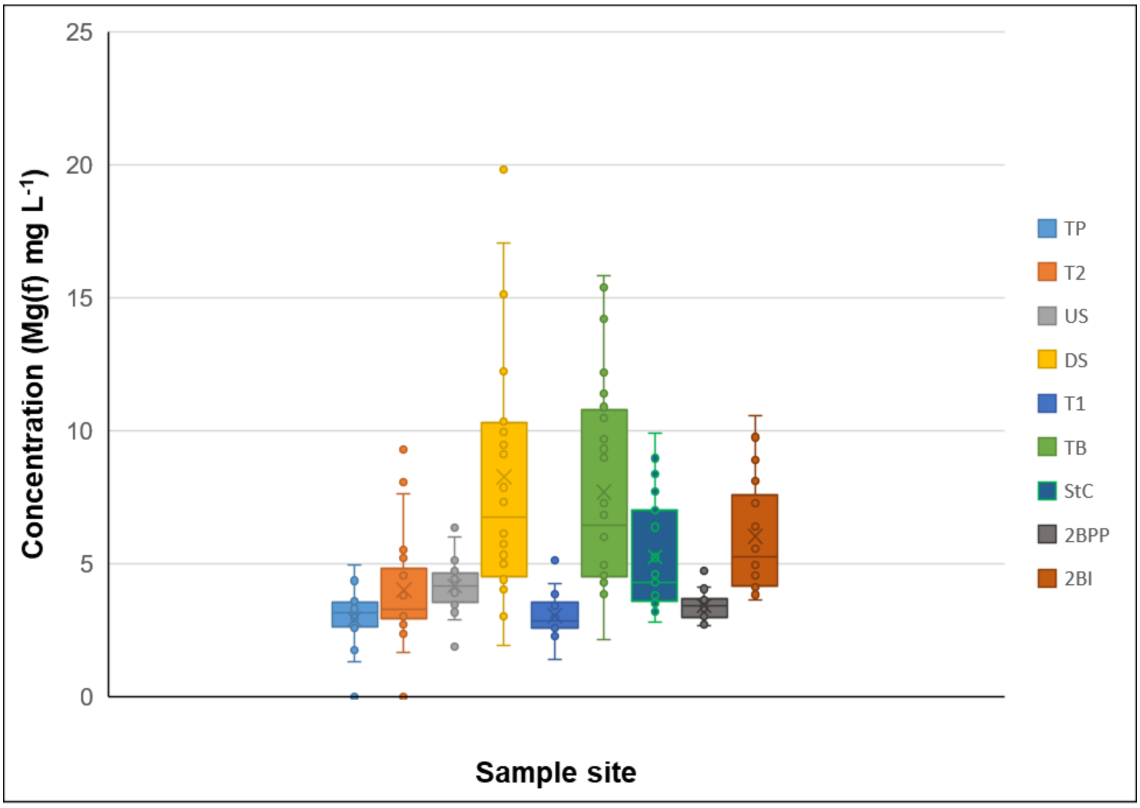


Figure 4.43 Magnesium concentrations for River Inny sample sites, excluding wastewater treatment works. Chart shows mean and median concentrations of magnesium at each sample site for the duration of the study period (n=24).

The concentration of magnesium was below 5 mg L^{-1} in the TP, T2, and US samples (Figure 4.43), together with the T1 and 2BPP samples. This suggests natural concentrations in the catchment are around 5 mg L^{-1}. Influence from the discharge inflates the mean Mg concentration at the DS site to 8.3 mg L^{-1} and to 7.7 mg L^{-1} at TB before falling to 5 mg L^{-1} at StC, and rising slightly to 6 mg L^{-1} at 2BI. Looking at the temporal concentrations (Figure 4.44), the now familiar pattern of peaks and troughs in concentration can be seen in the discharge influenced samples by season, with fall and rise in river flow and hence dilution.

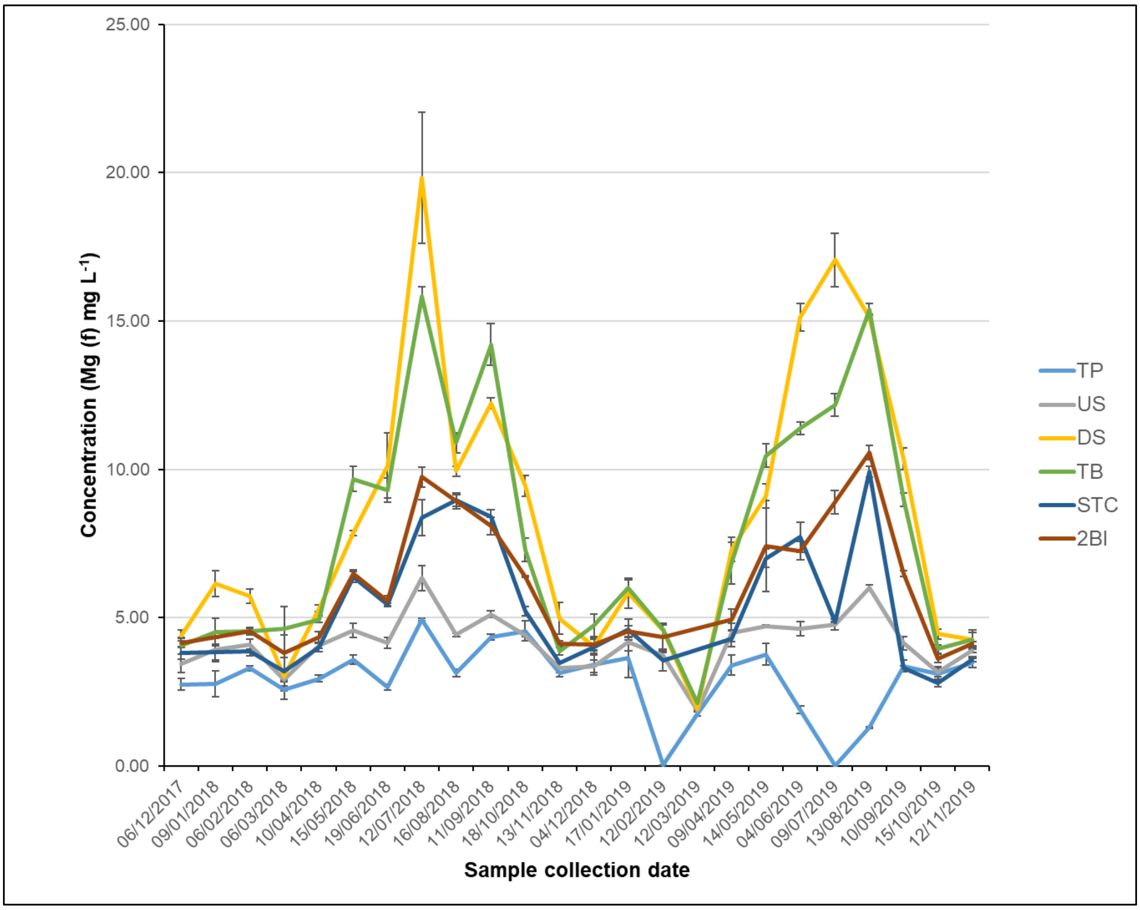


Figure 4.44 Magnesium concentrations for monitored sites monthly, December 2017 to November 2019. Error bars represent ± 2x St. Dev.

Within the discharge (WwTW3) the mean concentration of magnesium was 32 mg L^{-1} ± 15 (Figure 4.45), with a median of 28 mg L^{-1}.

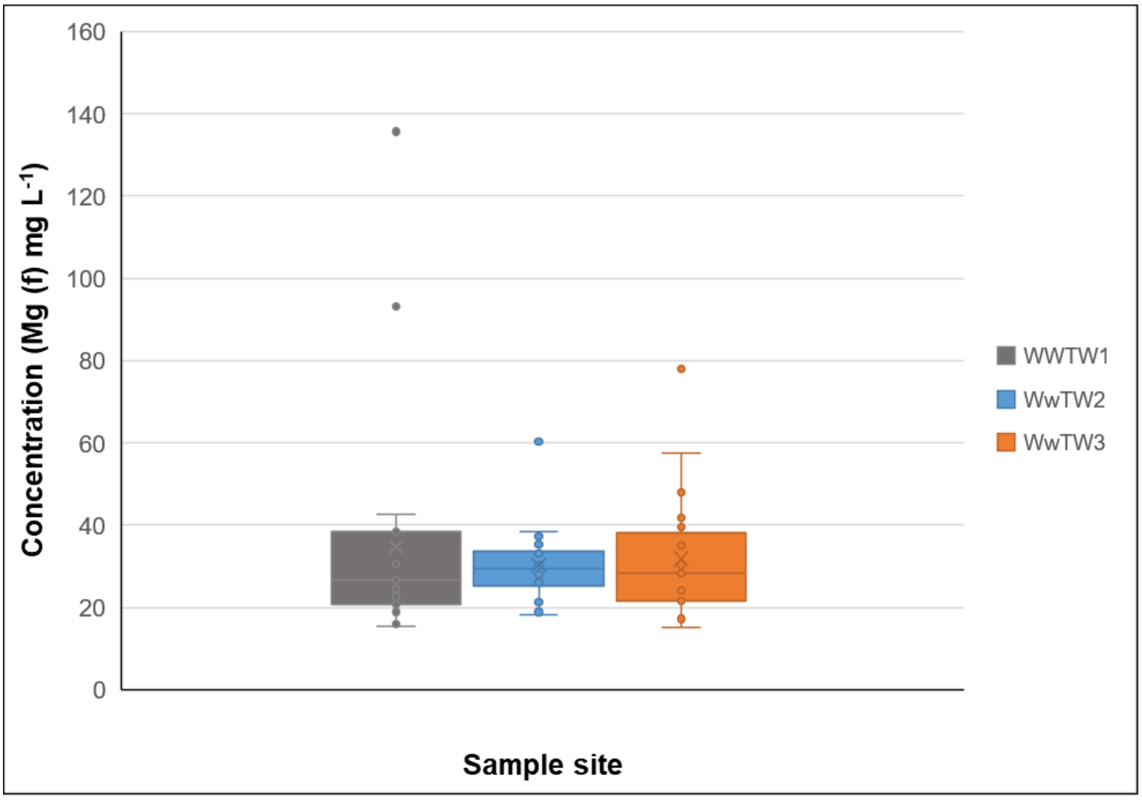


Figure 4.45 Magnesium concentrations for WwTW samples. WwTW1 post treatment, WwTW2 composite sample, WwTW3 effluent entering the River Inny. Chart shows mean and median concentrations for each sample site for the duration of the study period (n=24).

4.8.6 Dissolved oxygen

Oxygen within the water body was measured as dissolved oxygen (Figure 4.46) and % saturated oxygen (Figure 4.47).

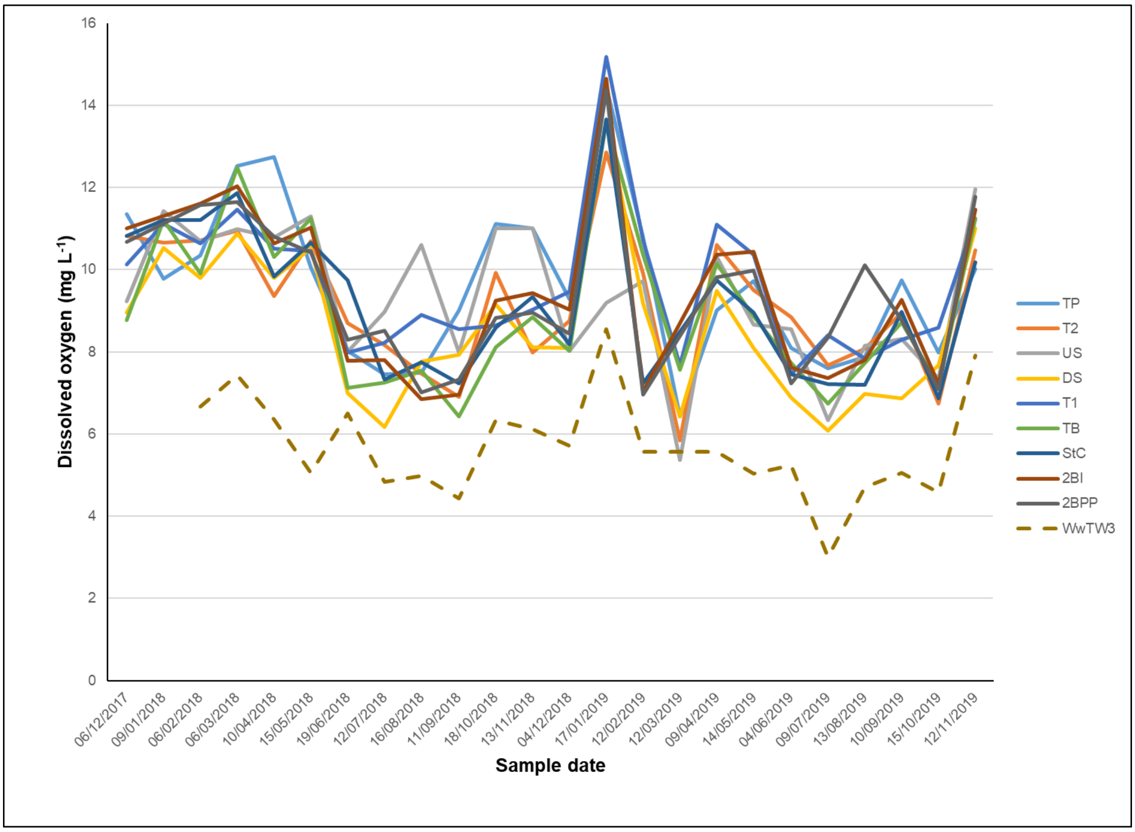


Figure 4.46 Temporal concentrations of dissolved oxygen. TP at the top of the catchment, 2BPP joins the Inny below 2BI. Brown dashed line represents concentration of dissolved oxygen in discharge sample.

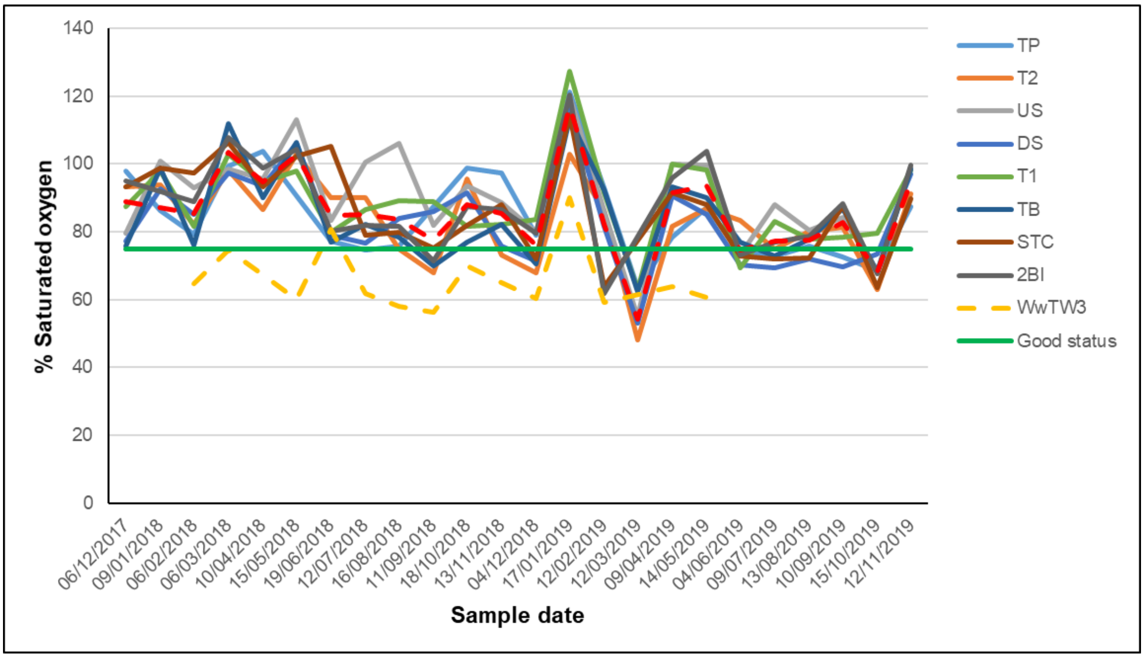


Figure 4.47 Temporal % saturated oxygen. Yellow dashed line is % saturated oxygen of discharge and green horizontal line represents EQS for % saturated oxygen

As expected, dissolved oxygen concentrations are higher in the late autumn to late spring period, when the solubility of oxygen in water is higher due to lower ambient temperature (Stiff, 1992). % Saturated oxygen for the survey period is shown in Figure 4.47. The EQS for oxygen ('Good') is represented by the horizontal green line. The River Inny is classed as 'High' (>80% saturated oxygen (European Union, 2015)) for dissolved oxygen levels, when monitored by the Environment Agency at St Clether Bridge. Late spring to late autumn sees a higher drop in concentration between US and DS as a result of the wastewater input (WwTW3) which has a concentration of dissolved oxygen below 8 mg L^{-1} on all but one sampling occasion. This is comparable with other treated WwTW effluent (Rodgers-Gray *et al*., 2000). Figure 4.48 shows the lower dissolved oxygen concentration in post-treated effluent (WwTW1) and that discharging into the River Inny (WwTW3). This results in the observed drop in dissolved oxygen from US to that measured at DS. T1 measured the same as US and this reflects the slight recovery, although not statistically significant (t(8)=2.101; *p=0.07)*, in dissolved oxygen at TB.

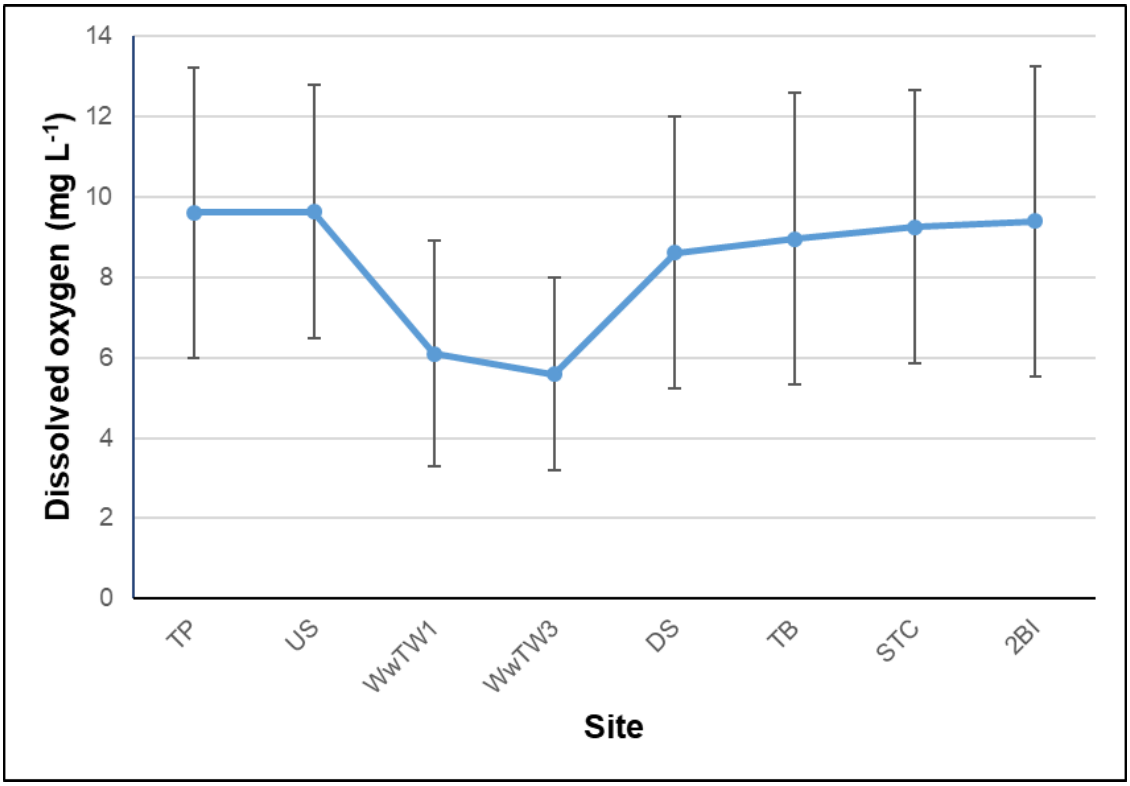


Figure 4.48 Annual dissolved oxygen concentrations, upstream and downstream of WwTW. WwTW2 excluded as composite collection vessel is refrigerated. Error bars represent ± 2x St. Dev.

4.8.7 Nitrates

Samples from 7 monitoring episodes were measured for nitrates by ion chromatography. On most occasions, samples measured below 10 mg NO_3^- L^{-1} (Figure 4.49). Site T1 was much lower, with a mean concentration of 4 mg L^{-1} ± 2. DS and TB were slightly raised and exhibited concentrations above the Canadian Water Quality Standard of 13 mg L^{-1} nitrate (Canadian Council of Ministers of the Environment, 2012) on two occasions. There is no UK standard for nitrate with regard to the protection of aquatic life, however there is a Groundwater Quality standard of 50 mg L^{-1} nitrate which would be of relevance to the Dairy as they abstract water from local springs. With the exception of DS and TB, river samples in this study measured well below both the Canadian Water Quality Standard and the Groundwater Quality standard.

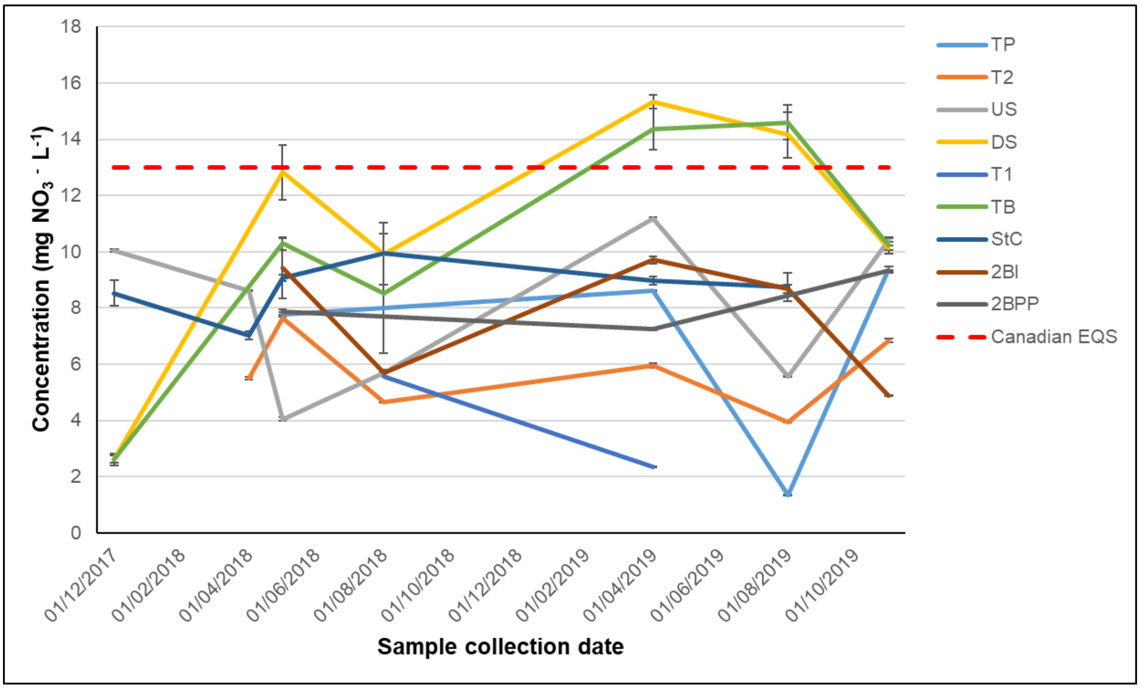


Figure 4.49 Nitrate concentrations measured in River Inny and associated tributaries, 2017 to 2019. Operational standard relates to Canadian Water Quality Guideline

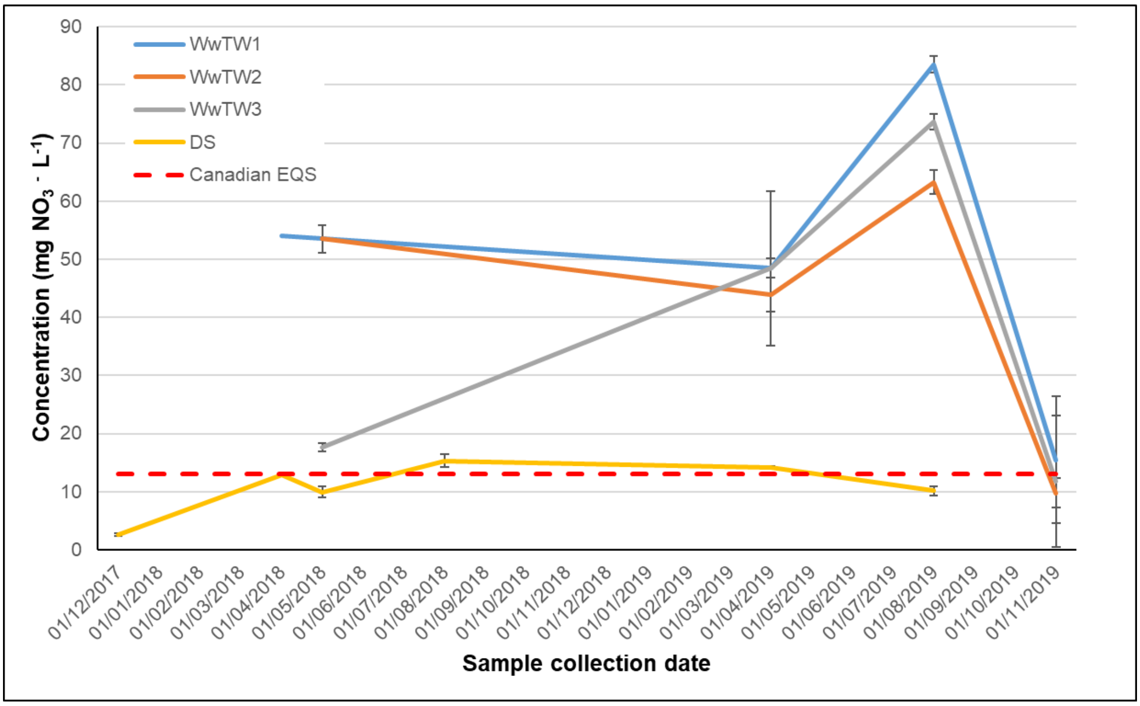


Figure 4.50 Nitrate concentrations measured in WwTW samples and at DS site, 2018 to 2019. Operational standard relates to Canadian Water Quality Guideline.

At St Clether Bridge and 2BI, concentrations had returned to concentrations comparable with those measured US. Concentrations of nitrate within the WwTW samples (Figure 4.50) measured 62 ± 19, 54 ± 10 and 47 ± 2 8 mg L^{-1} respectively for sites WwTW1, 2 and 3. These mean concentrations exclude the measurements for November 2019 which took place during plant maintenance so are not representative of usual activity.

4.8.8 Water temperature

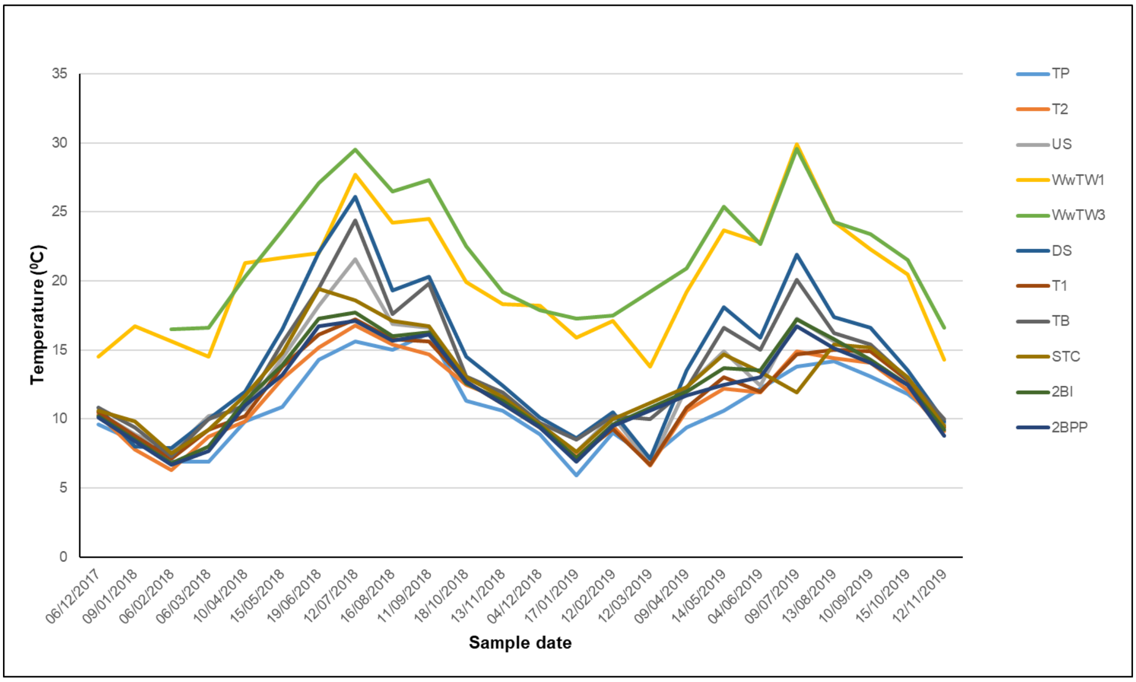


Figure 4.51 Water temperature at sample points throughout the sampling programme.WwTW2 excluded as composite collection vessel is stored in refrigerated container.

Water temperature within the River Inny shows a similar pattern to other parameters, where river flow is having an influence. Effluent post treatment and as it enters the River Inny (WwTW3) were of a higher temperature than other samples throughout the sampling programme (Figure 4.51).

In Figure 4.52 the temperature of the discharge, normalised to the US water temperature, is shown in blue. Current operations controlled by Permit Number EPR/BN6137IK/V007, August 2014 are not subject to a permit for the temperature of the discharge. For illustration, a superseded permit, number 302733 issued in May 2003, stated in section 1.5.8 that

'the discharge shall not cause the temperature in the receiving water to be elevated by more than 1.5 degrees C above ambient at a point marked "B" [equates to sample

site TB] *on the attached plan at any depth, at any time of the year, when measured with a portable meter*.

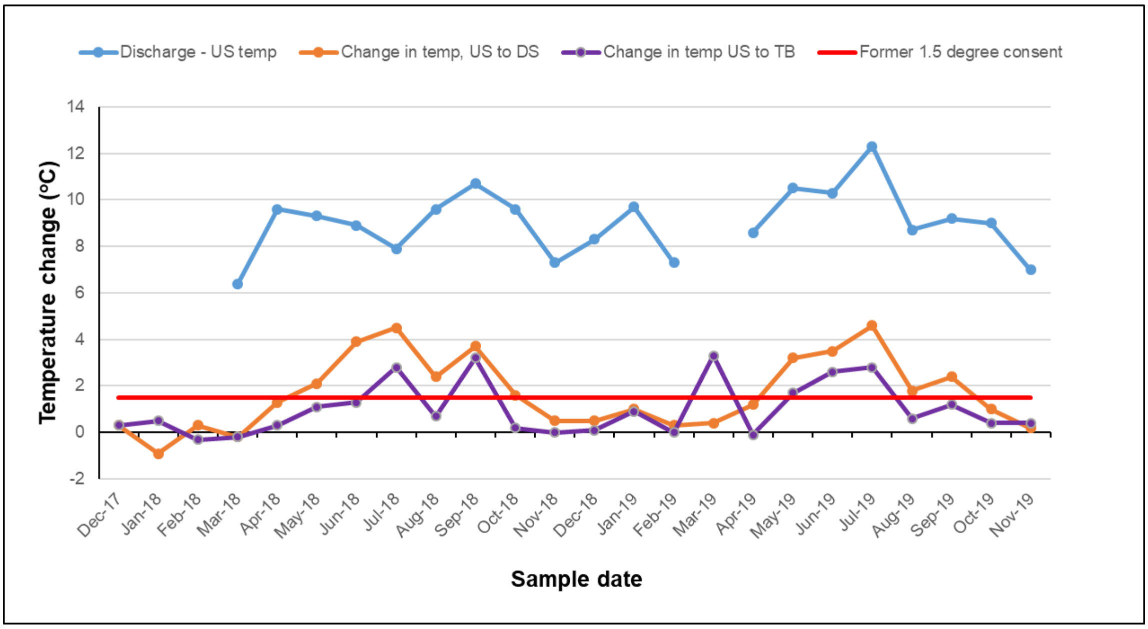


Figure 4.52 River Inny water temperature changes associated with Saputo discharge

The 1.5 ºC degree limit was associated with a maximum discharge volume of 2600 m^3 per day. In Figure 4.52 the horizontal red line shows 1.5 ºC, the orange line shows difference between US and DS water temperatures and the purple line shows the difference between US and TB, which equates to point B stated in the permit. To meet the permit requirements, there should not be an increase in temperature resulting from the discharge of more than 1.5 ºC, when measured at Trewinnow Bridge. Of the 24 sampling episodes, 6 exceeded the 1.5 ºC increase. These occurred between May and September when river levels were experiencing lower summer flows.

4.8.9 Suspended solids

Suspended solids reached their peak in March 2019 (Figure 4.53), when flow was high and several sampling points could not be accessed. Other peaks were associated with spring/summer storm events. TB does not show any significant increase in suspended solids, associated with its location downstream of the discharge. In Figure 4.54, the March 2019 storm event is evident. TP measured 515 mg L^{-1}, whilst WwTW3, StC, 2BPP and 2BI could not be accessed. Concentrations of suspended solids within the discharge, WwTW3, were below the permit level of 20 mg L^{-1} for the majority of the sampling period. Variability was more prior to the installation of upgraded filtration equipment in February 2019.

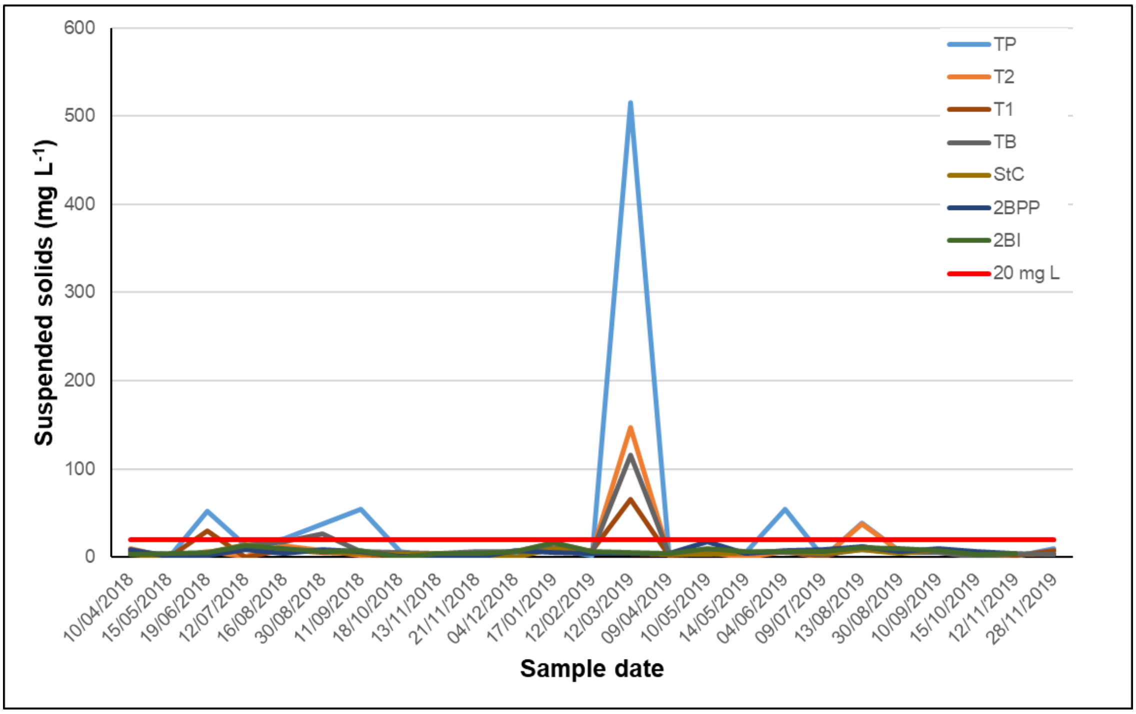


Figure 4.53 Suspended solids measured in River Inny through sampling period, excluding WwTW sites, US and DS. Red line illustrates 20 mg L^{-1} permit level that Saputo work to.

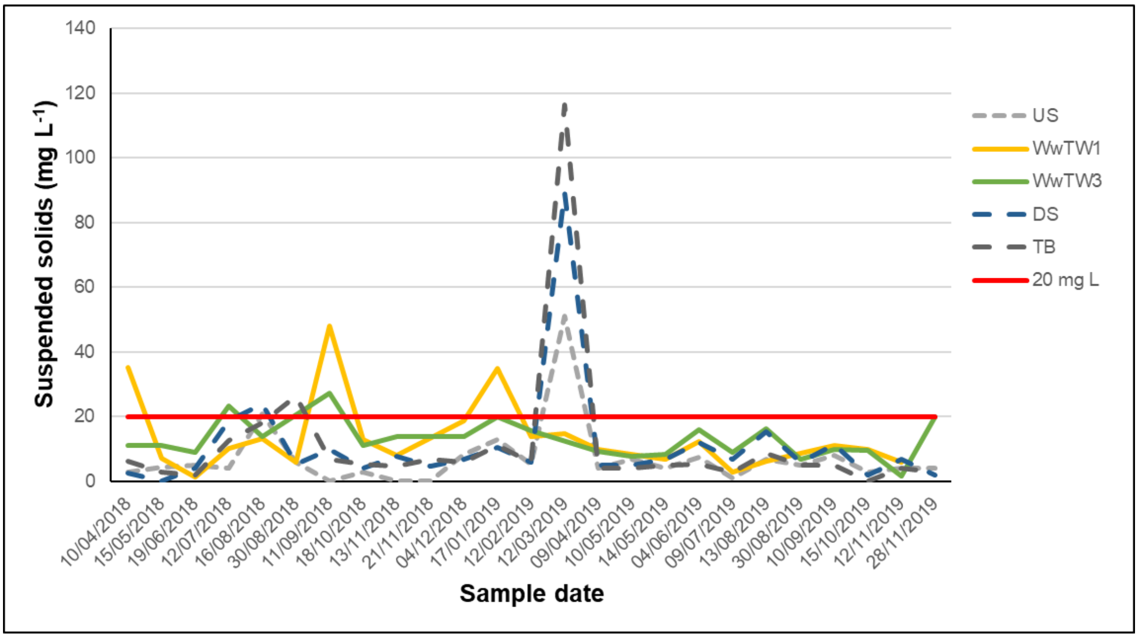


Figure 4.54 Suspended solids measured post treatment (WwTW1), in discharge (WwTW3), US DS and at TB. Red line illustrates 20 mg L^{-1} permit level that Saputo follow. Dashed lines represent samples from the River Inny.

4.9 Discussion

4.9.1 Phosphorus

The mean SRP concentration measured over the duration of this study at WwTW3 was <500 µg L^{-1}. However, this was inflated due to the unstable concentrations measured between the start of monitoring and April 2019. The final period of monitoring measured SRP below 200 µg L^{-1}. Within the receiving waters, at the end of the mixing zone (TB), SRP was measured as 102 µg L^{-1}. Looking at the recent stable measurements, the average SRP concentration at TB is 45 µg L^{-1}, at a site where the EQS for good is 30 µg P (TRP) L^{-1}. SRP is the bio-available form of P and the form that at increased levels will influence the productivity of macrophytes and phytobenthos.

RP is the P species against which the WFD assesses water quality to manage the risk of adverse ecological impacts from nutrient enrichment (UKTAG, 2014b). At the end of the mixing zone (TB), the EQS is 30 µg P L^{-1}. For the period April 2019 to the end of the monitoring, the mean TRP concentration was 58 µg P L^{-1}, exceeding the good EQS and pushing the watercourse into the 'moderate' quality class. Upstream of the discharge, the mean concentration of P as TRP at the US site across the monitoring period was 47 µg P L^{-1} where the EQS is 30 µg P L^{-1} indicating that the dairy is not the only source of nutrient enrichment impacting on the river ecology.

TP measured at WwTW3 over the duration of this study showed a mean and median that exceeded the 1mg P L^{-1} permit issued by the regulator. The temporal picture shows that since March 2019, the discharge was compliant. Prior to this point, there had been considerable fluctuation in concentration, suggesting issues with treatment plant management of P loading. Total phosphorus concentration is a measure used for compliance and includes non-reactive, i.e. bio-unavailable phosphorus. Hence, not all total phosphorus will impact on the downstream habitat. The complex nature of phosphorus chemistry and in channel cycling means that the use of total phosphorus as a regulatory measure gives a conservative control of the discharge.

4.9.2 Iron

Mean concentration of filtered Fe at sites T2, US, DS and TB are similar (103 - 134 µg L^{-1}) whilst TP, T1, StC, 2BI and 2BPP share their own similarity (53 - 73 µg L^{-1}). All samples are well below the established EQS of 1000 µg L^{-1} (filtered). Mean concentration from the outfall was below the EQS for sampling period. Total iron showed greater variation with some particularly high measurements (TP: 37,799 µg L^{-1}) associated with higher flow and suspended sediment.

The impact of iron on the river ecology is complex. Oxidation of iron from (Fe (II)) to insoluble Fe (III) in the channel can inhibit light from the channel bed and reduce the photosynthetic potential of the phytobenthos. Freshwater invertebrates can suffer from smothering of their gills by iron precipitates (Peters *et al*., 2012). Bioassays of iron compounds are often confused as to whether mortality is caused by toxicity to iron or by smothering. For macrophytes, dissolved Fe is an essential micronutrient, a constituent of several enzymes and plant pigments. However, owing to the complex iron chemistry, toxicity and smothering effects associated with particulates, industry now tends to follow the proposed threshold of 0.73 mg L^{-1} total iron for the protection of sensitive taxa, and a threshold of 1.84 mg L^{-1} total iron for the protection of the whole community (Peters *et al*., 2012).

4.9.3 Supporting chemistry

Sodium, potassium and chloride concentrations are all significantly inflated downstream of the discharge. From US to DS sites, mean concentration of sodium increased by 468 mg L^{-1}, potassium by 127 mg L^{-1} and chloride by 631 mg L^{-1}. This increase in the ionic concentration of the water has the potential to impact the osmoregulation systems of fish and freshwater macroinvertebrates. Further investigations of Na^+, K^+ and Cl^- are undertaken in chapter 6.

Concentrations of silicon within the river are not significantly influenced by the composition of the discharge. Reactive silicon is a potentially limiting macronutrient for phytoplankton as it required by diatoms to form their silicate frustules. Limitation can be observed at concentrations in the region 0.3 mg Si L^{-1} (Bowes *et al*., 2016).

Within the river, additional nitrates will provide nutrients for macrophytes and phytobenthos, increasing productivity and leading to a potential decline in water quality. There is no statutory EQS for nitrates within UK rivers, however using the Canadian standard as a guideline the monitoring showed just DS and TB as exceeding the 13 mg L^{-1} guidance.

Throughout most of the monitoring period, the % saturated oxygen was measured as above the EQS for ‘Good’ status. However, with the chemical composition measured in the water, it should be noted that the solubility of oxygen can be reduced by an increase in dissolved salts, particularly sodium (Stiff, 1992). This suggests that % saturated oxygen levels downstream of the discharge are being reduced due to the high concentration of dissolved salts within the discharge.

Temperature stress is apparent from the monitoring regime. Although there is no current permit for temperature, the data gathered, viewed in terms of an historic permit condition, (Figure 4.52) shows that during hot spring and summer periods, water temperature at the end of the mixing zone is more than 1.5 ^{0}C warmer than upstream. The warmer conditions can increase macrophyte productivity, leading to an increase in channel vegetation. The increase will also impact negatively on the % saturated oxygen potential in the water, leading to increased pressures on fish and freshwater invertebrates.

Throughout most of the monitoring period, suspended solids measured within the river remained consistent, below 20 mg L^{-1}, the concentration to which Saputo are permitted. On only two occasions the 20 mg L^{-1} permit was exceeded in the outfall and WwTW samples. Additional sediments entering the channel can lead to sedimentation of interstitial spaces within the channel bed and be detrimental to freshwater invertebrate habitats. An addition to the sediment loading of the waterbody can diminish light levels from reaching the riverbed, thereby reducing the photosynthetic potential of the diatom community.

In chapter 5, the ecology of the River Inny will be discussed, looking at freshwater invertebrates, diatoms and macrophytes and comparing the current condition with historic data.

5 Ecological study of the upper Inny catchment

5.1 Introduction

This chapter looks at the use of biological indicators to assess water quality. A pollution event altering the water chemistry will impact on biota at different rates, with rapid effects on diatoms, but over longer timeframes for freshwater invertebrates and macrophytes (Hering *et al*., 2006). A review of available historic Environment Agency data is made and modelled against expected conditions, then compared with data collected during this study. Particular reference is made to the ecology of freshwater invertebrates, diatoms and macrophytes of the River Inny. By monitoring the presence or absence of these organisms, the condition of the water body can be determined over differing timescales. Field and modelling data can be found in Appendix 5. The work contained therein fulfils objective 3 of the study (Figure 1.1).

5.2 Freshwater invertebrates and their role in water quality

Freshwater invertebrates comprise a substantial fraction of biomass within the riverine environment. They consist of those organisms without backbones that live within the stream habitat, be it on the surface, within the water column or within the channel bed sediments. Assessment of river quality using freshwater invertebrates can be traced back to the early part of the last century in continental Europe but only the latter half of the last century in Britain (Hawkes, 1998) (Table 5.1).

Freshwater invertebrates, living within the stream, spend most of their life in contact with the water and thus the components of the water. As a result, their communities are excellent indicators of river health and can be reflective of the quality and suitability of the water for their existence and well-being over a prolonged period of time (SEPA, n.d.). Invertebrate communities and therefore the value of biotic indices vary widely between sites of the same quality, so they cannot be used directly to indicate environmental health (The Freshwater Biological Association, 2021).

Table 5.1 A time line of the development of freshwater invertebrate bioindicators in Britain (Hawkes, 1998; Clarke et al., 2003)

Time period	Progress in developing bioindicators
Early 20th century	Simple biological methods used in continental Europe
1920s	Butcher *et al*. study effects of sewage effects on plants and animals
1930s	MAFF study look at effects of beet-sugar wastes, sewage and milk wastes on water courses
1946	Butcher presents 'The biological detection of pollution', research on UK rivers
1950s	Use of saprobic classification system
1960s	Trent Biotic System enters use in the UK. Became the basis of several national indexes used across the EU
1963	Water Resources Act establishes Water Authorities with responsibility of preserving the life in waters across England and Wales
1970s	UK National River Pollution Survey. First combined biological and chemical classification of UK rivers
1976	First meeting of the Biological Monitoring Working Party (BWMP)
1978	Final BWMP scoring revision reported
1983	Principle of average score per taxa introduced
1990s	River Invertebrate Prediction and Classification System adopted
2003	Inclusion of biological monitoring within EU Water framework Directive
2008	River Improvement Classification Tool (RICT) devised to add predictive element to indices

Time period	Progress in developing bioindicators
2013	WHPT introduced to integrate the abundance weighting limitation of the BWMP

Some nutrient enrichment of a channel will provide the basis for increased macrophyte growth, which will provide additional forage for grazing communities. Above a threshold concentration, nutrient cycling will start to alter the physiochemical balance of the water and reductions in dissolved oxygen will have a negative impact on the freshwater invertebrate communities.

Different families of freshwater invertebrates have varying requirements for the quality of the water in which they are found (Everall *et al*., 2017), with some being very sensitive to pollution and others ubiquitous in many conditions – Plecoptera (stone flies) are more readily found in pristine waters, whereas Hirudinea and Oligochaeta (leeches and worms) are not as sensitive.

Ecological monitoring makes use of these diverse ranges in water condition requirement by using a presence / absence method to ascertain quality of water.

Biotic indices have been developed which make comparison between unimpacted ‘reference sites’ and specific sites of interest. The search for sites at ‘reference condition’ in European rivers is not without issue due to the long history of human settlement across much of the continent (Kelly 2008; Pardo *et al.*, 2012). Values used within biological monitoring are often the best quality available, but not necessarily in a reference state (WFD-UKTAG, 2014b). The ratio of observed value / expected value gives a quality class from which a WFD grade of quality can be expressed.

Macroinvertebrate biomonitoring is one of the key indicators for compliance of 'Good' ecological status under the Water Framework directive.

5.3 Biological Monitoring Working Party (BMWP)

Following ecological studies by scientists of the UK Ministry of Agriculture and Fisheries and Food (MAFF) on the effects of beet-sugar wastes in the River Lark, sewage effluents in the River Tees and milk wastes in the Bristol Avon, Butcher (Table 5.1) presented his paper 'The biological detection of pollution' (Butcher *et al.* 1931; Butcher *et al*. 1937; Pentelow *et al*., 1938, cited in Hawkes, 1998). The techniques were criticised and largely ignored until the coming together of the Biological Monitoring Working Party (BMWP), after which biological monitoring of water quality advanced considerably. At the first meeting in 1976, this UK group developed a bio indicator metric based upon benthic macroinvertebrates to classify river water quality in England and Wales, with a final report produced in 1978 (Walley & Hawkes, 1996). The metric, referred to as the BMWP score system, assigned invertebrate families a value of 1 to 10 based upon its perceived sensitivity to organic pollutants (Walley & Hawkes, 1997). A high value is indicative of high sensitivity to pollution. An average score per taxa could be derived (ASPT) by dividing the total BMWP score by the number of different taxa counted (NTAXA). Although not originally a part of the working parties system, the ASPT method would take account of seasonal factors to which some taxa are sensitive. The working party concluded that it would not be useful to attempt to correlate chemical and biological assessments, suggesting that the biological assessment was probably of greatest value when it did not confirm the chemical assessment, thus revealing the effect of other physico-chemical factors (Walley & Hawkes, 1996).

Although the BMWP scoring approach was used by UK regulatory authorities since 1980 limitations of the metric included no adjustment being made for abundance of organisms and no adjustment being made for different stream types. A modification was undertaken to take account of this (Walley & Hawkes, 1997). Abundance was given four group ratings: 1: 1-9 individuals present; 2: 10-99 individuals present; 3: 100-999 and 4: ≥ 1000. A characterisation of site was introduced, based on three bed composition types: Riffle: ≥ 70% boulders and pebbles; Pool: ≥ 70% sand and silt; Riffle/Pool (i.e. mixture of riffle and pool). The derivation of a site and abundance related indicator value gave a much more reliable score than the original BMWP score.

5.4 Whalley, Hawkes, Paisley & Trigg (WHPT) metric

The WHPT metric was introduced for the classification of UK river invertebrate status under the WFD in the second River Basin Management Plan. From 2015, it replaced the BWMP metric which had been in use since the 1980 National River Quality Survey (Environment Agency, 2015). The metric evolved from the BMWP system and scored selected taxa on the basis of their occurrence (presence-absence). Artificial intelligence systems were used to interrogate large datasets to better understand and remodel organic pollution sensitivities of scoring families (Paisley *et al*., 2014). More invertebrate families were added to the metric together with a function for $\log_{10}$ abundance weighting, allocating abundance scores to one of four categories (1-9, 10-99, 100-999 and >999 individuals) (Wilkes *et al.*, 2017). The metric is suitable to rate river channels for general degradation and organic pollution stress. Using the standard 3-minute kick sample procedure, a sample is collected and identified to family level with scores allocated. The metric delivers:

- WHPT=Sum of scores
- NTAXA = Number of WHPT scoring taxa
- ASPT= Average score per taxa (WHPT/NTAXA)

A high score is indicative of sensitivity to organic pollution whilst a low score is more tolerant, so a low score for WHPT, NTAXA and ASPT is indicative of poor quality i.e. presence of organic pollution.

5.5 River Invertebrate Prediction and Classification (RIVPACS)

A limitation of biotic indices is that their values vary between different regions for reasons other than pollution. Upland areas have higher gradients so increased velocity and generally more oxygen rich waters, more suitable for sensitive taxa. Some areas, e.g. NE England have legacy pollution from its former rich industrial past. This makes it problematic to make comparisons between sites.

The RIVPACS project started in 1977 with the aims of forming a classification system of unpolluted river sites in Great Britain and determining whether the community of freshwater macroinvertebrates found at a site could be predicted from the physical and chemical characteristics of the site (Wright, 2000).

RIVPACS introduced the concept of reference condition, where the invertebrate community of an unpolluted site could act as a benchmark or reference site against which sites that were influenced by pollutants or human activity could be compared.

A standardised survey method was developed that could be repeated at each site identified as a possible reference site. In total, 614 were surveyed for their invertebrate communities and a host of environmental data which would form ‘predictor variables’. These included abiotic factors such as altitude, location (NGR), temperature, velocity, width and depth, distance from source, geochemistry including natural alkalinity (derived from catchment geomorphology), substrate as % clay/silt, % sand, % gravel/pebbles, % cobbles/boulders (Abel, 1996). A TWINSPAN (Two-Way indicator species Analysis) Classification was undertaken which produced a hierarchical classification. This was based on the fauna sampled and gave 43 end-groups, of similar invertebrate communities. In subsequent revisions, these were further classified to size of water body: small stream; upland streams and river; intermediate streams and rivers and lowland streams and rivers to give 614 end groups (Clarke *et al*., 2003, FBA, 2018)

The predictive model takes the environmental characteristics for the sampled channel and compares them with the reference sites. The result could be similarities between a number of different end groups, for example, 20% Group A, 50% Group B, 30% Group C. The predicted NTAXA for the site is calculated by applying the probability that the site belongs to that end group, by the mean taxa of that end group, to give a contribution of that end group to the prediction for the site (FBA, 2018).

An Environmental Quality Index is produced which, reports the ratio of NTAXA OBSERVED at the site / NTAXA predicted (EXPECTED) at the site. This EQI ratio ranges from zero to 1, where 0 is indicative of a degraded system and 1 indicative of a good system. An EQI is calculated from the NTAXA and the ASPT and the lower of the two, referred to as the MINTA (<u>Mi</u>nimum of <u>NT</u>AXA or <u>A</u>SPT) is used to rate the quality of the channel. The ratio is expressed within WFD Ecological status classes, Bad, Poor, Moderate, Good and High. Class boundaries are set for both WHPT and ASPT ratio (FBA, 2018) (Table 5.2).

Table 5.2 Environmental Quality Ratio Water Framework Directive classification boundaries (WFD-UKTAG, 2014b)

Status boundary	WHPT NTAXA EQR	WHPT ASPT EQR
High/Good	0.8	0.97
Good / Moderate	0.68	0.86
Moderate/Poor	0.56	0.72
Poor/Bad	0.47	0.59

5.6 River Invertebrate Classification tool (RICT)

RICT, The River Invertebrate Classification Tool (Davy-Bowker, *et al.* 2008) was devised to produce a set of predictive models based on RIVPACS that could be used to classify the ecological status of rivers for compliance monitoring under the Water Framework Directive. RICT is used with RIVPACS iteration IV.

RICT is the software tool that the RIVPACS model run through. It has been developed by the UK's environment agencies (Environment Agency (EA), Natural Resources Wales (NRW), the Northern Ireland Environment Agency (NIEA) and the Scottish Environment Protection Agency (SEPA)). Currently on iteration RICT2, the software is housed on an Azure Studio platform administered through the Freshwater Biological Association (FBA). Geographically, separate experiments are available for Great Britain, including Scotland and Northern Ireland, which can then be run for different prediction and classification measures (Table 5.3).

Table 5.3 Experiments available within RICT 2

Experiment	Description
Single Year - Spring/Autumn – Prediction and Classification	Predicts WHPT ASPT and NTAXA and undertakes unofficial status classification for spring, autumn and the official spring + autumn
Multi - Year – Spring/Autumn	As Single Year above but using data from more than one site
Single Year – Summer – Prediction and Classification	Predicts WHPT ASPT and WHPT NTAXA and undertakes unofficial status classification for summer
Compare Two Sets of Sites/Samples	Indicates the statistical difference between two classifications
All indices – Prediction	Predicts a wide range of biotic indices in spring, summer and autumn
Single Year – Taxa Prediction	Predicts species and families and their abundance in spring, summer and autumn

A limitation of benthic macroinvertebrate biotic indices is the lack of a validated standard to inform on trophic status (Holmes *et al.*, 1999). For this reason, diatoms and macrophytes are also utilised in determining overall biological quality.

5.7 Functional feeding groups

For the last 50 years, research into freshwater invertebrate biology has tended to follow two distinct paths. One group of researchers have focussed on invertebrate taxonomy and nomenclature, whilst the other group have looked at invertebrate ecology. This later branch of entomology has looked in part at the feeding behaviour and adaptation to habitat (Cummins, 2016). Freshwater invertebrates engage different methods to feed in order to fully exploit a diverse range of food resources (Table 5.4).

Functional feeding groups (FFG) were devised by Cummins and Merritt following their work from the 1960s looking at feeding types of different families of north American freshwater invertebrates (Cummins, 2016). The groups form a classification system based on how the organism acquires their food. Seven functional feeding groups were identified and are described in Table 5.4. Organisms may shift between groups, depending on species or different stage of life cycle (Merrit & Cummins, 2006). Often determination is by analysis of gut content, but this may lead to confusion when the gut content contains an organism plus the prey's last meal.

Table 5.4 Macroinvertebrate functional feeding groups (FFG), reproduced from Cummins (2019)

Functional feeding groups (FFG)	Examples of taxa	Adaptations for acquiring food resources
Scrapers (SC)	Ephemeroptera: Heptageniidae, Ephemerellidae *Drunella* Trichoptera: Uenoidae, Glossosomatidae Helicopsychidae, Psychomyiidae Hemiptera: Corixidae Coleoptera (larvae): Psephenidae, Elmidae Gastropoda	Mandibles with knife-like leading edge in aquatic insects, and file –like radula in Mollusca that removes attached algae; in Ephemeroptera, alga removal may be assisted by front legs
Algal piercers (APR)	Trichoptera: Hydroptilidae	Piercing mouth parts that suck contents from individual algal cells
Detrital shredders (DSH)	Plecoptera: Pteronarcyidae, Nemouridae, Capniidae, Peltoperlidae, Leuctridae, Taeniopterygidae Trichoptera: Limnephilidae, Calamoceratidae, Lepidostomatidae Tipulidae: *Tipula* Crustacea: Amphipopda, Isopoda, Decapoda	Chewing mouthparts, selection for softest portions of conditioned (colonised by microbes, especially aquatic hyphomycete fungi) vascular plant tissue
Gathering collectors (GC)	Ephemeroptera: Baetidae Leptophlebiidae, Ephemerellidae, Tricorythidae, Caenidae	Non-specialised mouth part morphology that facilitates sweeping fine FPOM into the mouth

Functional feeding groups (FFG)	Examples of taxa	Adaptations for acquiring food resources
	Trichoptera: Leptoceridae, Odontoceridae Coleoptera: Elmidae (larvae), Hydrophilidae (adults) Diptera: Chironomidae Chironomini, Orthocladiinae Oligochaeta	
Filtering collectors (FC)	Ephemeroptera: Isonychiidae Trichoptera: Hydropsychidae, Philopotamidae, Polycentropidae Diptera: Simulidae, Chironomidae, Tanytarsini Mollusca: Sphaeriidae, Unionidae	Filtering fans or setae on front legs or silk nets or strands that trap FPOM from the passing water column
Herbivore shredders (HSH)	Lepidoptera: Crambidae, Noctuidae Coleoptera: Cocinellidae *Galerocella*	Chewing mouth parts and crochets (Lepidoptera) that hold plant in place while feeding
Predators (P)	Plecoptera: Perlidae, Perlodidae Trichoptera: Rhyacophilidae Odonata: Anisoptera, Zygoptera Megaloptera: Corydalidae, Sialidae Hemiptera: Belastomatidae, Naucoridae, Coleoptera: Dytiscodae, Hydrphilidae(larvae), Dytiscidae(adults)	Crushing, piercing or grasping mouth parts and/or front legs; active, with large eyes or ambush predators; with swimming hind legs, crawling legs or welts or prolegs

Functional feeding groups (FFG)	Examples of taxa	Adaptations for acquiring food resources
	Diptera: Tipulidae, Tabanidae, Empididae, Chironomidae, Tanypodinae	
Categories are based on morphological and behavioural adaptations for acquiring specific food categories		

In the context of water quality invertebrate bioindicators, FFG analysis allows useful data to be gathered on aquatic ecosystems of concern (Cummins, 2019) Examination of the distribution of the FFGs present can give the enquirer wider information about the state of the waterbody and assist in comparison and classification of different sampling sites.

5.8 Freshwater invertebrates

Living within in the stream, freshwater invertebrates spend most of their life in contact with the water, sediment and components thereof. This makes them an excellent organism to monitor the effects of physico-chemistry on biota. Surface waters can receive pollution from both anthropogenic point source discharges and diffuse sources which can impair freshwater biodiversity through impacts of habitat or through direct toxicity (Reid *et al*., 2019).

5.8.1 Methodology

Freshwater invertebrate samples were collected tri-annually from all stream channel sites (i.e not the WwTW effluent samples) (Figures 2.2, 2.3 and 5.1). This gave spring, summer and autumn invertebrate sets. Surveys were undertaken at least 3 days after any spate flows, to ensure the sample set was representative of the communities normally present.

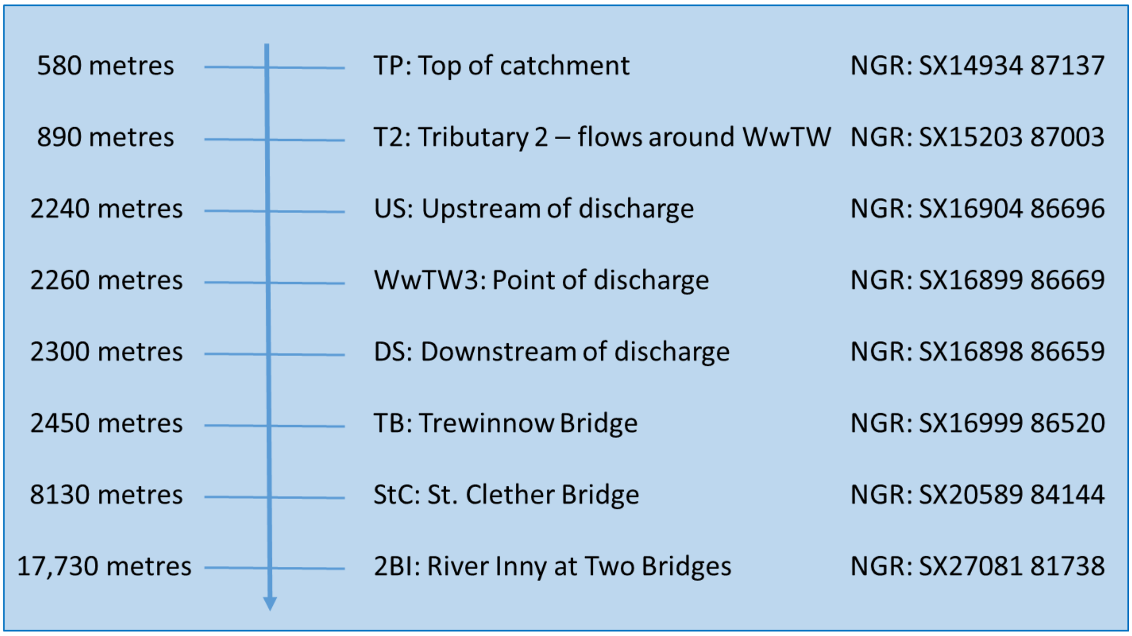


Figure 5.1 Schematic of River Inny sample locations, showing distance from top of catchment to end of monitoring reach (not to scale).

Sampling was undertaken according to the standard method used for the River Invertebrate Prediction and Classification System (RIVPACS) (Murray-Bligh, 2002). Invertebrate sampling occurred before pH, conductivity, and dissolved oxygen measurements were taken, together with channel width, mean channel depth and velocity. This ensured a maximum catch of invertebrates for each section surveyed, without scaring individuals away. Within each identified habitat type, a substratum particle size assessment was undertaken (Table 5.5) to determine the % occurrence of each size category.

Table 5.5 Substratum particle size categories recorded for RIVPACS, from UK invertebrate sampling and analysis procedure for STAR project (Murray-Bligh, 2002)

Category	Longest axis (mm)	Description
Silt/clay	<0.06	Soft in texture and not abrasive to the hands when rubbed

Sand	0.06-2	Smaller than coffee granules, and unlike silt/clay, abrasive to the hands when rubbed.
Pebbles/gravel	2-64	Coffee granule to tennis ball size
Boulders/cobbles	>64	Larger than tennis ball

RIVPACS guidance (Murray-Bligh, 2002) was followed and a survey area of 10 – 50 m (~ seven channel widths) was chosen at each site. Within this area, a survey reach was chosen that was representative of the survey area according to the channel width and habitat types. Using a standard FBA net with 1 mm mesh bag, a manual survey was carried out for one minute to capture any surface active invertebrates. This was followed by a 3-minute active kick /sweep sample of the chosen stream reach. A final manual survey of 1-minute of large rocks logs or vegetation completed the survey. Each time period of the survey was active surveying / net sweeping, so did not include the time taken to move to a different part of the reach to survey. All habitat types within the stream reach, pool, riffle, deep riffle received a proportionate amount of the 3+1+1 minute survey time. Specimens captured were tipped into a sorting tray, to remove large stones and debris. These were carefully inspected for any invertebrates before being discarded. Invertebrates and finer materials were decanted into 1 litre lidded pots to approximately 75% full and labelled with date, sample name, river and collectors name. A second label written in pencil on waterproof paper was placed inside each sample pot and details compiled within a sample log. Finally, 80 mL formalin was added to each litre pot to fix the samples. Where samples were large, 2 x 1 litre pots were used and labelled as 1 of 2, 2 of 2.

On return to the laboratory, the samples were washed within a fume hood with plenty of water through a 500 µm and 250 µm stacked sieves. The smaller sieve was attached to stop sediment from washing into the drain. The clean samples were returned to empty sample pots and covered with 70% industrial denatured alcohol (IDA) as a preservative and refrigerated to await identification.

A small amount of sample (1 teaspoon) was placed into a sorting tray with a 4 x 4 grid underneath and sufficient water added to allow the material to spread across the tray. Specimens from the one quarter of the tray were identified to family level and removed from the sorting tray to a labelled x4 collection pot. On completion, the rest of the tray was scanned and any families not previously found were identified and removed to a labelled x1 pot. All identified species were tallied on a data collection sheet, ensuring the correct multiplier (1 or 4) was used. Remaining material was transferred to a 'sorted' pot for archiving and the next spoonful of sample added to the sorting tray. A different 'quarter' of the sorting tray was used with each new spoonful of sample. Once complete, the sampled material pot, the x4 and x1 individuals pots were inspected to ensure adequate IDA covered the samples then a few drops of glycerine were added to reduce evaporation of the IDA.

Samples collected for this study were ordered by priority to Upstream and Downstream of the discharge, Trewinnow Bridge, then St Clether Bridge, Tributary 1, Tributary 2, Top of Catchment, Inny at Two Bridges and finally Penpont Water at Two Bridges (Figure 5.1). This allowed samples to be identified in relation to possible impact from the discharge. Priority 1 samples were identified to family level and logged on a WHPT freshwater macroinvertebrate biotic index recording sheet, after Davy-Bowker (2006). The recording sheet, as an MS Excel file calculates metric values for the number of WHPT Scoring taxa (NTAXA), the sum of all of the taxa scores (WHPT Score) and the sum of all of the taxa scores divided by how many scoring families were found (Average Score per Taxon, ASPT). These three values for each sample site were transferred to the RICT2 data checker (downloaded from RICT website) where site physical parameters are added and checked to ensure they fit within the range that the RICT 2 model has been validated to (Table 5.6). Cells that contain data but were highlighted red will not run and the model experiment will fail. Cells highlighted amber are at the extremes of the model tolerance and should be checked. Where data sets were incomplete, discharge was used as a proxy for velocity and calcium used as a proxy for alkalinity.

Once checked, the data set was saved as a .csv file and imported into the Microsoft Azure Machine Learning Studio, on which RICT runs. A variety of pre-programmed experiments are available. In this study, RICT - Prediction and Classification GB Single Year v4.0 was used for spring and autumn samples whilst RICT- Prediction and Classification GB Summer Single Year v3 was used for the summer samples. On completion of the model run, an output results data sheet was generated as .csv for downloading.

Table 5.6 Screenshot of data requirements and format for RICT2 model. Top section holds phys-chem measurements. Bottom half holds invertebrate scoring data, where Spr, Sum, Aut refer to survey season, TL2 =Taxonomic Identification Level 2, WHPT ASPT = WHPT Average sensitivity score per taxa, WHPT NTaxa = Number of scoring taxa in sample. Bias score is a corrective measure applied to inaccuracy within identification

SITE	Waterbody	Year	NGR	Easting	Northing	Altitude	Slope	Discharge	Velocity	Dist from Source	Mean Width	Mean Depth	Alkalinity	Boulder Cobbles	Pebbles Gravel	Sand	Silt Clay	Hardness	Calcium	Conductivity
INYVAL	Inny	1991	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			
INYVAL	Inny	1992	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			
INYVAL	Inny	1994	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			
INYVAL	Inny	1995	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			
INYVAL	Inny	2000	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			
INYVAL	Inny	2003	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			
INYVAL	Inny	2006	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			
INYVAL	Inny	2008	SX	15400	87010	230	17.4	1		1.65	1.98	11.33	48.5	21	45	22	13			

SITE	Waterbody	Year	Spr Season ID	Spr TL2 WHPT ASPT	Spr TL2 WHPT Ntaxa	Spr Ntaxa Bias	Sum Season ID	Sum TL2 WHPT ASPT	Sum TL2 WHPT NTaxa	Sum Ntaxa Bias	Aut Season ID	Aut TL2 WHPT ASPT	Aut TL2 WHPT Ntaxa	Aut Ntaxa Bias
INYVAL	Inny	1991	1	6.25	29	1.62	2	6.27	29	1.62	3	5.28	23	1.62
INYVAL	Inny	1992	1	6.4	31	1.62	2	5.75	28	1.62	3	5.18	16	1.62
INYVAL	Inny	1994					2	4.97	22	1.62	3	5.25	20	1.62
INYVAL	Inny	1995	1	6.04	19	1.62					3	5.95	23	1.62
INYVAL	Inny	2000	1	6.94	30	1.62					3	5.12	21	1.62
INYVAL	Inny	2003	1	7.05	31	1.62					3	6.3	31	1.62
INYVAL	Inny	2006	1	6.95	36	1.62					3	6.26	22	1.62
INYVAL	Inny	2008	1	7.01	31	1.62					3	6.7	28	1.62

Freshwater invertebrate communities feed using different methods. The feeding strategy used (Table 5.7) can be the basis of a classification (Cummins *et al*., 2005). Functional feeding groups (FFGs) were allocated to the families identified from the study kick sampling by using the www.freshwaterecology.info database (Schmidt-Kloiber & Hering, 2015) FFGs are often assigned to species and determined through examination of food items within the organism (Galizzi *et al*., 2012). As invertebrates grow and develop into higher instars, different functional feeding groups might be engaged. Under such circumstances, additional groups were allocated (Table 5.7).

Table 5.7 Freshwater invertebrate functional feeding groups. CPOM=Coarse particulate organic matter, FPOM=Fine particulate organic matter, POM=Particulate organic matter.

Functional feeding group		
Type	Definition	Abbreviation used
Filter	Feed from suspended FPOM or CPOM; micro prey is whirled; food is actively filtered from the water column (Active Filter Feeder) or feed from suspended FPOM or CPOM, prey; food is filtered from running water, e.g., by nets or specialised mouthparts (Passive Filter Feeder).	Fil
Filter / Predator	Different instars of the family feed by filter or predator methods.	Fil/Pre
Gatherer	Feed from sedimented FPOM.	Gat
Gatherer / Filter	Different instars of the family feed by gatherer or filter methods.	Gat/Fil
Gatherer / Predator	Different instars of the family feed by gatherer or predator methods.	Gat/Pre
Grazer	Feed from endolithic and epilithic algal tissues, biofilm, partially POM, partially tissues of living plants.	Gra
Grazer / Filter	Different instars of the family feed by grazer or filter methods.	Gra/Fil
Grazer / Filter / Predator	Different instars of the family feed by grazer, filter or predator methods.	Gra/Fil/Pre
Grazer / Gatherer	Different instars of the family feed by grazer or gatherer methods.	Gra/Gat
Grazer / Gatherer / Filter	Different instars of the family feed by grazer, gatherer or filter methods.	Gra/Gat/Fil
Grazer / Gatherer / Filter / Predator	Different instars of the family feed by grazer, gatherer, filter or predator methods.	Gra/Gat/Fil/Pre
Grazer / Gatherer / Filter / Shredder / Predator	Different instars of the family feed by grazer, gatherer, filter, shredder or predator methods.	Gra/Gat/Fil/Shr/Pre

Functional feeding group		
Type	Definition	Abbreviation used
Grazer / Gatherer / Predator	Different instars of the family feed by grazer, gatherer or predator methods.	Gra/Gat/Pre
Grazer / Shredder	Different instars of the family feed by grazer or shredder methods.	Gra/Shr
Grazer / Shredder / Gatherer	Different instars of the family feed by grazer, shredder or gatherer methods.	Gra/Shr/Gat
Grazer / Shredder / Gatherer / Predator	Different instars of the family feed by grazer, shredder, gatherer or predator methods.	Gra/Shr/Gat/Pre
Grazer / Shredder / Gatherer / Filter / Predator	Different instars of the family feed by grazer, shredder, gatherer, filter or predator methods.	Gra/Shr/Gat/Fil/Pre
Grazer / Shredder / Predator	Different instars of the family feed by grazer, shredder or predator methods.	Gra/Shr/Pre
Grazer / Xylophagus Shredder / Predator	Different instars of the family feed by grazer, xylophagus, shredder or predator methods.	Gra/Xyl/Shr/Pre
Grazer / Xylophagus Shredder / Gatherer / Predator	Different instars of the family feed by grazer, xylophagus, shredder, gatherer or predator methods.	Gra/Xyl/Shr/Gat/Pre
Parasite	Feed from host	Par
Predator	Feed from prey	Pre
Shredder	Feed from fallen leaves, plant tissue, CPOM	Shr
Shredder / Predator	Different instars of the family feed by shredder or predator methods.	Shr/Pre
Xylophagus	Feed from woody debris	Xyl

Invertebrates identified from kick sampling upstream and downstream of the discharge and at Trewinnow Bridge were allocated appropriate FFG as per Table 5.7. An ordination analysis was performed using the package Vegan (2.5-7) through R (R version 4.0.5 (2021-03-31) -- "Shake and Throw") to see if there were any differences in community structure upstream and downstream of the outfall.

FFG community data contained the number of organisms of each functional feeding guild, together with site and survey period. A non-metric multidimensional scaling analysis (NMDS) was performed which used a Bray-Curtis index to calculate the pairwise dissimilarities between objects in a low-dimensional space. It compares distances between samples in the ordination space with distances of samples in the matrix. NMDS is commonly regarded as the most robust unconstrained ordination method in community ecology (Pastorino *et al*., 2020; Minchin, 1987).

5.8.2 Freshwater Invertebrate results

An Environmental Quality Index (EQI) was generated by dividing the observed value of both NTAXA and ASPT by the expected value, which has been generated by the RICT2 model. The resulting ratios were assigned WFD classes by referring to Figure 5.2.

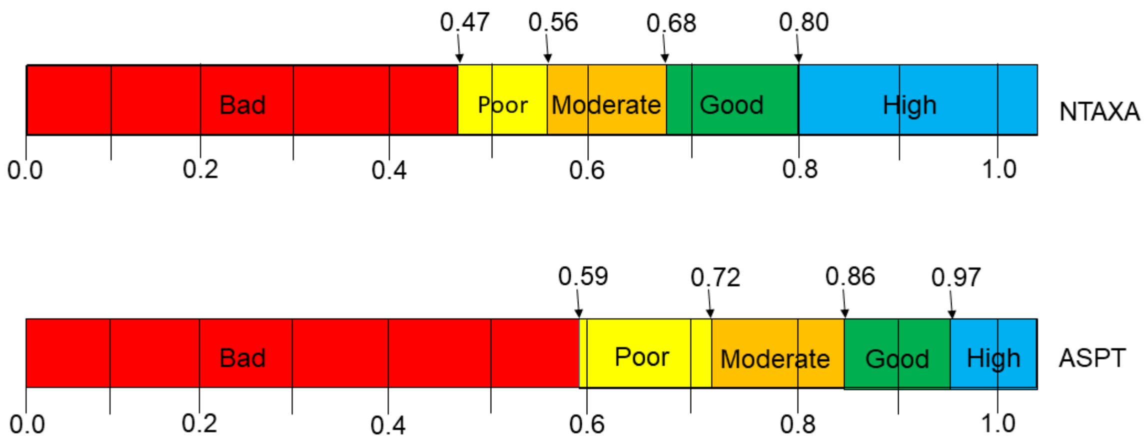


Figure 5.2 WFD quality classes for WHPT EQI (reproduced from Freshwater Biological Association RIVPACS/RICT Bio assessment training manual (2018)).

5.8.3 Historic invertebrate data

Freshwater macro invertebrate data, together with site physical characteristics was downloaded from https://environment.data.gov.uk/ecology/explorer . Referred to as Historic Environment Agency (EA) data, the data sets were transcribed to the RICT2 validation spreadsheet (Table 5.6). The data set included samples retrieved on an irregular basis between 1990 and 2017. Sites without at least spring and autumn samples were excluded from the modelling. The model failed to run on the first attempt due to lack of alkalinity or associated proxy data, therefore a default of 63 mg $CaCO_3$ L^{-1} was used. This represented a value between the upper and lower sites and reflected well with the value measured on site during this study. The model ran successfully but it was noted that the discharge categories within the data set ranged from 1 to 3, representing <0.31 m^3 sec^{-1} to 1.25 m^3 sec^{-1}. The historic data set was adjusted to a discharge category of 1 for all sites, in line with the discharge categories measured during the monitoring conducted within this study. The amendment resulted in one change in class, from ‘High’ to ‘Good’ for the St Clether site in spring 1990. Results from the model are shown in Table 5.8 to Table 5.10. StCEA is sampled from St Clether Bridge, INYVALEA from Inny Vale, downstream of the water abstraction point, TBEA from Trewinnow Bridge and 2BIEA from the River Inny at Two Bridges. Before 2003, the discharge from the WwTW entered the River Inny at Inny Vale. This is reflected in the WFD quality classes generated through modelling which show INYVALEA to be of ‘Moderate’ class before 2003, whilst further downstream at TBEA, STCEA and 2BIEA, the model returns a class of ‘Good’ or ‘High’. Between 1994 and 2017 the historic data shows that most sites reached a quality class of ‘Good’ or ‘High’. INYVALEA was consistently exhibiting the lowest quality class compared to the other sites until 2000 when it was last classed as ‘Moderate’.

Table 5.8 RIVPACS modelling results for historic spring, summer and autumn surveys using Environment Agency data sets, 1990 to 1992. Spr and Aut experiments run using RICT-Prediction and Classification GB Single Year v4.0. Su experiments run using RICT-Prediction and Classification GB Summer Single Year v3. EQI (Observed /Expected (O/E)) Ntaxa = Environmental Quality Index (O/E) for Number of taxa. >1 indicates more taxa observed than expected. EQI (O/E WHPT ASPT) = Environmental Quality Index (O/E WHPT Average Score per taxa). >1 indicates higher score observed than expected. MINTA = lowest (i.e. worst) score of NTAXA and ASPT

Site	Yr	Season	EQI (O/E Ntaxa)	EQI (O/E WHPT ASPT)	MINTA
StCEA	1990	Spr	1.00	1.00	H
StCEA	1990	Su	1.11	1.03	H
StCEA	1990	Aut	1.00	1.00	H
INYVALEA	1991	Spr	1.05	0.88	G
INYVALEA	1991	Su	1.14	0.92	G
INYVALEA	1991	Aut	0.88	0.79	M
TBEA	1991	Spr	1.07	1.02	H
TBEA	1991	Su	1.03	1.05	H
TBEA	1991	Aut	1.13	0.89	G
2BIEA	1991	Spr	1.38	0.96	G
2BIEA	1991	Su	1.52	1.01	H
2BIEA	1991	Aut	1.01	0.98	H
INYVALEA	1992	Spr	1.12	0.90	G
INYVALEA	1992	Su	1.10	0.84	M
INYVALEA	1992	Aut	0.61	0.77	M
TBEA	1992	Spr	1.14	0.96	G
TBEA	1992	Su	0.95	0.97	H
TBEA	1992	Aut	0.91	0.96	G
StCEA	1992	Spr	0.78	1.02	G
StCEA	1992	Su	1.15	1.06	H
StCEA	1992	Aut	0.91	1.00	H
2BIEA	1992	Spr	0.78	1.00	G
2BIEA	1992	Su	0.85	0.98	H
2BIEA	1992	Aut	1.12	0.96	G

Table 5.9 RIVPACS modelling results for historic spring, summer and autumn surveys using Environment Agency data sets, 1994 to 2000. Spr and Aut experiments run using RICT-Prediction and Classification GB Single Year v4.0. Su experiments run using RICT-Prediction and Classification GB Summer Single Year v3. EQI (O/E) Ntaxa = Environmental Quality Index (O/E) for Number of taxa. >1 indicates more taxa observed than expected. EQI (O/E WHPT ASPT) = Environmental Quality Index (O/E WHPT Average Score per taxa). >1 indicates higher score observed than expected. MINTA = lowest (i.e. worst) score of NTAXA and ASPT

Site	Yr	Season	EQI (O/E Ntaxa)	EQI (O/E WHPT ASPT)	MINTA
INYVALEA	1994	Su	0.87	0.73	M
INYVALEA	1994	Aut	0.77	0.78	M
TBEA	1994	Su	1.03	0.91	G
TBEA	1994	Aut	0.98	0.87	G
StCEA	1994	Spr	0.98	1.01	H
StCEA	1994	Aut	1.05	1.02	H
2BIEA	1994	Spr	1.11	1.09	H
2BIEA	1994	Su	0.96	1.10	H
2BIEA	1994	Aut	0.87	1.08	H
INYVALEA	1995	Spr	0.69	0.85	M
INYVALEA	1995	Aut	0.88	0.89	G
StCEA	1995	Spr	1.32	1.04	H
StCEA	1995	Aut	1.45	1.02	H
2BIEA	1995	Spr	1.01	1.04	H
2BIEA	1995	Aut	1.26	1.03	H
INYVALEA	2000	Spr	1.08	0.98	H
INYVALEA	2000	Aut	0.80	0.76	M
StCEA	2000	Spr	1.32	0.99	H
StCEA	2000	Aut	1.13	1.07	H
2BIEA	2000	Spr	1.11	0.96	G
2BIEA	2000	Aut	1.34	1.07	H

Table 5.10 RIVPACS modelling results for historic spring, summer and autumn surveys using Environment Agency data sets, 2003 to 2017. Spr and Aut experiments run using RICT-Prediction and Classification GB Single Year v4.0. Su experiments run using RICT-Prediction and Classification GB Summer Single Year v3. EQI (O/E) Ntaxa = Environmental Quality Index (O/E) for Number of taxa. >1 indicates more taxa observed than expected. EQI (O/E WHPT ASPT) = Environmental Quality Index (O/E WHPT Average Score per taxa). >1 indicates higher score observed than expected. MINTA = lowest (i.e. worst) score of NTAXA and ASPT.

Site	Yr	Season	EQI (O/E Ntaxa)	EQI (O/E WHPT ASPT)	MINTA
INYVALEA	2003	Spr	1.12	1.00	H
INYVALEA	2003	Aut	1.19	0.94	G
2BIEA	2004	Spr	1.11	1.00	H
2BIEA	2004	Aut	1.12	0.99	H
INYVALEA	2006	Spr	1.30	0.98	H
INYVALEA	2006	Aut	0.84	0.93	G
INYVALEA	2008	Spr	1.12	0.99	H
INYVALEA	2008	Aut	1.07	1.00	H
2BIEA	2008	Spr	1.21	1.05	H
2BIEA	2008	Aut	1.12	1.03	H
2BIEA	2011	Spr	1.25	1.03	H
2BIEA	2011	Aut	1.23	1.04	H
2BIEA	2014	Spr	1.08	1.01	H
2BIEA	2014	Aut	1.34	1.03	H
2BIEA	2017	Spr	1.15	1.01	H
2BIEA	2017	Aut	1.16	1.07	H

5.8.4 River Inny invertebrate sampling

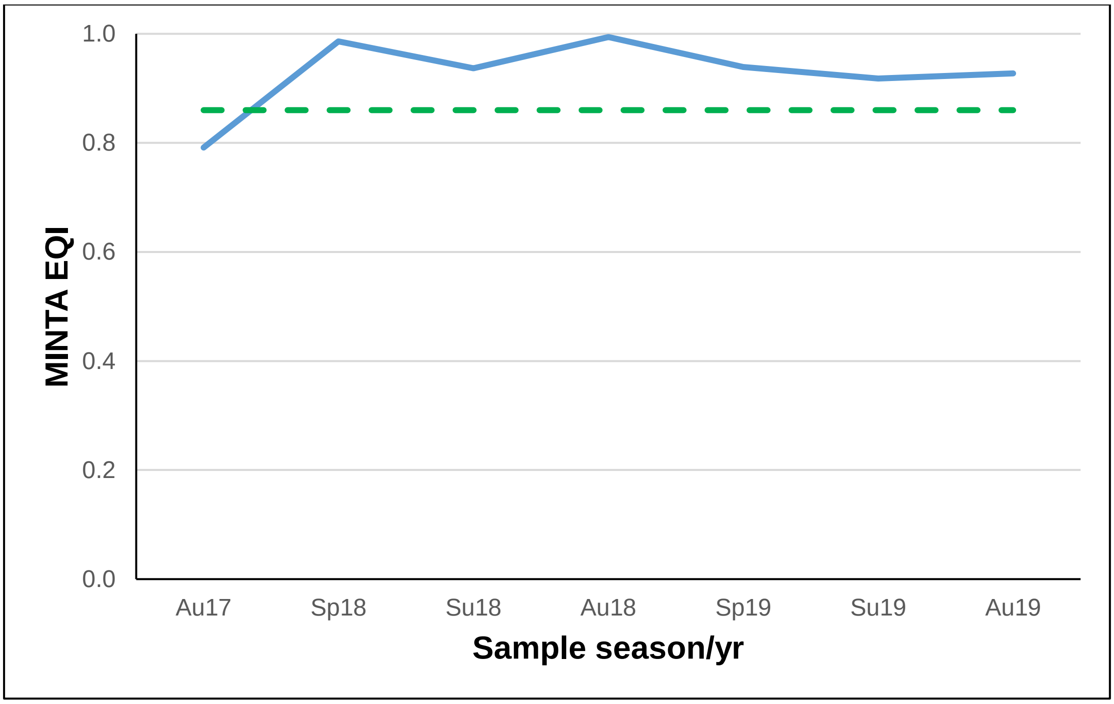
Site reference codes relate to the sample locations illustrated in Figures 2.2 and 2.3 and described in Figure 5.1. Invertebrate data collected in this study for all River Inny sites where data was available (Table 5.11) showed a ‘Moderate’ quality for Autumn 2017, although both Upstream and Downstream sites had a higher number of scoring taxa than would be expected. T1 and Trewinnow Bridge both downstream of the discharge both had a ‘Moderate’ score for the number of taxa observed, but a ‘Good’ quality for the WHPT scores. In 2018, the spring survey showed a ‘Good’ quality of invertebrates at TP with ‘High’ quality Upstream of the discharge and within T1, the tributary immediately Downstream of the discharge. Downstream, St Clether and 2BI showed a ‘Good’ class of invertebrates, whilst Trewinnow Bridge was ‘Moderate’.

In August 2018, a pollution incident led to a deterioration in the quality of the freshwater invertebrate community downstream of the Saputo discharge. The invertebrate surveys took place at the end of August, within two weeks of the event. Upstream and T1 were ‘Good’ (Table 5.11), whilst Downstream and Trewinnow Bridge were classed as ‘Bad’. Figure 5.3 A to C shows the MINTA score plotted against survey season for the sites Upstream, Downstream and Trewinnow Bridge for the invertebrate data sampled during this study. Autumn surveys took place at the end of November and signs of recovery were observed (Table 5.11). Upstream showed a ‘High’ class community, whilst Downstream and Trewinnow Bridge were classed as ‘Moderate’. Apart from the downstream Autumn 2019 survey, all those undertaken throughout 2019 (Table 5.11) yielded ‘Good’ class of invertebrate community, with consistency across sites.

Table 5.11 RIVPACS modelling results for spring, summer and autumn surveys of the River Inny invertebrate communities, 2017 - 2019. Spr and Aut experiments run using RICT-Prediction and Classification GB Single Year v4.0. Su experiments run using RICT – Prediction and Classification GB Summer Single Year v3.

Site	Yr	Season	OBS Ntaxa	OBS WHPT ASPT	EXP Ntaxa	EXP WHPT ASPT	EQI (O/E Ntaxa)	EQI (O/E WHPT ASPT)	MINTA
US	2017	Au	22	5.39	26.5	6.77	0.83	0.80	M
DS	2017	Au	21	5.80	26.2	6.79	0.80	0.85	M
T1	2017	Au	15	6.43	26.1	6.71	0.58	0.96	M
TB	2017	Au	16	6.18	27.2	6.83	0.59	0.91	M
TP	2018	Sp	19	6.09	26.0	6.96	0.73	0.88	G
T2	2018	Su	13	5.12	26.0	6.73	0.50	0.76	P
US	2018	Sp	30	7.07	29.2	7.14	1.03	0.99	H
US	2018	Su	29	6.34	26.7	6.77	1.09	0.94	G
US	2018	Au	29	6.77	27.0	6.79	1.08	1.00	H
DS	2018	Sp	24	6.76	29.0	7.16	0.83	0.94	G
DS	2018	Su	12	4.89	26.6	6.76	0.45	0.72	B
DS	2018	Au	18	6.22	26.9	6.80	0.67	0.91	M
T1	2018	Sp	28	7.01	27.6	7.08	1.01	0.99	H
T1	2018	Su	25	6.00	25.4	6.79	0.98	0.88	G
TB	2018	Sp	30	5.89	29.3	7.18	1.02	0.82	M
TB	2018	Su	12	4.84	26.9	6.75	0.45	0.72	B
TB	2018	Au	30	5.52	27.0	6.82	1.11	0.81	M
StC	2018	Sp	28	6.80	31.2	7.14	0.90	0.95	G
2BI	2018	Sp	24	6.93	31.2	7.12	0.77	0.97	G

Site	Yr	Season	OBS Ntaxa	OBS WHPT ASPT	EXP Ntaxa	EXP WHPT ASPT	EQI (O/E Ntaxa)	EQI (O/E WHPT ASPT)	MINTA
US	2019	Sp	34	6.73	28.8	7.13	1.18	0.94	G
US	2019	Su	30	6.23	26.4	6.79	1.14	0.92	G
US	2019	Au	27	6.31	26.7	6.77	1.01	0.93	G
DS	2019	Sp	37	6.48	28.4	7.16	1.30	0.91	G
DS	2019	Su	34	6.39	26.1	6.76	1.30	0.94	G
DS	2019	Au	24	5.82	26.5	6.79	0.90	0.86	G
TB	2019	Sp	36	6.82	29.0	7.17	1.24	0.95	G
TB	2019	Su	27	6.00	26.6	6.75	1.01	0.89	G
TB	2019	Au	21	6.29	26.8	6.82	0.78	0.92	G


1.0
0.8
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MINTA EQI
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Sp18
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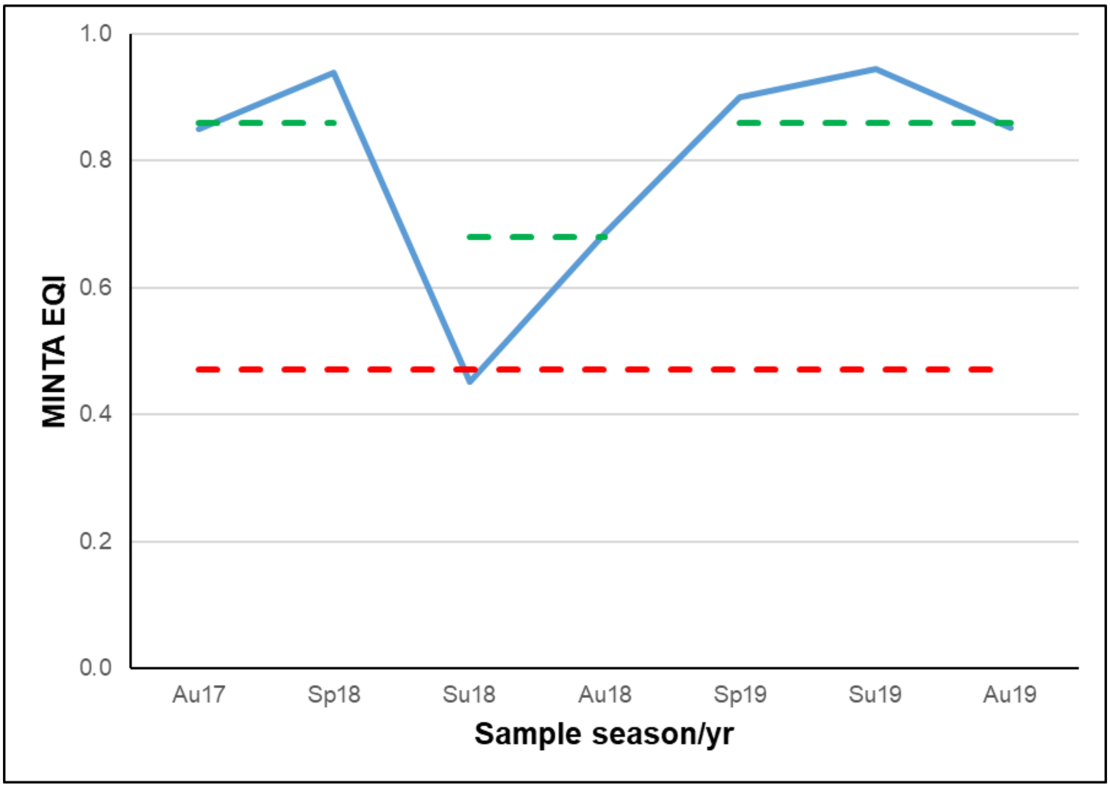
Sample season/yr
A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MINTA EQI
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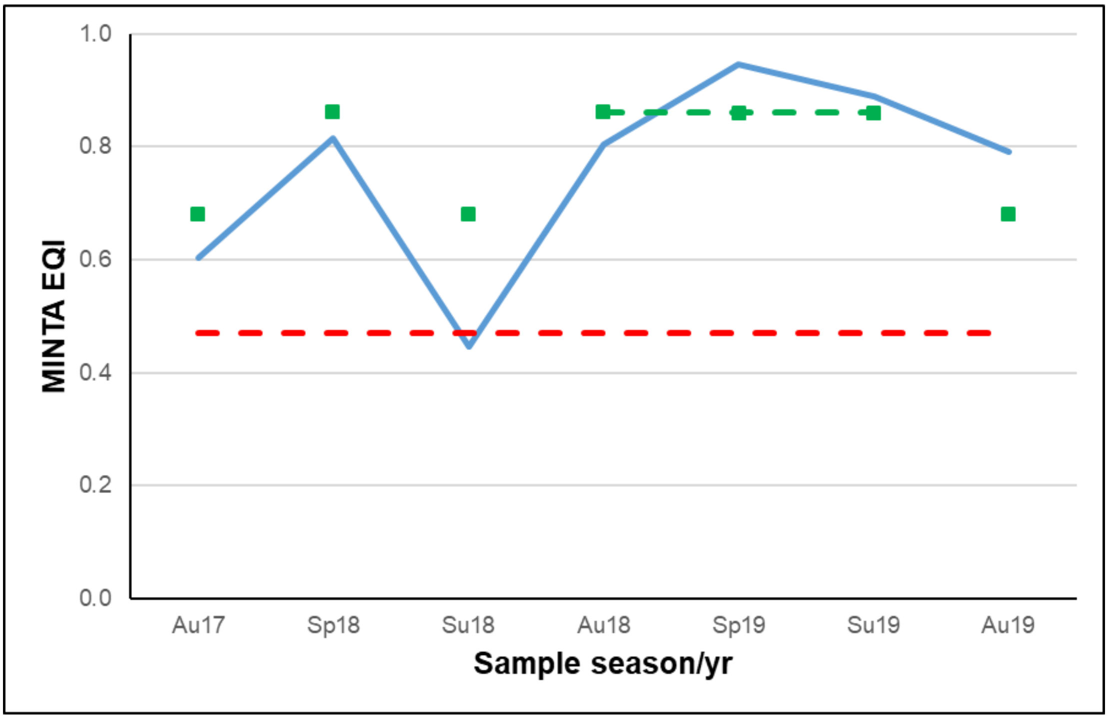
Su18
Au18
Sp19
Su19
Au19
Sample season/yr
B



C

Figure 5.3 ASPT/NTAXA scores and Water Framework Directive class boundaries. A) Blue line = US MINTA: Minimum score of NTAXA and ASPT. For Upstream site, ASPT was consistently lower than NTAXA. Green dashed line represents the 'Good/Moderate' status boundary for ASPT. B) Blue line = DS MINTA: Green dashed line represents the 'Good/Moderate' status boundary for the MINTA value of ASPT (upper) or NTAXA (lower). Red dashed line represents 'Poor/Bad' status boundary for NTAXA class. C) Blue line = TB MINTA: Green dashed line represents the 'Good/Moderate' status boundary for the MINTA value of ASPT (upper) or NTAXA (lower). Red dashed line represents 'Poor/Bad' status boundary for NTAXA class.

Plotting SRP and TRP concentrations against the EQI NTAXA and EQI WHPT ASPT scores gives an indication as to whether there is a relationship between these factors. Figure 5.4 shows a weak negative linear correlation that is significant (F (1, 26) =5.329; *p=0.029*)) between SRP concentration and EQI NTAXA although this is likely driven by two high SRP values. There was no significant relationship between TRP and EQI NTAXA. There was a negative linear relationship between SRP and EQI WHPT ASPT which proved to be significant (Figure 5.5) (F (1, 26) = 17.579; *p=0.0003*)) but this was largely influenced by 4 of the 28 data points exhibiting an SRP concentration >150 µg SRP L^{-1}, whilst 19 exhibiting an SRP concentration <50 µg SRP L^{-1}. The trend line for all data plotted returned an R^2 value of 0.4. R^2 values for individual site relationships ranged between 0.09 for US to 0.84 for TB and 0.98 for T1. Figure 5.6 shows a negative linear relationship between TRP and EQI ASPT, which was also significant (F (1, 26) =11.458; *p=0.002))*. The trend line for all data plotted returned an R^2 value of 0.31. R^2 values for individual site relationships ranged between 0.07 for US to 0.74 for TB and 0.99 for T1.This follows expectations, as the average score per taxa is a value which includes sensitivity to organic pollution.

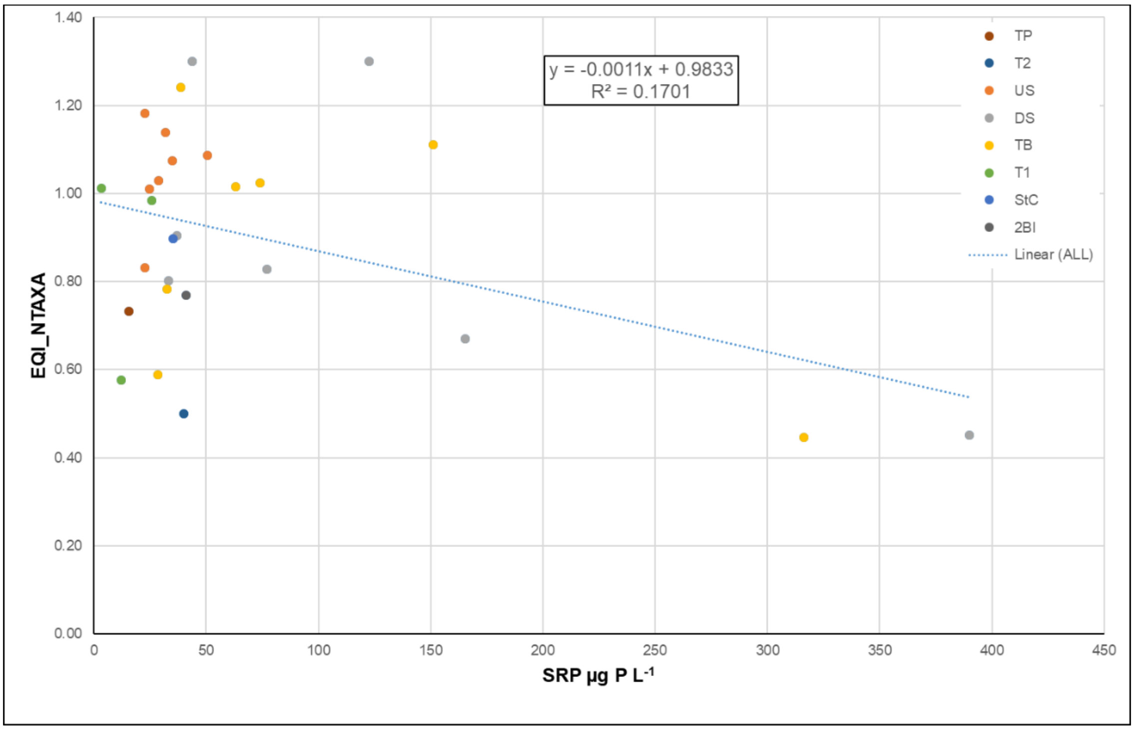


Figure 5.4 Relationship between Soluble reactive phosphorus concentration and EQI NTAXA

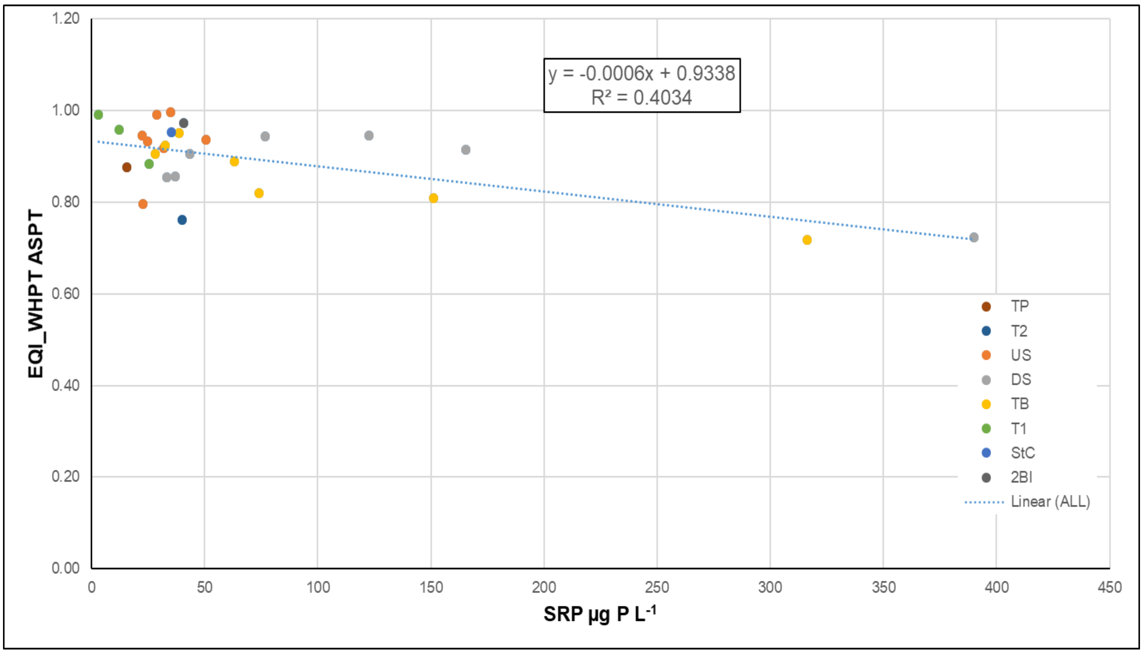


Figure 5.5 Relationship between Soluble reactive phosphorus concentration and EQI WHPT ASPT score

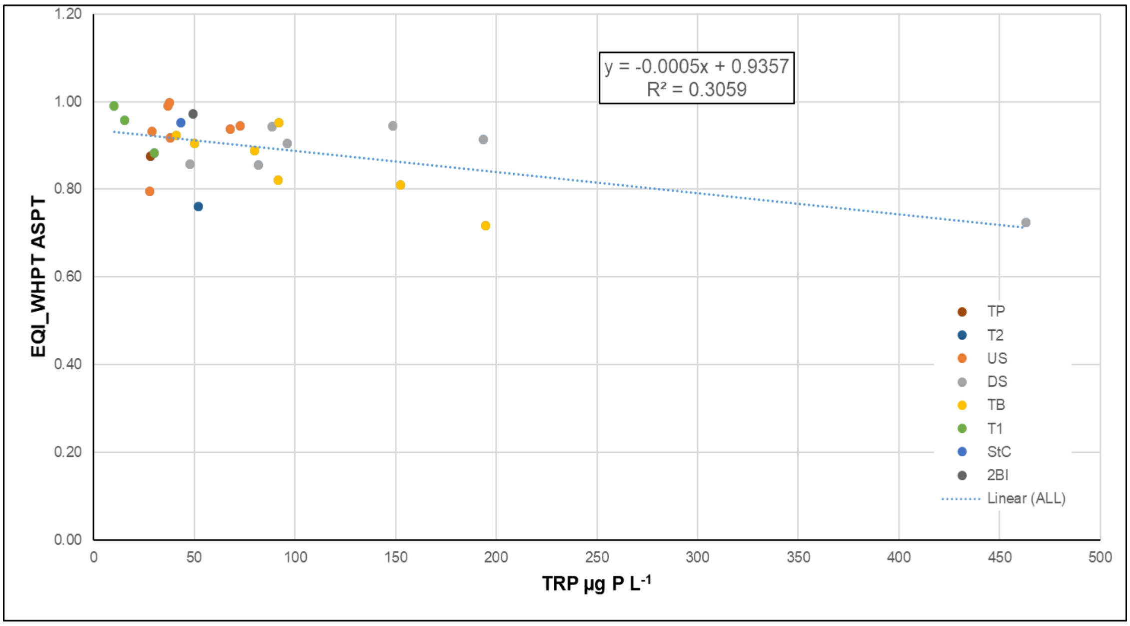


Figure 5.6 Relationship between Total reactive phosphorus concentration and EQI WHPT ASPT score for all sample sites

During sample processing it was observed that survey counts of *Gammarus* showed significant difference between upstream and downstream sites (t (10) = 7.116877; *p<0.0001)*. This relationship was not apparent for molluscs.

5.8.5 Functional feeding group NMDS ordination results

The resulting plot of stress scores from the NMDS ordination results show how well the calculated dissimilarities correlate with the data (Figure 5.7).There is a good linear fit for R^2 (R^2=0.967), and across twenty runs of the analysis, the stress score ranged from 0.073 to 0.086. A stress score <0.1 indicates a good representation of the data.

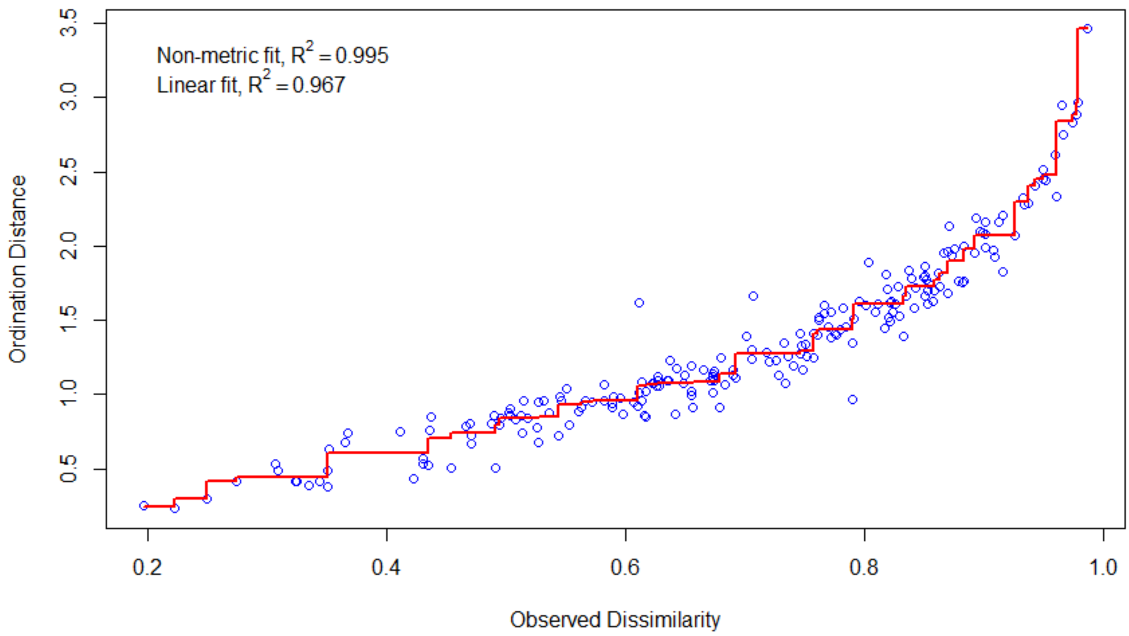


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Figure 5.7 Stress plot showing goodness of fit of the NMDS analysis

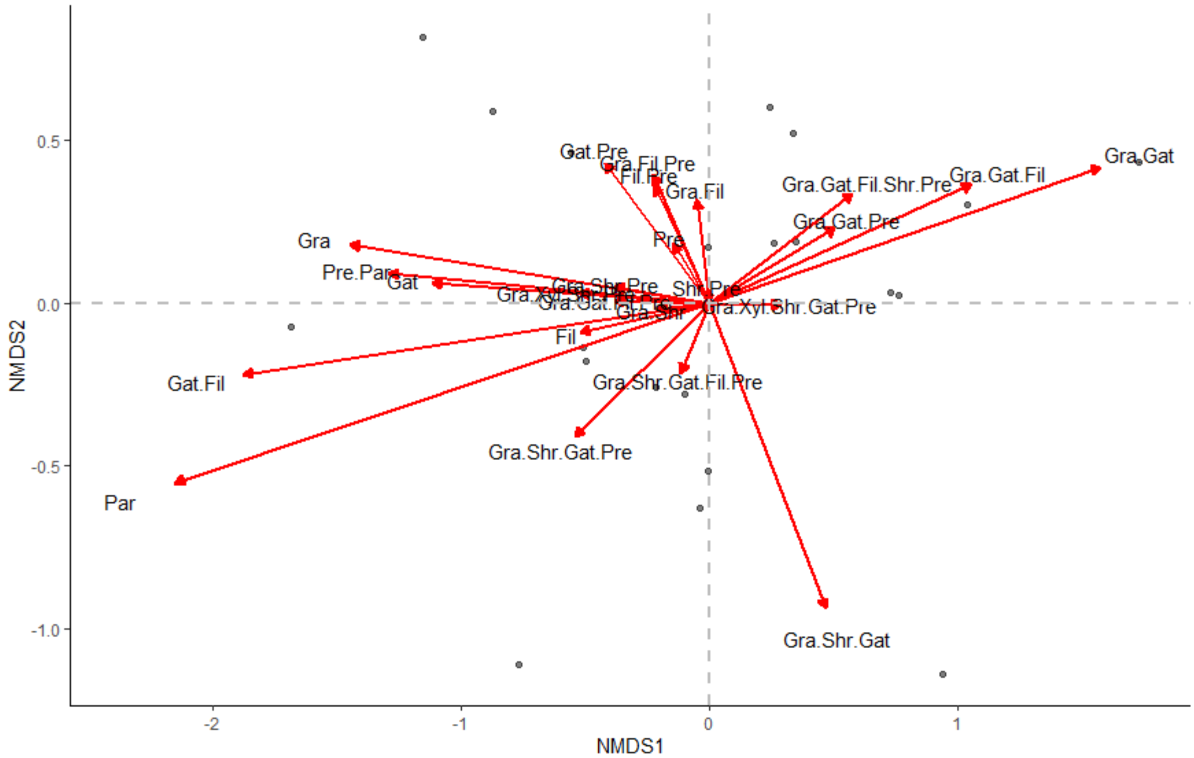


Figure 5.8 NMDS ordination plot of allocated functional feeding guilds and site locations for freshwater invertebrate survey data, 2017 – 2019 conducted during this study. Feeding guild abbreviations: Fil= Filter, Fil/Pre= Filter/Predator, Gat= Gatherer, Gat/Fil= Gatherer/Filter, Gat/Pre= Gatherer/Predator, Gra= Grazer, Gra/Fil= Grazer/Filter, Gra/Fil/Pre= Grazer/Filter/Predator, Gra/Gat= Grazer/Gatherer, Gra/Gat/Fil= Grazer/Gatherer/Filter, Gra/Gat/Fil/Pre= Grazer/Gatherer/Filter/Predator, Gra/Gat/Fil/Shr/Pre= Grazer/Gatherer/Filter/Shredder/Predator, Gra/Gat/Pre= Grazer/Gatherer/Predator, Gra/Shr= Grazer/Shredder, Gra/Shr/Gat= Grazer/Shredder/Gatherer, Gra/Shr/Gat/Pre= Grazer/Shredder/Gatherer/Predator, Gra/Shr/Gat/Fil/Pre= Grazer/Shredder/Gatherer/Filter/Predator, Gra/Shr/Pre= Grazer/Shredder/Predator, Gra/Xyl/Shr/Pre= Grazer/Xylophagus Shredder/Predator, Par= Parasite, Pre= Predator, Shr= Shredder, Shr/Pre= Shredder/Predator, Xyl= Xylophagus

The FFGs shown in the centre of the ordination plot (Figure 5.8) have similar requirements and therefore occur together on this representation of axis of most variance. In the top right of the plot, FFG grouping consists of mainly mixed grazing communities, illustrating their similarities in requirements. Clarity of the plots is affected by the changes in feeding guild categories, which occur with instar development. The NMDS plot (Figure 5.9) shows the grouping of FFGs by site, and illustrates a grouping of US FFG types (green) and grouping of Trewinnow Bridge FFG types (purple) and a downstream grouping (DS) which shows a mix between the US and TB FFG types. Looking at Figures 5.8 and 5.9 together, the mixed group Gra/Str/Gat can be seen in the lower right of the Figure 5.8 plot, which corresponds with survey results from the US set (see Figure 5.9). The majority of the grazing communities appear in the top right of the ordination plot (Figure 5.8) which is associated with the DS and TB survey sets. This suggests differing community structure associated with differing water chemistry.

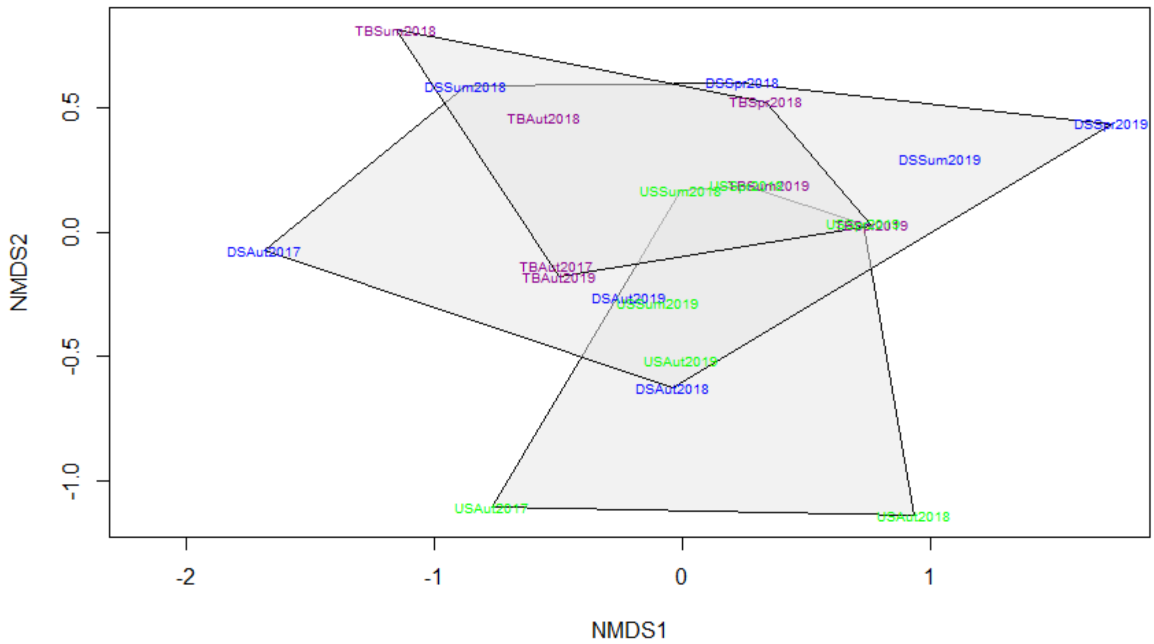


Figure 5.9 NMDS plot showing grouping of FFGs by survey season and according to the site sampled upstream of the discharge (green font, US), downstream of the discharge (blue font, DS) and at Trewinnow Bridge (purple font, TB).

5.9 Diatoms and their role in water quality

Benthic diatoms react rapidly to physico-chemical disturbance of the water body in which they live (Solak & Acs, 2011). Water quality monitoring has shown that some genera of diatoms thrive under conditions of gross pollution in rivers, whilst others are intolerant (Kelly, 2007). Monitoring of diatoms has become an accepted component of the Water Framework Directive to assess the trophic status of rivers and streams (Kelly, 2001).

Figure 5.10 Photographic example of a pinnate diatom. Diatom samples contain fragments of broken diatom from their environment and damage during processing.

Early attempts to bring macrophytes and phytoplankton into biotic monitoring systems for trophic status of lakes were seen to be particularly complex. Attempts had been made to use phytoplankton species diversity and composition as indicators of the trophic status of lakes. However, presence or absence of an algal species is not always directly related to trophic status (Friedrich *et al.*, 1996).

Diatoms are unicellular algae (Figure 5.10) consisting of a nucleus, cytoplasm, plasma membrane and a cell wall. The cell wall has a structure similar to a petri dish. It is composed predominately of siliceous material. The structure is referred to as a frustule with an upper valve (epivalve) and a lower valve (hypovalve). Each valve has a connecting bands known as a girdle (the hypo and epigirdles) (McLaughlin, 2012). It is the structure and features of the diatom cell wall that is predominately used in the identification of different species.

About 80 genera of diatoms are likely to be found in temperate freshwaters (Kelly, 2007). They can be found as plankton and living as part of the benthic community either on the surface of rocks and detritus or on the surface of submerged vegetation. With diatoms obtaining their nutrients directly from the water column and having generation times measured in days rather than months, they stand to be a useful assessment tool in measuring short (seasonal) changes in nutrient status (Holmes *et al*., 1999).

Diatoms have been used as a tool in paleoecology to determine historical environmental conditions, for example hydrochemistry which can influence lake conditions (Woodbridge & Roberts, 2011). In such research, diatoms are extracted from preserved lake sediments. Their identification can yield information which shows different genera having a preference for differing environmental conditions. Scientists have also observed that some genera thrive under conditions of gross pollution in rivers, whilst others are intolerant (Kelly, 2007). These characteristics were taken and used to develop an index for use in regular water quality monitoring.

Benthic diatom communities react rapidly to physico-chemical disturbance of water, often resulting in changes to species composition or diversity (Solak & Acs, 2011).

Routine diatom monitoring in UK waters commenced in 1991 in an attempt to help regulatory authorities meet the requirement of the Urban Wastewater Treatment Directive (UWWTD) (Directive 91/271/EEC) which set standards for sewage treatment across Europe. The Directive's objective was to protect the environment from the adverse effects of urban wastewater discharges and discharges from certain industrial sectors.

Under the UWWTD, there was a requirement to designate areas where more stringent treatment of wastewater should take place. Such areas might include discharges from large sewage works to waterbodies that were

"e*utrophic, or which in the near future may become eutrophic if protective action is not taken* "(UWWTD Annex 2, cited in Kelly, 1998) These works were required to install phosphorus stripping facilities

> "…*unless it can be demonstrated that removal [of P] will have no effect on the level of eutrophication.*" (UWWTD Annex 2 cited in Kelly, 1998).

Although the Environment Agency and its predecessor (National Rivers Authority) had an extensive network of chemical monitoring of river water quality across the country, which in some areas informed a high level in the concentration of nutrients, the availability did not indicate the biological response and there was no means of measuring this response. The community structure of invertebrates was being measured and compared against expected communities using RIVPACS (River Invertebrate Prediction and Classification System) (Wright *et al.*, 1989), however, as invertebrates are consumers rather than primary producers, there was no nationally accepted method for the direct assessment of these components of river biota. From this need, research into methods of assessment of eutrophication was developed. Two directions were followed, one looking at macrophytes, the Mean Trophic Rank, after

Holmes and the second the Trophic Diatom Index, after Kelly and Whitton (Kelly, 1998).

5.10 The Trophic Diatom Index

Through the development of the Trophic Diatom Index (TDI), a database of benthic diatom samples collected over 20 years was assembled. In total, 1051 samples were included with matching environmental data. The physico chemical parameters of interest included soluble reactive phosphorus (SRP), nitrate, as nitrogen, (NO_3-N), alkalinity (as mg L^{-1} $CaCO_3$), calcium, pH, altitude, slope, channel width and distance from source. However, during the early stages of the TDI development, no attempt was made to differentiate between the responses of diatoms to P and N. Owing to the frequency of high correlation between trophic variables, it was considered a better option to model a broad response to nutrients using a single variable as a proxy. As a result molybdate-reactive phosphorus (filterable reactive phosphorus (FRP), also referred to as "orthophosphate" was selected, owing to the underlying assumption that P rather than N was the limiting nutrient factor in most river systems (Kelly, 2001).

From the historic database, diatoms were allocated to one of five groups according to their tolerance to nutrients, with 's' scores ranging from 1 (low tolerance) to 5 (high tolerance) cited by Kelly & Whitton (1995) in (Kelly *et al.*, 2008). Allocation was made from graphs summarising percentage count of valves vs. dissolved phosphorus (FRP) concentrations for 86 taxa (Kelly, 1998). The sensitivity values were broadly based on OECD criteria for lakes, according to Table 5.12.

Table 5.12 Nutrient sensitivity scores associated with the Trophic Diatom Index (reproduced from Newman 1988, cited by Kelly & Whitton, 1995).

Sensitivity score	Nutrient concentration (mg L^{-1})	Status
1	<0.01	Favouring very low nutrient concentrations
2	≥0.01 to <0.035	Favoured by low concentrations
3	≥0.035 to <0.1	Favoured by intermediate concentrations
4	≥0.1 to <0.3	Favoured by high concentrations
5	≥0.3	Favoured by very high concentrations

The values were assigned to each taxon depending upon the concentration at which taxa were most abundant, with 'Indicator values' allocated according to the spread of values around these peaks (Kelly & Whitton, 1995). From the database, 'reference sites' were selected to represent sites unimpacted by human activity. The TDI is a measure of the effect of nutrients (predominately phosphorus) on stream communities, giving an indication of floristic change in communities from increased nutrient concentration (Kelly, 2001). It is calculated using a "weighted average" equation, devised by Zelinka & Marvin in 1961 (Kelly, 1998):

$$\text{Weighted Mean sensitivity} = \frac{\sum_{j=1}^{n} a_j s_j v_j}{\sum_{j=1}^{n} a_j v_j}$$

where a_j = abundance (proportion of taxon *j* in the sample, s_j = pollution sensitivity (1 – 5) of taxon *j* and v_j = the indicator value (1 – 3) of species *j*.

The Trophic Diatom index is then calculated as (WMS x 25) – 25, calculated using the weighted average formula above. The index has a scale of 0 – 100, with higher values indicating progressively higher levels of nutrients. Ecological Quality Ratios (EQRs) were generated ranging from ≥1, where the diatom assemblage showed no impact, to 0, where the diatom assemblage was indicative of major anthropogenic activities (Kelly, 2008). The EQR was derived from the production of site specific TDI predictions based on alkalinity.

To bring the TDI into Water Framework Directive classifications, a boundary between 'high' and 'good' status was defined as the 25^{th} percentile of EQRs of all reference sites. The boundary between 'good' and moderate' status was set at the point which nutrient sensitive and nutrient tolerant taxa were present in equal relative abundance.

Sampling of diatoms should be undertaken with some thought. Sampling sites should ensure adequate availability of suitable substrates from which to sample, a sufficiently open canopy to allow light penetration and water depth shallow enough such that light levels at depth will not inhibit diatom growth. Although collection can occur throughout the year, cell growth rate is lower in winter, so diatom communities have less opportunity to reflect their prevailing environmental conditions. and seasonal factors such as high river flows scouring away diatom film and affecting water quality can have a determining effect on diatom communities (Kelly, 2001). The TDI does not differentiate between nutrients and organic pollution, which is frequently associated with high nutrient concentrations. Under situations of organic (or other) pollution, supplementary factors can be influencing community composition and these can negatively affect the validity of the TDI when inorganic nutrient levels are sufficiently high that phosphorus is no longer a limiting nutrient (Kelly, 2001).

Revisions of the TDI have been made to ameliorate the identified limiting factors of the model. These have included the addition of further diatom taxa to the index and additional reporting metrics such a % pollution tolerant taxa metric. Reporting the percentage pollution tolerant valves (%PTV) alongside the TDI score gives a reliability factor to the TDI as a measure of eutrophication. A %PTV of 20 or greater, indicates that nutrients are probably the major factor influencing the floral composition (Kelly, 1998). Reporting of the %PTV should be observed with caution as it is a measure to be taken into account with the TDI and not solely a measure to report levels of organic pollution. Other water quality issues can influence the composition of diatom flora that contribute to the %PTV score, both up and downstream of sewage treatment works (Kelly, 2001).

Headwater streams are typically dominated by growth forms adapted to withstand or recover rapidly from disturbances. The distribution of different diatom taxa within the community will change even without human impacts as one moves down stream (Molloy, 1992). Typically, there is an increase in sedimentation downstream of a sewage treatment works. This can impact on diatom communities by offering a smothering effect to non-motile species, whereas motile species are able to move above sediments. The % motile valves can be used to make comparisons between samples which may highlight non-nutrient factors influencing the flora. A difference of

20% should be used as a threshold when making such comparisons, with less <20% suggesting that a comparison between the two sites is valid.

Sas (1989) cited in (Kelly, 2001) identified distinct zones in lakes where reductions to nutrient loading had been made. The zones allowed for evaluation to be made in response to reduction in P loading. Thresholds between the zones are recognized, above which the system is saturated with nutrients and no further ecological change will occur. However, cross correlations between P and other limiting factors may allow the relationship to continue but would not be as apparent in rivers compared with lakes as circulation through mixing within the river water column will be greater than those experienced within the lake environment.

Nutrient concentrations corresponding to this threshold have not yet been established in a manner that is widely applicable. However preliminary data suggests that it may be as low as 0.3 mg L^{-1} "available" phosphorus (i.e. as orthophosphate or SRP) (Kelly, 2001). Although the assumption that a positive relationship between the TDI and nutrient concentration exists, other factors including stream velocity, turbidity, light levels and presence of grazing organisms will influence the TDI value (Kelly, 2001).

5.10.1 DARLEQ and DARLEQ3

DARLEQ is the Diatom Assessment of River and Lake Ecological Quality, devised by the DARLEQ Consortium (Kelly *et al., 2008.*). The assessment combined two projects, 'Diatoms for Assessing River Ecological Status' (DARES) and Diatoms for Assessing Lake Ecological Status' (DALES).The purpose was to create an assessment tool that could be used to estimate ecological class, as required by the Water Framework Directive, using the Trophic Diatom Index (Bowburn Consultancy, 2013). A key requirement was that a reference condition could be compared against the observed value of a site and expressed as an ecological quality ratio (EQR). The tool was evaluated and revised to ensure it could be used effectively with LEAFPACS to give an overall combined assessment of phytobenthos and macrophytes (WFD-UKTAG, 2014a). The revised software tool, DARLEQ2, ran on MS Excel. Subsequent revisions have resulted in DARLEQ3, a package which runs using R (Juggins & Kelly, 2018).

5.10.2 Methodology

Freshwater diatom samples were collected tri-annually from all stream channel sites at the time of invertebrate sampling. This gave spatial and temporal samples that aligned with the water chemistry sampling (Figures 2.2, 2.3 and 5.1). Samples were collected using the WFD UKTAG River Assessment Method for Macrophytes and phytobenthos where five cobbles were collected from mid-stream and placed into a tray with a little water. The upper surface of the cobbles was brushed with a clean tooth brush to remove the biofilm (Kelly & Whitton, 1995). The liquor was collected into 250 mL plastic bottles to which 25 mL of IDA was added to fix the diatoms. All sample bottles were uniquely numbered and this reference was noted, together with details of stream reach, pH, dissolved oxygen and conductivity. The collection equipment and toothbrush was rinsed well before leaving site and again on arrival at the next site.

Owing to Covid related laboratory closure, insufficient time was available to undertake the slide preparation and processing so this element of work was outsourced to a commercial ecological consultant (APEM, Stockport, UK) who processed the collected samples, identified and provided species counts.

Diatom slides for early sample collections were prepared using the hydrogen peroxide method as described in (Kelly *et al*., 2001). The diatom sample in its field collection container was homogenised by shaking, before 5-10 mL of the suspension was transferred into a glass beaker. 20 mL 30% hydrogen peroxide was added and heated on a hotplate set at 90 ^{0}C (± 5 ^{0}C) until all of the organic material has been oxidized. This typically took 1-3 hours. Care was required when pouring cold concentrated hydrogen peroxide onto organic rich material and also during the heating process. The reaction was complete when the evolution of bubbles of carbon dioxide stopped. Whilst heating, the samples were regularly monitored, as the diatoms suffer damage if all of the hydrogen peroxide is evaporated off. The beakers were removed from the heat and allowed to cool before running a few drops of 1M hydrochloric acid into the beakers to remove any remaining hydrogen peroxide and any carbonates. The sides of the beakers were washed down with distilled water. The contents of the beakers were transferred to labelled 50 mL centrifuge tubes and topped up with distilled water to approximately 1 cm from the top and centrifuged. The centrifuging aspect of the method is purely to separate the solid and liquid states. Speeds and times of 3000-5000 rpm and 3 – 5 minutes are generally used. The resultant supernatant was carefully poured off for disposal with plenty of water. The pellet was re-suspended with distilled water to 1 cm from the top of the centrifuge tube and the centrifuging stage repeated twice more.

Once all traces of hydrogen peroxide and hydrochloric acid were removed, the cleaned material was transferred into a small vial using a clean pipette. The vial was labelled with collection date, water body and sample site. A few drops of preservative (ethanol) were added to prevent microbial growth.

To prepare the diatom slides, the vial of material was shaken to homogenise. A pipette was used to apply a drop of the material onto the centre of two round coverslips for each sample. The drops were allowed to spread out across the cover slip and evaporate in air, leaving an evenly spread pale residue. Before fixing the sample, the density of valves was checked by placing the coverslip face down on to a microscope slide and examining it under a medium power objective. Assuming a maximum final density of around 15 valves per field of view at 1000 x magnification, the dry mount should have a maximum of around 30 valves per field of view. If the density is too high, the coverslip should be remade but with a more dilute suspension. Once an appropriate density of material was achieved on the coverslips, permanent slides were prepared. One slide for each sample was placed on a hot plate and warmed. Four drops of Naphrax diatom mountant, supplied by Brunel Laboratories were placed onto the slide as two groups. Once the Naphrax had spread and bubbled, the coverslip was placed material side down onto the Naphrax. Gentle pressure was applied to remove the bubbles. Care was taken to avoid excessive heating, as this would degrade the Naphrax and produce a poor quality slide. Once the slide had cooled, the sample name and collection date were added with permanent pen. Slides were then stored for identification with oil emersion lens.

5.10.3 Environment Agency Diatom data (2009 – 2016)

Historic diatom monitoring data were downloaded from the Freshwater and Marine Biological Surveys for Diatoms England repository. Environment Agency data were not available for all the sites monitored within this study but provided an insight into the diatom assemblage along the study reach. The data were transcribed into the required DARLEQ3 format in order for the model to run using the TDI5LM version. TDI5LM is the Trophic Diatom Index iteration 5 score for Light Microscope identified diatoms. eTDI5LM is the expected value for the site, generated from the following equation:

$$TDI_{exp} = 9.933 \times \exp(\log_{10}(\text{alkalinity}) \times 0.81)$$

Where alkalinity is the mean alkalinity of the sampled site. The majority of sites yielded a quality class of ‘Moderate’ or ‘Poor’, with just 4 of the 21 surveys yielding ‘Good’ status and three yielding ‘High’ status. These ‘Good’ sites were at St Clether Bridge in Spring and Autumn 2014, and St Clether Bridge in Summer 2016, at the River Inny at Two Bridges in Spring 2014 and Summer 2016. The ‘High’ status sites were Penpont Water at Two Bridges throughout 2016.

Diatom classes attaining to the WFD scoring metric can be seen in Appendix 5. The % scoring taxa is 100% for all but 3 of the 26 samples. This indicates that for the majority of samples all diatoms identified were the scoring taxa, i.e. not planktonic used to generate the metrics. 4 samples contained >3% of saline tolerant valves. The percentage of organic pollution tolerant valves in samples ranged from 8.7 to 77% but did not correlate with WFD quality class. Figure 5.11 shows the sample date plotted against the DARLEQ3 output of EQR TDI5LM for Inny Vale, St Clether Bridge, the River Inny at Two Bridges and Penpont Water at Two Bridges. Penpont Water shows the highest quality status of diatom community in the historic data set, but also had one of the worst qualities in October 2013. Data for Inny vale was only available in

2009. The other sites showed a trend of general improvement in WFD class across the period Summer 2012 to Autumn 2016.

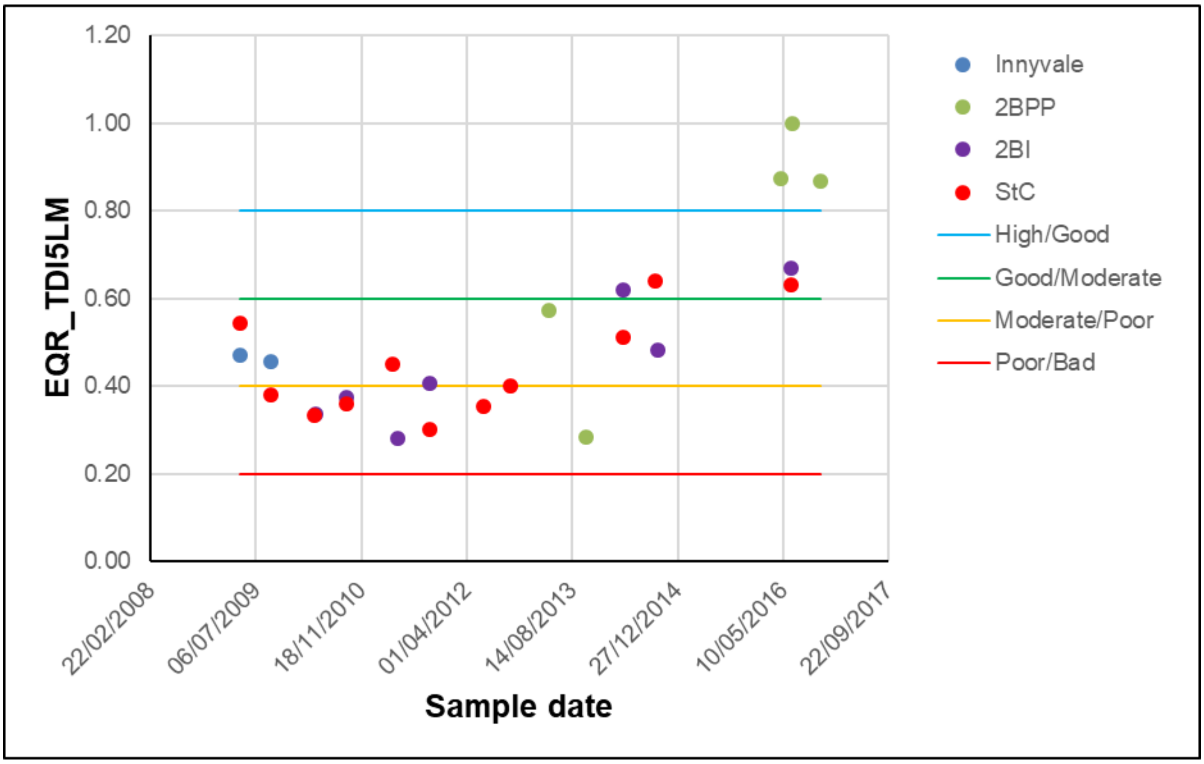


Figure 5.11 Historic diatom sampling and their calculated EQR. Sites are represented as blue dot=Inny Vale, Red dot = St Clether Bridge, Purple dot = Two Bridges, River Inny and Green dot = Two Bridges, Penpont Water. WFD Boundary status classes are represented by the horizontal coloured lines, where top line, blue = 'High /Good' status boundary, 2nd line, green = 'Good/Moderate' status boundary, 3rd line, orange = 'Moderate/Poor' status boundary and bottom line, red = 'Poor / Bad' status boundary. Produced using Environment Agency data modelled using DARLEQ3. EQR boundary status values taken from UKTAG, (2014).

5.10.4 Diatom sampling results (2017 – 2019)

Data received from APEM were tabularised and species names checked against the definitive diatom list, downloaded from the DARLEQ3 repository on GitHub. The data was imported into the 'shiny' interface 'DARLEQ3 for diatom-based water quality assessment' using R version 4.0.5 (2021-03-31) -- "Shake and Throw" and RStudio 1.4.1106. The TDI5LM (for light microscope) was selected for the modelling. TDI5LM scores were generated, together with a modelled 'expected' score likely to be found in pristine water. An EQR was derived to illustrate any deviation from the reference condition. Sample dates have been plotted against these, together with the WFD quality class boundaries (Figure 5.12). A further output, the percentage of organic tolerant valves, give an indication of nutrient influence on the diatom community (Appendix 5). A score of 20 or less indicates nutrients are a key limiting factor influencing the floral composition (Kelly, 1998) of the diatoms identified. Samples upstream of the discharge ranged in their % of Organic tolerant valves from 12.78% to 25.23%. Downstream they ranged 13.81% to 61.76%, at Trewinnow Bridge 12.79% to 52.66% and at St Clether Bridge 12.26% to 39.50%.

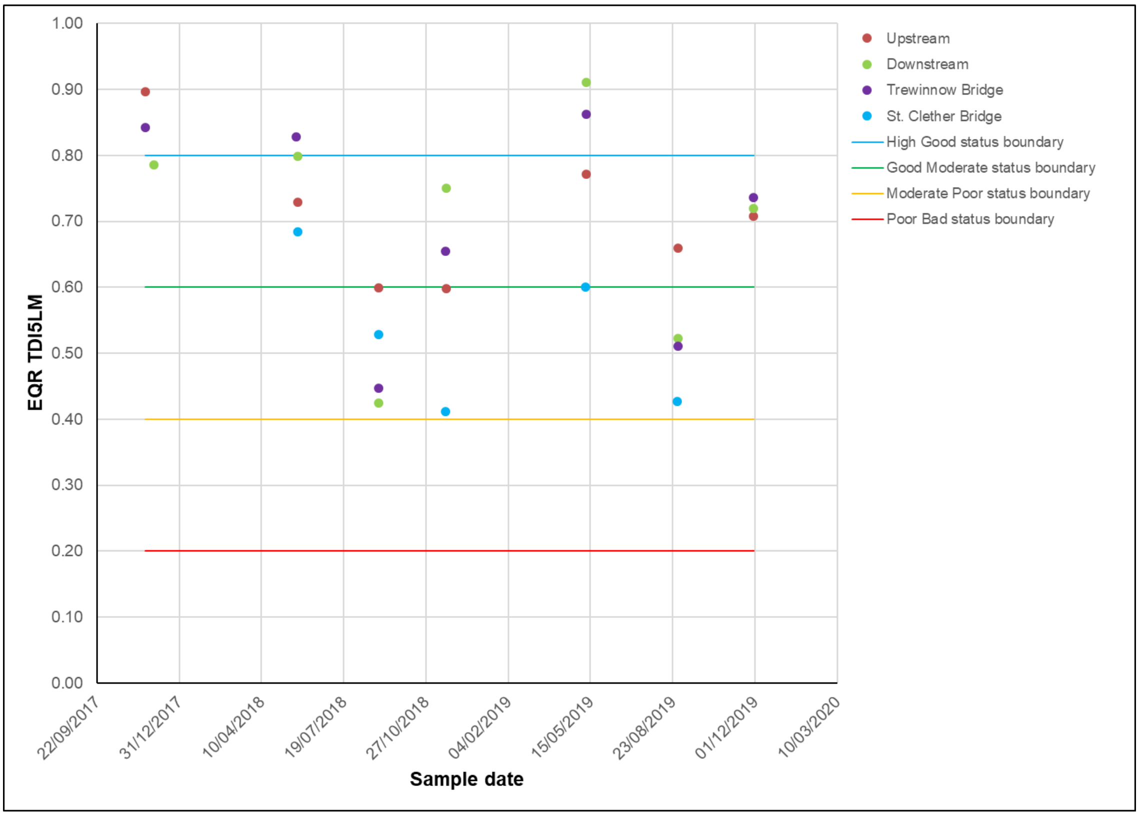


Figure 5.12 Diatom sampling Autumn 2017 to Autumn 2019 and their calculated EQR. WFD boundary status classes are represented by the horizontal coloured lines, where top line, blue = 'High/Good' status boundary, 2nd line, green = 'Good/Moderate' status boundary, 3rd line, orange = 'Moderate/Poor' status boundary and bottom line, red = 'Poor/Bad' status boundary. Diatom EQR boundary status values taken from UKTAG, (2014)

The chart of 2017-2019 diatom data plotted in (Figure 5.12) suggests that the River Inny did not show significant changes in the quality of diatom biodiversity in association with the quality decline experienced within the invertebrate communities scoring in Summer 2018. A deterioration in class was observed upstream of the discharge, suggesting that season is an influencing factor. Recovery upstream can be seen in the autumn sampling event, but quality falls to the 'Moderate' class again in Summer 2019. This study shows sites upstream and downstream of the discharge are being impacted by nutrients suggesting other sources of nutrients affecting the River Inny upstream of the Saputo discharge.

Concentration of SRP plotted against EQR TDI5 for all data shows a significant small negative correlation (t= (25), 2.06, $p=0.0002$).Figure 5.12 shows the diatom samples US of the outfall presenting an EQR TDI5 of 0.6 to 0.9 and a seasonal SRP concentration 23 µg P L^{-1}. DS, TB and StC present EQR TDI5 values between 0.4 and 0.9 at seasonal SRP concentrations within a range extending 21 to 390 µg P L^{-1}. The relationship between the reactive phosphorous species and EQR TDI5LM is further explored in Figure 5.13 and Figure 5.14. For SRP, there is a good fit in the US and DS relationships (R^2=0.58 and 0.62, respectively) between SRP concentration and EQR TDI5LM, whereas with TRP the relationship is weak (R^2=0.07). This illustrates the different effects of the bioavailable phosphorus (i.e soluble and reactive) vs the TRP (i.e soluble and insoluble and reactive, so therefore less bioavailable).

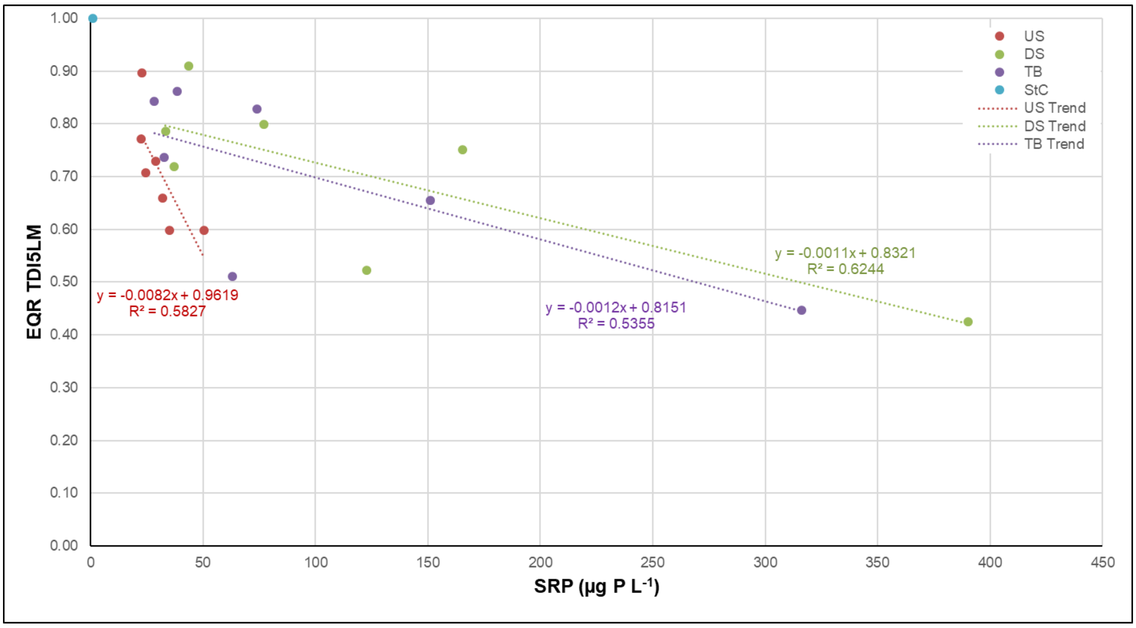


Figure 5.13 Relationship between concentration of SRP and EQR TDI5LM

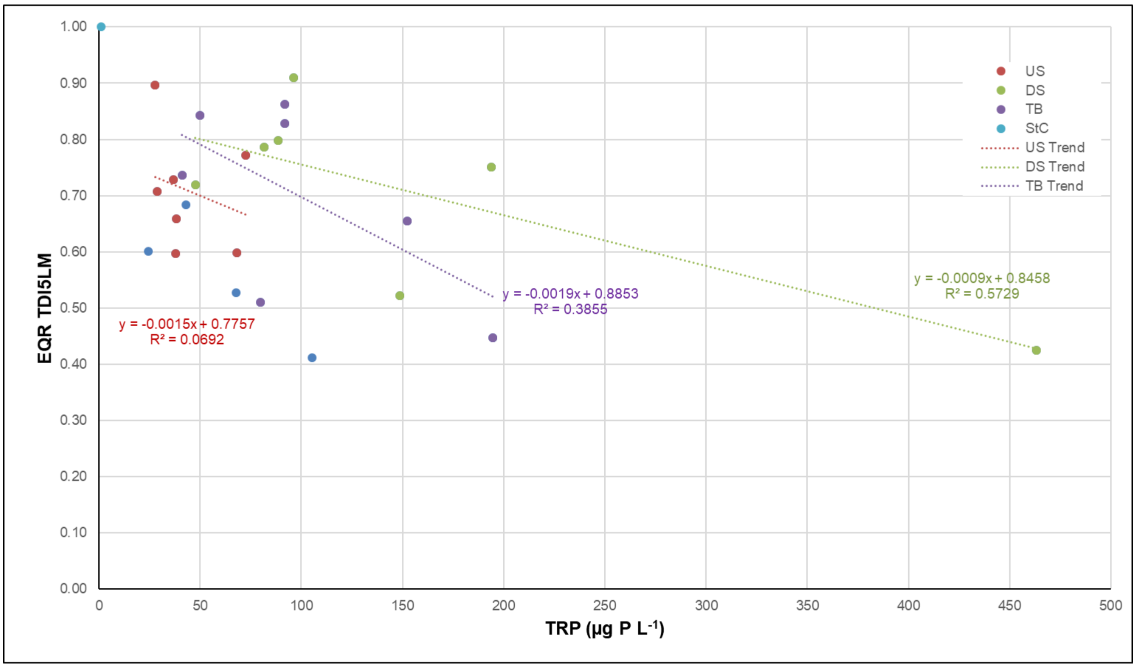


Figure 5.14 Relationship between concentration of Total reactive phosphorus and EQR TDI5LM

5.11 Macrophytes

Plants and animals living in or in close proximity to the watercourse will have a relationship with the quality of the water. Different species have varied tolerances to changes in physical water characteristics (temperature, pH, suspended solids, and dissolved oxygen) and chemical composition of the water (organic compounds, nutrient levels). By monitoring the plant communities, freshwater invertebrate communities and phytobenthic communities, the biotic ecological quality of the water can be determined.

5.11.1 The Mean Trophic Rank (MTR)

In the presence of severe pollution, plants cannot survive but in a less polluted river system nutrient enrichment effects may be observed which actively promote plant growth (Friedrich *et al.*, 1996), making their inclusion in a biotic monitoring system complex. Developed by Holmes, the Mean Trophic Rank (MTR) (Holmes, 1999) was an additional attempt to implement the monitoring requirements necessary for the UK to meet the EU Urban Waste Water Directive. The system was originally used to assess differences in nutrient loading upstream and downstream of WwTWs, but has additionally become used to detect diffuse sources of nutrient enrichment within a catchment.

Organic pollution biotic indices that utilise diatoms and invertebrates indicate on a short timescale owing to how the pollutants might impact on the organism. Macrophytes have a longer life cycle so are more indicative of persistent degradation (Holmes, 2010). An advantage to using macrophytes as a biotic indicator is their comparative ease of survey to data process, compared with diatoms and macroinvertebrates, where sample processing and identification can take some time.

The MTR system was refined over a number of years as a definitive list of taxa suitable for assessing UK rivers. 129 Taxa were listed, including 7 algae, 7 liverworts, 23 mosses, 3 vascular cryptogams and 89 flowering plants (Holmes, 2010). Each species on the list were assigned a Species Trophic Rank (STR) of 1 – 10, depending on its perceived tolerance to eutrophication (1 = tolerant; 10 = intolerant). A survey stretch typical of the reach being studied is identified, of length 100m. The abundance of macrophytes is expressed in terms of the percentage of the survey length covered by each taxon present. A Species Cover Value (SCV) is allocated, according to the percentage abundance, where 1: > 0.1%, 2: 0.1-1% 3: 1-2.5% 4: 2.5-5% 5: 5-10% 6: 10-25% 7: 25-50% 8: 50-75% 9: <75% cover (Holmes, 1999). Multiplying the STR by the SCV gives a Cover Value Score (CVS). Individual SCV and CVS scores are added together and this total is divided by the CVS (Figure 5.15). By multiplying this value by 10, an index from 10 - 100 is realised. This is the MTR value. A low MTR value corresponds to a eutrophic channel.

Generally, surveys of macrophytes are used for conservation assessments of rivers, whilst diatoms are used for water quality. UK water quality is currently assessed using a combination of the two (Holmes *et al.*, 1999).

1. Allocate Species Trophic Rank (STR) Value
2. Allocate Species Cover Value (SCV)
3. Calculate Cover Value Score
    - (CVS = STR x SCV)
4. Add individual SCV and CVS scores together
5. Divide by total CVS score
6. Multiple by 10 to give MTR score.

Figure 5.15 Summary of the Mean Trophic Rank calculation

5.11.2 LEAFPACS2

The MTR and TDI are still in use and provide a foundation on which river quality can be assessed for both macrophytes and diatoms. They have now been modified to provide an assessment process that is appropriate to the Water Framework Directive (Environment Agency, 2013).

LEAFPACS was the second iteration of macrophyte survey which, in addition to having a revised nutrient index, the River Macrophyte Nutrient Index (RMNI), also applied other factors that impact on macrophyte communities. LEAFPACS incorporated an impact value into the overall score that related to the site slope and alkalinity (Environment Agency, 2009). LEAFPACS was used in the first river basin planning cycle. It has now been replaced by LEAFPACS2 which includes an updated species nutrient index, together with measures of diversity and abundance (WFD-UKTAG, 2014c). Modifications have allowed a more cohesive relationship with diatom classifications by focussing macrophytes on eutrophication impacts.

Where available and appropriate, LEAFPACS2 outputs are combined with DARLEQ3 outputs. The overall macrophyte/phytobenthos combined classification is the worst of either of the sub elements (WFD-UKTAG, 2014c).

With regard to measuring the impact of nutrient enrichment on river plants, the macrophyte and phytobenthos assessment methods both respond to nutrient enrichment and so help identify where eutrophication is a problem. Under some circumstances, a reliable assessment of the impact of nutrient enrichment on plants can be obtained using either of the assessment methods. The diatom assessment method can be used on its own if mean alkalinity is <75 mg $CaCO_3$ L^{-1} and the macrophyte method can be used on its own if mean alkalinity is >200 mg $CaCO_3$ L^{-1} However, it is recommended that both assessment methods are used wherever possible, as they each give insights into separate aspects of ecosystem functioning (UKTAG, 2013a).

By assessing the diversity and abundance of macrophytes within the river, an indication of nutrient status can be determined (Holmes, 1999 and 2010). Developed as a part of monitoring requirements for the EU Urban Wastewater Directive, macrophyte monitoring is now one of the established monitoring tools to assess compliance under the WFD.

5.11.3 Macrophyte survey methodology

Aquatic macrophyte surveys were undertaken in June 2018 and July 2019. In June 2018, a 50 m survey stretch was measured from the discharge upstream. From the top of the reach, the survey stretch was subdivided into 5m sections. Within each of these sections, 3 randomly selected measurements were generated to selected transects across the river. Along these transects, a 0.5 m^2 quadrat was used to identify all species at 1) left bank, 2) mid channel and 3) right bank. Conductivity, water temperature pH, depth, dissolved oxygen suspended solids and turbidity were measured at the top and bottom of the reach. Bed structure was assessed on a scale of 1 to 10, where 1 represented silt and 10 represented boulder / bedrock. In July 2019, two 50 m stretches were surveyed: one from 50 m above the discharge and the second from the discharge, 50 m downstream. During the survey, macrophytes were identified to species where possible or samples were collected for further analysis in the laboratory.

Historic macrophyte survey data were downloaded from Freshwater river macrophyte surveys (Biosys). For the River Inny, data were available for St Clether Bridge and upstream of Two Bridges. Macrophyte surveys are resource heavy and consequently are undertaken on a low frequency, with the historic data sets only available for 2011, 2013 and 2014. The St Clether data set was transcribed into the LEAFPACS2 (WFD-UKTAG, 2014c) calculator, downloaded from http://www.wfduk.org/resources/rivers-macrophytes to generate metrics used in WFD compliance monitoring.

5.11.4 Aquatic macrophyte results

Focusing on channel characteristics and using the data collected in the 2019 survey, a principal component analysis was performed using Minitab 19, which showed the factors from where most variation in the data has come. A score plot (Figure 5.16) was produced showing scores of the first factor plotted against the scores of the second factor. The plot shows distinct upstream / downstream clustering in the data, with upstream values exhibiting a higher score for both the first and second components. Within the analysis, 15% of the variation is explained by the first and second components; however, this does not distract from the clear up and downstream separation of the data points.

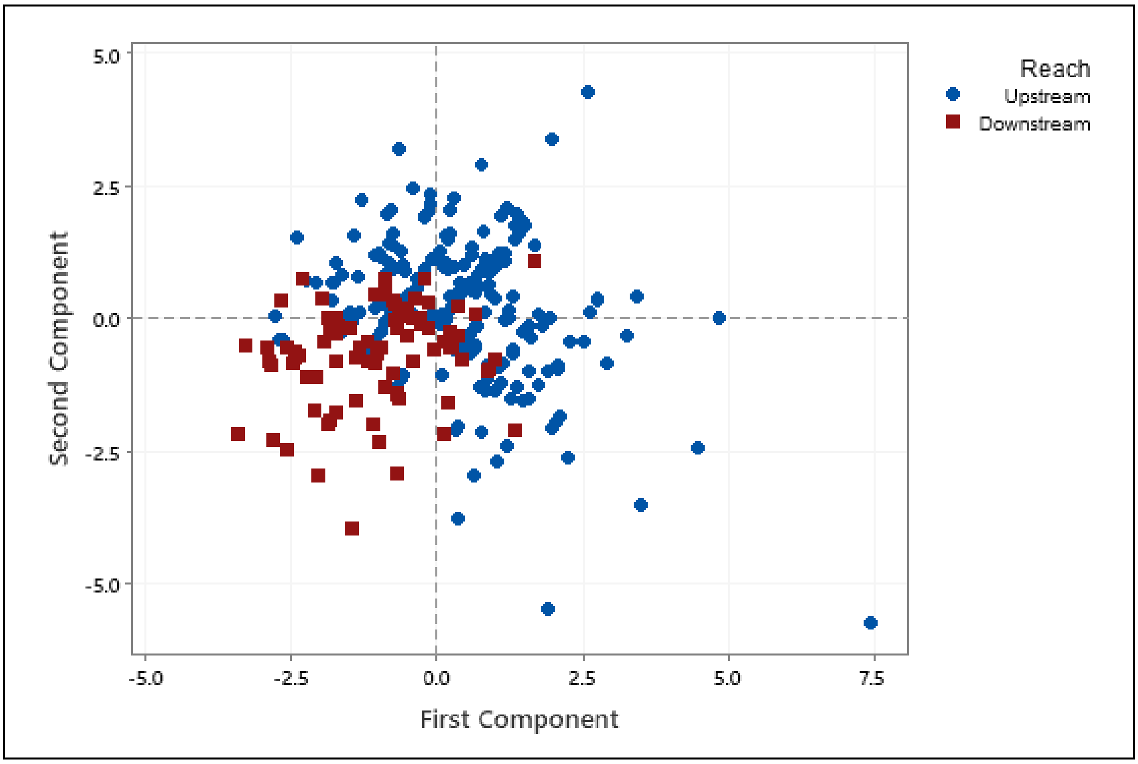


Figure 5.16 Principal component ordination score plot of macrophyte species assemblages from 2019 survey. All species, together with slope, coarseness of bed score and percentage coverage were included. First and second components account for 15% of variability.

The loading plot (Figure 5.17) describes which variable has largest effect

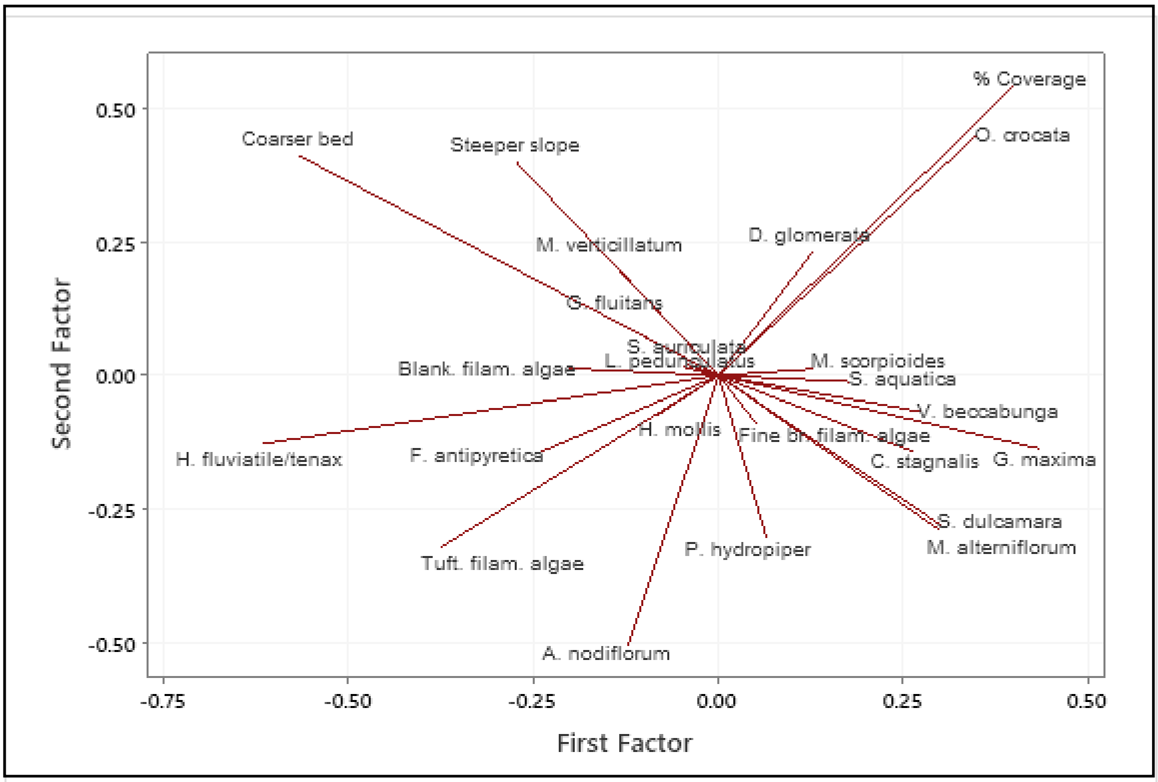


Figure 5.17 Loading plot showing relationships between macrophyte species, percentage coverage and environmental variables (slope and bed score).

on the factors. Figure 5.17 shows (left hand side of the plot) that the benthic macrophytes e.g. *Hygroamblystegium fluviatile/tenax*, *Fontinalis antipyretica* were more consistently associated with the sample locations with a steeper slope and coarser bed material. These were seen to differ upstream and downstream of the discharge, where the upstream reach had a lower bed score (tending towards silts) and lower slope, whilst below the discharge, generally the reach had a higher bed score (coarser bed) and was steeper. Figure 5.17 shows (right hand side of plot) that the dense high coverage of the more highly competitive marginal aquatic species, e.g. *Oeanthe.crocata*, *Glyceria maxima, Veronica beccabunga* were more typically associated with slower flow and a finer bed material. These sample locations occurred upstream of the discharge point

The quality status of aquatic macrophytes is determined under the WFD using the LEAFPACS2 model, which calculates expected values for the River Macrophyte Nutrient Index (RMNI), NTAXA, the Number of Functional Groups (NFG) (WFD-UKTAG, 2014c) and returns the Ecological Quality Ratio (EQR). A final EQR value is translated into the appropriate WFD quality class.

Historic macrophyte data for St Clether were interrogated in an attempt to see how macrophyte quality may have changed in the longer term (Table 5.13). St Clether is the sampling station from where the Environment Agency (Regulatory Authority) determine macrophyte status for WFD compliance.

Table 5.13 Historic River Inny data inputted to LEAFPACS2 calculator. Contains UKTAG information © UKTAG and database right. Data from data.gov.uk, Open Government Licence. ALG represents the percentage cover of filamentous algae.

Site	RMNI	NTAXA	NFG	ALG	Slope (m km^{-1})	Distance to source (km)	Source altitude (m)	Alkalinity ($CaCO_3$ mg L^{-1})
StClether2011	5.49	14	6	1.0	7.4	8	295	77.5
StClether2013	5.34	14	7	0.55	7.4	8	295	77.5
StClether2014	5.51	14	7	1.0	7.4	8	295	77.5

Source altitude does not appear accurate, when compared with Ordnance Survey map (180 m) and GPS (Garmin etrex) measured altitude for the St Clether Bridge site (167 m). Alkalinity was the mean value used by the Environment Agency as base data from January 1995.

Using the survey data collected during the study, Species Cover Values (SCV) were entered into the River LEAFPACS2 survey metric calculator, downloaded from UKTAG website (http://wfduk.org/resources/rivers-macrophytes) on 1 June 2021. This tool calculates the River Macrophyte Nutrient Index (RMNI), the number of truly aquatic scoring macrophyte taxa (NTAXA), number of functional groups (NFG), where individual taxa are allocated to one of 24 functional groups and the percentage cover of green filamentous algae over the whole surveyed section of the river (ALG) (WFD-UKTAG, 2014c). Output data are displayed in Table 5.14.

Table 5.14 Output data for LEAFPACS2 calculator generated from 2018 and 2019 River Inny macrophyte survey. Contains UKTAG information © UKTAG and database right.

Site	RMNI	NTAXA	NFG	ALG	Slope (m km^{-1})	Distance to source (km)	Source altitude (m)	Alkalinity ($CaCO_3$ mg L^{-1})
US2018	5.9	9	7	0.5	45.06	2.24	256	48
US2019	6.72	7	5	3.8	45.06	2.24	256	48
DS2019	6.71	7	5	1.7	40.34	2.34	256	71
100mUSDS2019	6.65	8	5	1.7	42.44	2.24	256	60

These metrics were entered into the River LEAFPACS2 classification tool, downloaded from the same source, above, to determine the WFD class of the reaches. Survey dates have been plotted against Macrophyte EQRs for both EA Historic data and current survey data (Figure 5.18). (Full LEAFPACS2 model outputs can be found in Appendix 5). Historic data produced macrophyte EQS scores of 0.93 for 2011, 0.97 for 2013 and 0.927 for 2014. All 3 EQS scores represent a 'High' class under WFD scoring. The 2018 survey for US returned a 'Good' classification whilst overall, the WFD classification for the River Inny at the US / DS sampling point is 'Moderate' This has been modelled on data that has been replicated from the relevant survey reach (US/DS) in order to achieve the 100 m survey reach length utilised in RIVPACS. The final site classification is returned as 'Moderate', with a confidence score of being that class of 76.6.

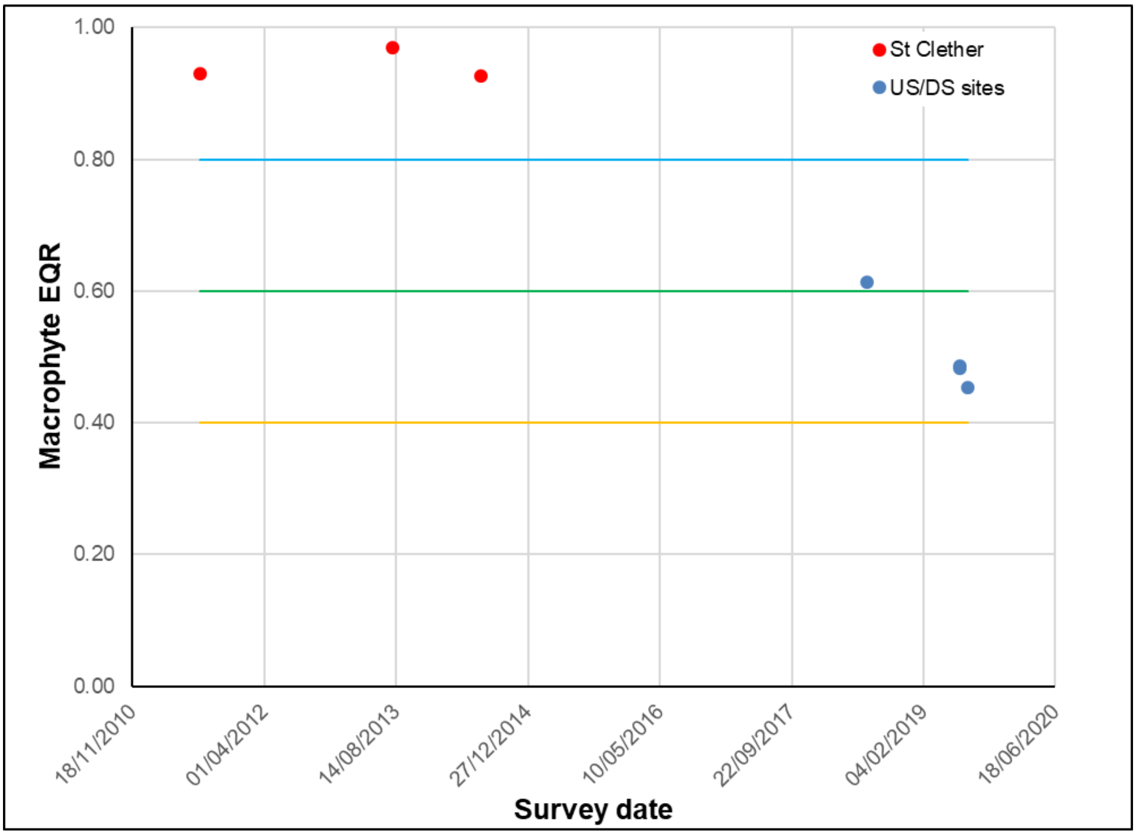


Figure 5.18 Historic and current Macrophyte EQRs. Red dots represent the EA historic data from St Clether Bridge survey. Blue dots represent current survey data from Upstream site (top blue dot) US/DS combined (middle blue dot) and Downstream site (bottom blue dot), WFD Boundary status classes are represented by the horizontal coloured lines, where top line, blue = 'High/Good status boundary, 2nd line, green = 'Good/Moderate status boundary, 3rd line, orange = 'Moderate/Poor status boundary. Macrophyte EQR boundary status values taken from (WFD-UKTAG, 2014a).

5.12 Discussion

The following section brings together the data from the three metrics engaged to monitor the ecology of the River Inny within this study.

5.12.1 Freshwater Invertebrates

Environment Agency data, referred to in this report as historic, did not cover the same spatial or temporal distribution, but at the Two Bridges River Inny site for 2017, the minimum and maximum, classes were ‘High’ and had been for several survey periods (Table 5.10). The modelled EA historic data set (Tables 5.8 and 5.10) cover a survey period across twenty-seven years but only use a limited number of data points of physical site characteristics; parameters such as channel bed composition, alkalinity and flow, from which modelled metrics are generated. St Clether covers a period of 10 years of survey but only one set of physical site characteristic data to inform the model. This questions the reliability of the modelled data when local changes to conditions, especially bed composition would be expected in a shorter time period. A varied bed composition will influence the expected invertebrates through the diversity in physical habitat.

Summarising the invertebrate data across the years and seasons of this study, Table 5.15 gives the minimum and maximum WFD classes derived. The classes throughout 2019, the last year of sampling were ‘Good’ whereas the lowest quality class was for the survey following the summer 2018 pollution incident. Recovery was seen in the scores of the following seasonal surveys. This suggests a good rate of recovery following the impact of the pollutants on the invertebrate community. Recovery of invertebrate communities has been monitored by the UK Citizen Science project Angler’s Riverfly Monitoring Initiative (ARMI). Trained anglers monitor counts of specified invertebrates and their data correlates well with the BWMP scoring metric.

Extensive baseline data allows recovery post incident to be monitored and they observed numbers of *G. pulex*, Ephemeroptera and Trichoptera to have returned to pre-incident levels after two months, with the abundance of both Ephemeroptera and Trichoptera recovering more quickly than *G pulex* (Brooks *et al*., 2019).

Table 5.15 Final Water Framework Directive classes for freshwater invertebrates at Upstream, Downstream and Trewinnow Bridge, 2017- 2019

Site	Lowest class	Highest class
Upstream	Moderate	High
Downstream	Bad	Good
Trewinnow Bridge	Bad	Good

Under the WFD (WFD Annex V, 1.4.2 (i)), the approach of 'one out, all out' is followed, where by the worst quality of any of the biological quality elements used in the assessment, regulates the overall ecological status of a waterbody (Carvalho *et al*., 2019; Latinopoulos *et al*., 2021). Figure 5.19 shows the site specific phosphorus EQS at the Upstream and Trewinnow Bridge sites (vertical green dash line), together with the Environmental Quality Index WFD class boundaries for freshwater invertebrates (horizontal lines). The data shows a spread above the invertebrate 'Moderate/Poor' status boundary, and either side of the P EQS of 30 µg L^{-1}.

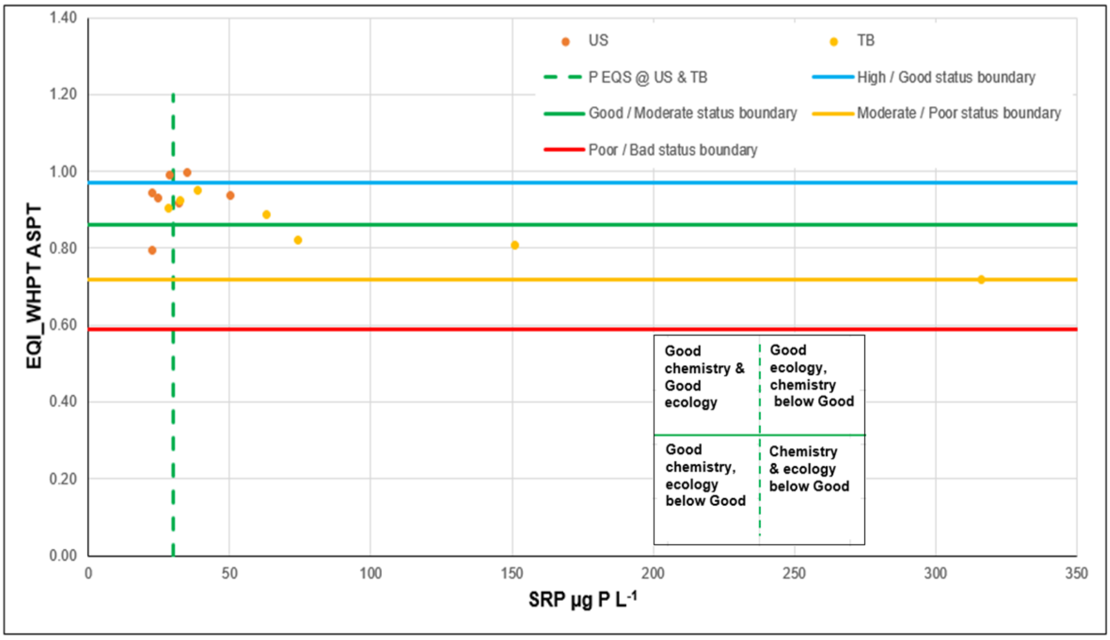


Figure 5.19 Soluble reactive phosphorus concentrations for Upstream and Trewinnow Bridge plotted against the EQI WHPT ASPT. Vertical green dashed line represents the site specific EQS for phosphorus at upstream and Trewinnow Bridge sites. Blue, green, yellow and red horizontal lines represent the WFD status boundaries for the EQI WHPT ASPT.

The chart shows that of 13 data points, 5 exceeded the 'Good/Moderate' class boundary for phosphorus (i.e. < 30 µg L^{-1}) and 10 exceeded 'Good/Moderate' class boundary for freshwater invertebrate WHPT ASPT score. Yet just 4 data points exceed the 'Good/Moderate' boundary for both ecology and chemistry.

5.12.2 Diatoms

Seven records with a quality status of 'Good' or above were determined from historic Environment Agency diatom data. These were from Autumn 2014 and Summer 2016 at St Clether Bridge, Spring 2014 and Summer 2016 at Two Bridges Inny and Spring, Summer and Autumn 2016 at Penpont Water at Two Bridges in 2016 which classified as 'High' status.

Table 5.16 Final Water Framework Directive classes for freshwater diatoms at Upstream, Downstream and Trewinnow Bridge, 2017 – 2019

Site	Lowest class	Highest class
Upstream	Moderate	High
Downstream	Moderate	High
Trewinnow Bridge	Moderate	High
St Clether Bridge	Moderate	High

Across the study period, diatom samples ranged from ‘Moderate’ to ‘High’ (Table 5.16), with the ‘High’ classes occurring for samples at the end of the monitoring period and the ‘Moderate’ classed samples occurring in summer. The 2017 sampling of US, DS and TB sites all contained a % of organic tolerant valves in excess of 20, which (Kelly, 1998) suggests as being indicative of a floral community influenced by nutrients and tolerant to organic pollution. That said, those sites returned WFD classes of ‘High’, ‘Good’ and ‘High’, respectively. Historic values for % organic tolerant valves recorded further upstream at Inny Vale were up to 3 times higher, suggesting that the communities are becoming less dominated by nutrient tolerant species. Further nutrient stress is observed in the floral composition DS of the outfall in summer, when dilution of the discharge is lower. % Saline tolerant valves would be expected DS of the discharge which has high concentration of Na, K and Cl. They are more apparent but also occur upstream (12 % Saline tolerant valves in Summer 2019 compared with 26.9% DS and 46.4% at TB and 21.5% at StC).

The relationship between SRP concentration and EQR TDI5LM is illustrated in Figure 5.20. Diatom samples across the monitoring period are presented from the Upstream (red dot) and Trewinnow Bridge (purple dot) sites. These two sites share the same concentration of RP for their site specific EQS. Points above the horizontal green line indicate 'Good' status of diatom community (above 0.8 indicates a 'High status). Points to the left of the green dashed line (<30 µg L^{-1}) indicate communities of diatoms at 'Good' status concentration of RP. Plotting TRP data for the same sites (Figure 5.21), instead of SRP compares concentrations of RP with the EQR which was developed using measurements of RP that were most likely unfiltered (the norm at the time) (Goddard *et al*., 2020), but discussed as 'molybdate-reactive P ≡ filterable reactive phosphorus (FRP) ≡"orthophosphate" in the literature (Kelly, 2001).

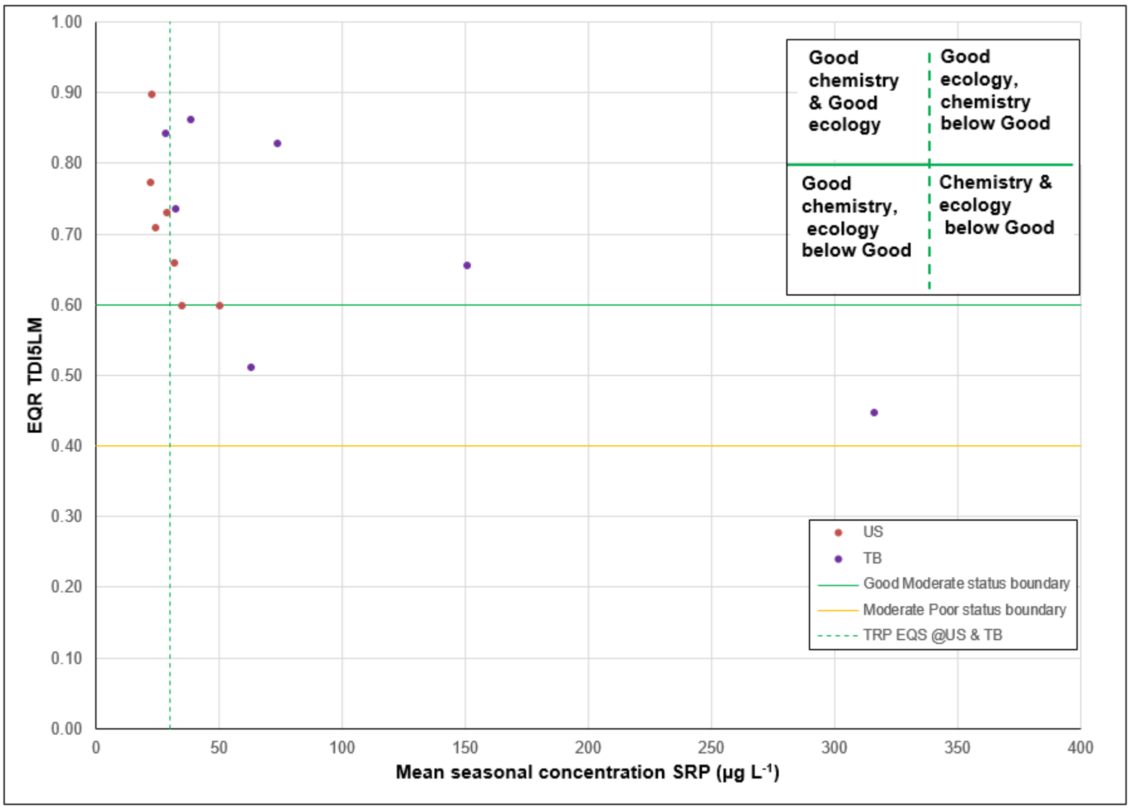


Figure 5.20 Mean concentration of seasonal Soluble reactive phosphorus and EQR TDI5LM at Upstream (red dot) and Trewinnow Bridge (purple dot) sites. Green horizontal line represents the 'Good/Moderate' status and yellow horizontal line represents the 'Moderate/Poor' status boundaries for diatoms. Green dashed vertical line represents 'Good/Moderate' status boundary for reactive phosphorus. Inset box interprets the chart in relation to WFD statuses.

Comparison of Figures 5.20 and 5.21 show that for both SRP and TRP the sites exhibit similar pattern of EQR TDI5LM values, with two results (both Trewinnow Bridge) failing to reach 'Good' status for diatoms and two (both upstream results) sitting on the 'Good/Moderate' boundary. As expected, the TRP concentrations are higher than SRP and only two results (upstream) lie below the 'Good/Moderate' status boundary. The chart of SRP concentrations show 5 values below the boundary.

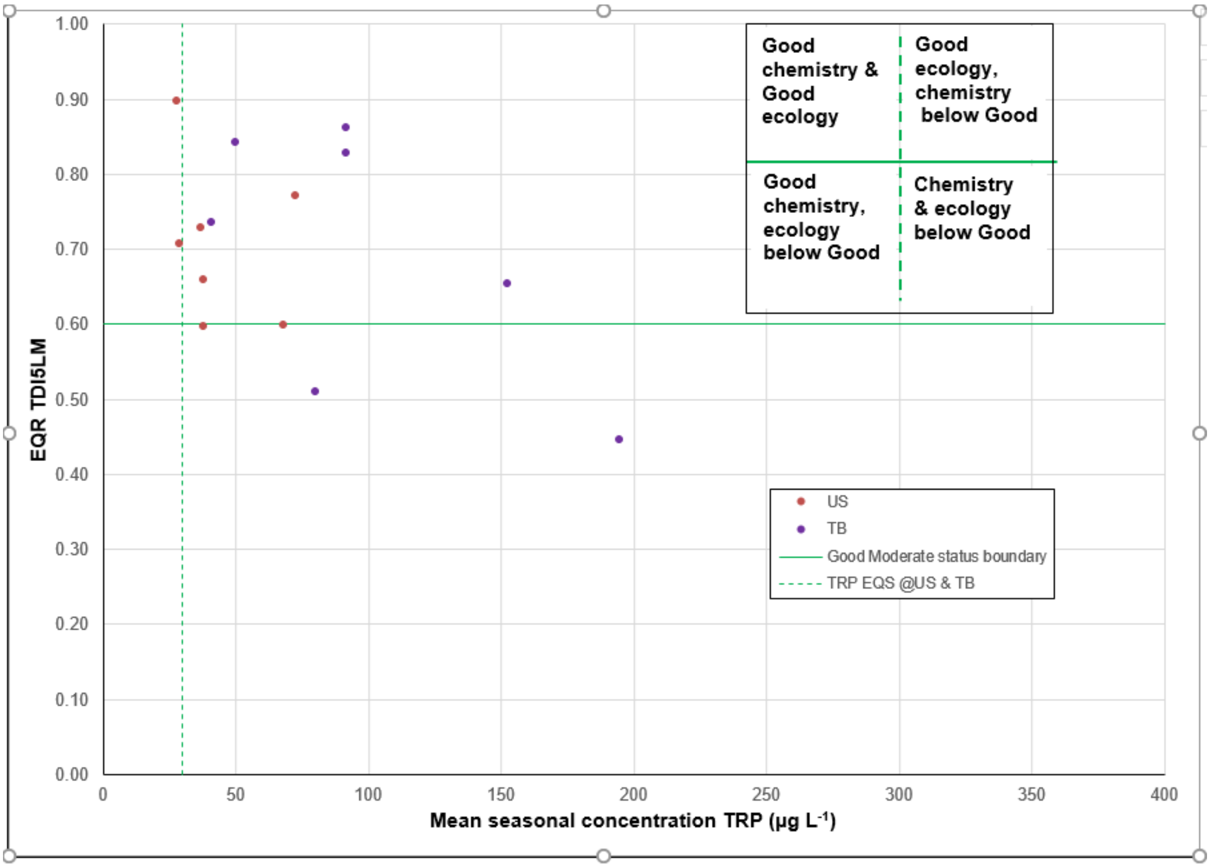


Figure 5.21 Mean concentration of seasonal Total reactive phosphorus and EQR TDI15LM at Upstream (red dot) and Trewinnow Bridge (purple dot) sites. Green horizontal line represents the 'Good/Moderate' status boundary for diatoms. Green dashed vertical line represents 'Good/Moderate' status boundary for reactive phosphorus. Inset box interprets the chart in relation to WFD statuses.

In Figure 5.22, upstream diatom samples were determined as having a TDI5LM score below 60, where a TDI5LM score of 0 would represent very low nutrients and 100 very high nutrient concentrations. Corresponding mean seasonal SRP concentrations for the upstream site ranged 23 to 50 µg P L^{-1}. The DS and TB samples follow similar patterns in both TDI5LM score and concentrations of SRP, with a higher TDI5LM score and higher SRP concentrations (DS range 33 to 390 µg P L^{-1}, TB range 28 to 316 µg P L^{-1}). However, at St Clether Bridge, the highest TDI5LM scores are seen with SRP concentrations more comparable with the US site.

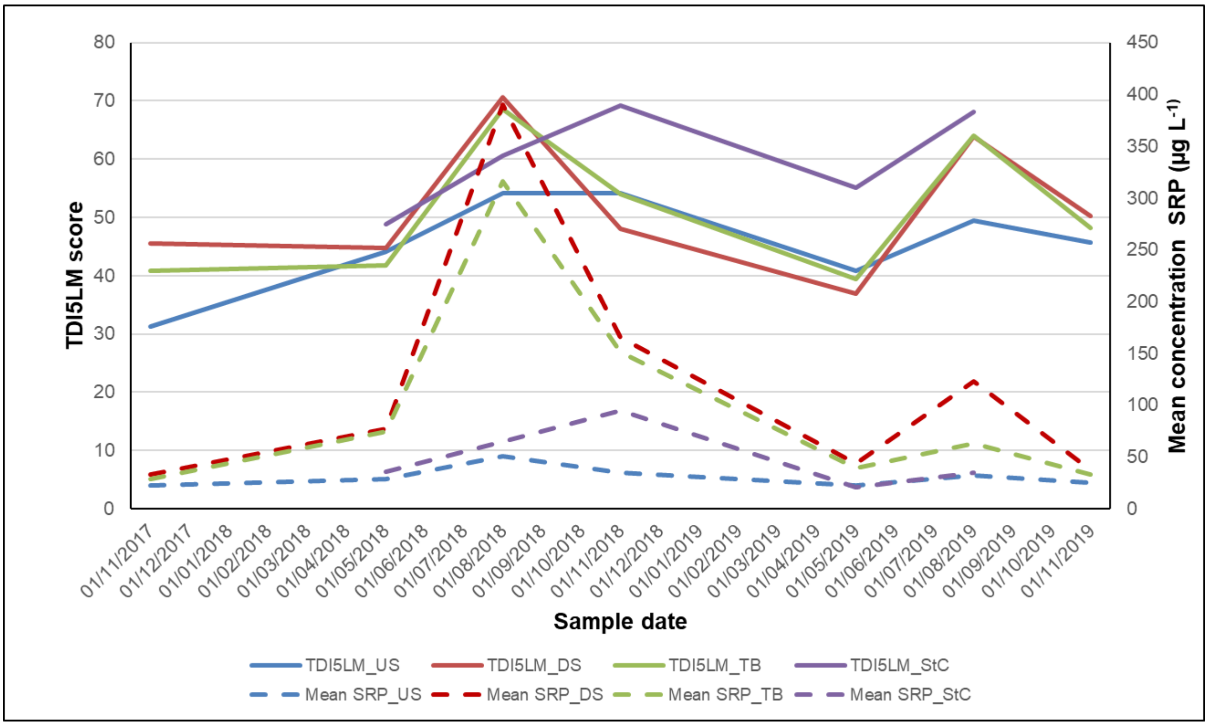


Figure 5.22 TDI5LM scores (primary y-axis) and mean seasonal Soluble reactive phosphorus concentrations (secondary axis). Solid lines show the TDI5LM scores whilst dashed lines show mean seasonal Soluble reactive phosphorus concentration. Blue = US, upstream of discharge; Red = DS, downstream of discharge; Green = TB, Trewinnow Bridge and Purple = StC, St Clether Bridge.

This low SRP concentration with high TDI5LM for St Clether Bridge illustrates how TDI5LM is not solely linked to nutrient enrichment from SRP. It should be noted that the US, DS and TB sites all share similar open environments without any tree cover, whereas the StC site is partially shaded, hence photosynthetic efficiency might be impacted.

5.12.3 Macrophytes

Historic data analysis at St Clether shows the macrophyte community assessed using LEAFAPCS2 being of ‘High’ quality, with a high level of confidence (2011, 2013 and 2014).

Table 5.17 Final Water Framework Directive classes for macrophytes at Upstream and Downstream sites, 2018-2019

Site	Lowest class	Highest class
Upstream	Moderate	Good
Downstream	Moderate	Moderate

Macrophyte surveys took place over two seasons and produced a limited data set. From this the suggestive WFD classes (Table 5.17) returned were ‘Moderate’ as the lowest class for Upstream and ‘Good’ for the highest class. At the Downstream site, quality was determined as consistently ‘Moderate.’

Like invertebrates and diatoms, there is an inconsistency in status class between chemistry and ecology. In Figure 5.23, macrophyte EQRs are plotted against (unfiltered) orthophosphate concentration. Data points all lie above the ‘High’ class macrophyte EQR boundary but none are above the ‘Good’ EQS for reactive phosphorus, with 2 of the 3 points falling below the ‘Moderate’ threshold.

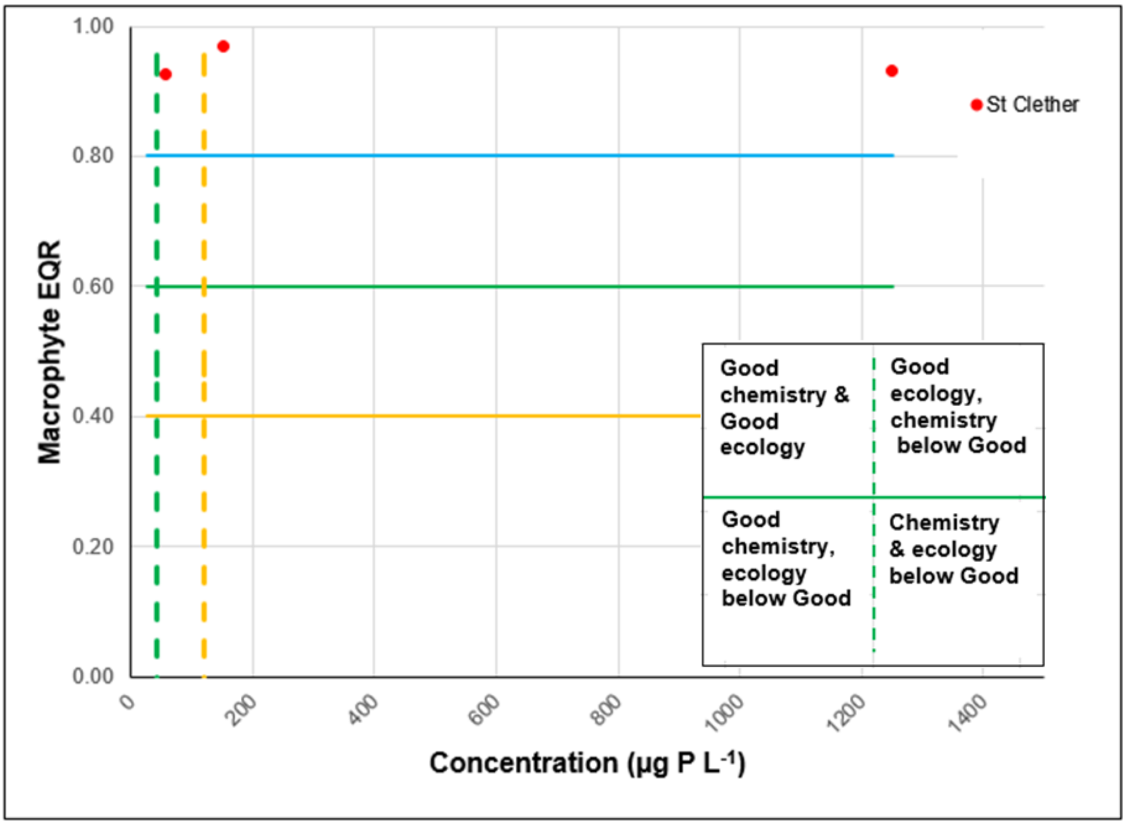


Figure 5.23 St Clether Bridge: Concentration of phosphorus as (unfiltered) orthophosphate plotted against macrophyte Ecological Quality Ratio. Horizontal colours represent WFD EQR classes for macrophytes; blue = 'High' class, green -= 'Good' and yellow = 'Moderate' Vertical dashed lines represent St Clether WFD EQS class for RP. reported against EA (un-filtered) orthophosphate data

Similarly, in Figure 5.24,'Good' WFD status does not marry for nutrients (phosphorus) and macrophytes. For the upstream survey, no data points fit in to the zone of good chemistry and good ecology, with one point exceeding good for ecology but less than good for chemistry, whilst the other data point falls in the zone where chemistry is good but ecology is approaching the 'Moderate/Poor' boundary. For illustration, the downstream data point is included for comparison with the macrophyte EQR. As it is a different site, the vertical EQS for phosphorus should not be applied.

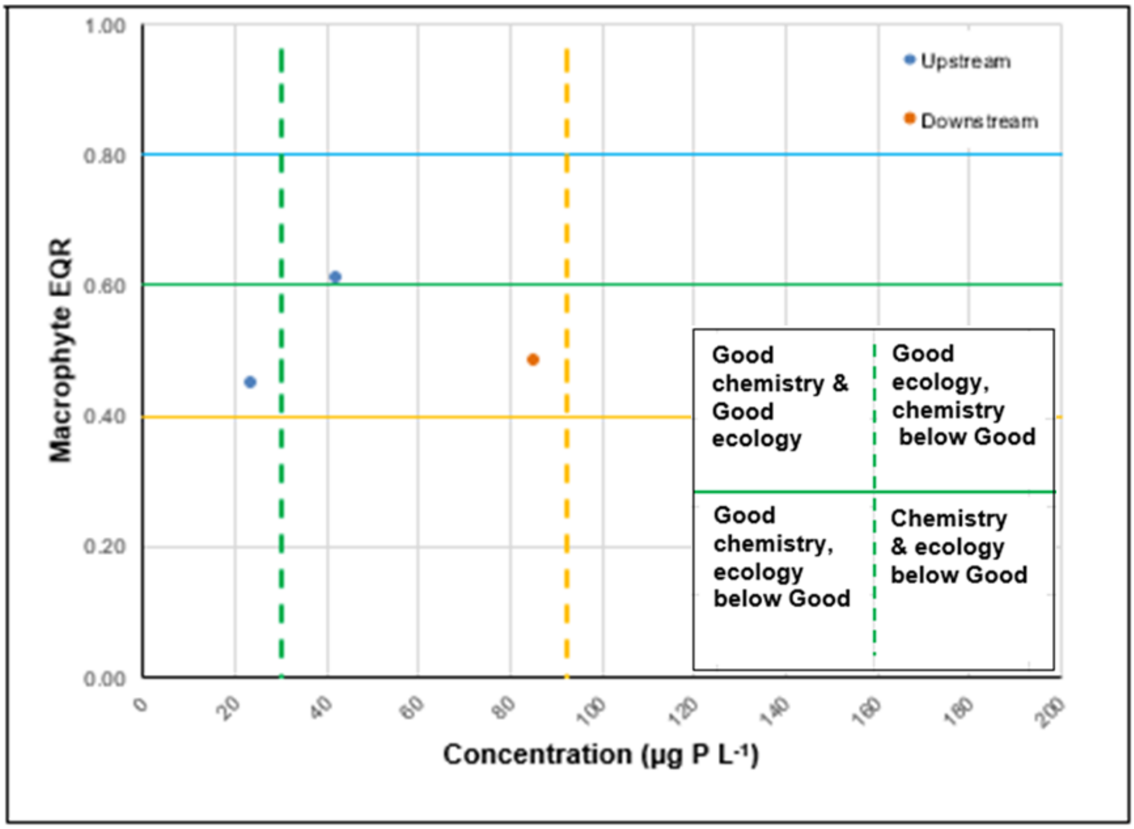


Figure 5.24 Water Framework Directive EQR classes for macrophytes and associated phosphorus EQS. Horizontal colours represent WFD EQR classes for macrophytes, Vertical dashed lines represent Upstream WFD EQS class for RP reported against measured Soluble reactive phosphorus data. Downstream EQS for P =41 µg L^{-1} (Good) and 116 µg L^{-1} (Moderate)

Within a river, macrophytes perform many functions, including habitat provision for fish and invertebrates. Structural diversity of the macrophyte community provides added habitat diversity for invertebrates (Holmes, 1999). The LEAFPACS2 method has been designed to reflect the impact on river macrophytes of nutrient enrichment, but may also be sensitive to other factors such as alterations in river flow and changes to morphological conditions of the channel (WFD-UKTAG, 2014c). Such metrics are subject to continued review of their effectiveness and suitability. Demars *et al*., (2012) questioned LEAFPACS suitability due to the metrics used as it was a multi-metric method which summed up five individual WFD compliant indices. Individual metrics were not better correlated with nutrient and hydro-morphological pressures than other models (e.g. Macrophyte Biological Index for Rivers). Macrophyte indices are more suited to detecting pressures from a large population of sites, rather than specific sites as requested under the WFD. Typically more than 90% of the variability in macrophyte indices is attributed to factors other than human pressures. The modification of LEAFPACS to LAFPACS2 dropped the hydraulic index metric which looked at substrate, depth and stream energy This modification improved the relationship of the macrophyte metric (LEAFPACS2) with diatom metric (DARLEQ2) (UKTAG, 2014a).

Each of the biotic models used within this study require alkalinity data. Alkalinity is used widely as a predictor of chemical and biological water quality standards in rivers under the WFD. The presumption that the concentration of alkalinity within a river system is a function of weathering of rocks might be acceptable in a pristine river system, but anthropogenic inputs from e.g. sewage / industrial sources, agricultural runoff, challenge this assumption (Tappin *et al*., 2018). The mean alkalinity over the study period, derived from Ca concentration was 47.5 mg L^{-1} at US, 71 mg L^{-1}, DS and 68 mg L^{-1} at TB. Hence an anthropogenically sourced increase in alkalinity downstream of the discharge of approaching 66%. At St Clether Bridge, historic data from the Environment Agency measure alkalinity at 94 mg L^{-1}, as $CaCO_3$ (n=95, sample period = 2000 to 2003, 2011 to 2019), whereas this study determined a concentration of 53 mg L^{-1} at St Clether Bridge. This leads to concern in the use of biotic modelling, for example with the TDI, where the trophic diatom index was predicted at reference sites based on alkalinity (Kelly *et al*., 2008), and alkalinity data are required as a predictor of the reference condition for the DARLEQ2 EQR (WFD-UKTAG, 2014c). However, as (Kelly *et al*., 2008) points out, there are few sites truly independent of all human pressures and alkalinity allows better predictions than other variables investigated in defining the model. A slight alteration to alkalinity by human activities would not cause disadvantage in predictions, nonetheless, care should be taken to establish that anthropogenic modifications are not detrimental to the running of the model.

Alkalinity concentrations (inc. influenced) determined within this study were < 75 mg L^{-1} $CaCO_3$. Alkalinity measured for the determination of the EA historic macrophyte data was 77.5 mg L^{-1} $CaCO_3$. In terms of establishing water quality assessments, analysis undertaken for UKTAG (UKTAG, 2013a) found that a DARLEQ2 based assessment would give a reliable classification if alkalinity is < 75 mg L^{-1} CaCO3. For higher alkalinity concentrations, a LEAFPACS2 based assessment alone is adequate at >200 mg L^{-1} $CaCO_3$. (UKTAG, 2013a).

5.12.4 Concluding comments

Overall, the water quality observed during this study with regard to freshwater invertebrates has improved since the start of the monitoring period. Quality is now more stable, showing a 'Good' class of freshwater invertebrate. Historic data suggests that the quality has deteriorated slightly as those records contain more assessments of a 'High' quality community. The latest Environment Agency monitoring report for the River Inny also classes the freshwater invertebrate community as being of 'High' quality (assessed at St Clether Bridge for the catchment). With regard to the diatom quality status, direct comparison is not possible owing to the low frequency of sampling at St Clether (n=2). However observation of the historic and current TDI5LM classes, suggests more communities of 'Good' or 'High' status in the current than the historic data sets. The Environment Agency's Catchment Explorer shows a classification of 'Moderate' for combined macrophytes and phytobenthos for the years 2013, 2014, 2015, 2016 and 2019. Within the cycle one report, for the period 2009 to 2014, each year had a separate grading for macrophytes and phytobenthos, the latter being classed as 'Moderate' for each, whilst macrophytes were graded as 'High' for 2010 to 2012, 'Good' in 2013 and 'High' in 2014.

To conclude, the overall site specific ecological quality for the River Inny is presented in Table 5.18 with the final biological standards and resulting ecological status. Using the precautionary principle, this takes the worst case as the determinant of the quality class (Carvalho *et al*., 2019; Latinopoulos *et al*., 2021).

Table 5.18 Final ecological quality classification of River Inny study sites determined from 2017 - 2019 survey data

Site	Freshwater Invertebrates	Diatoms	Macrophytes	WFD class
Upstream	Moderate	Moderate	Moderate	Moderate
Downstream	Bad	Moderate	Moderate	Bad
Trewinnow Bridge	Bad	Moderate	Not available	Bad
St Clether Bridge	Not available	Moderate	Not available	Moderate

Caution should be employed in the interpretation as the 'Bad' status for both Downstream and Trewinnow Bridge relates to the post pollution event survey and subsequent surveys yielded a status of 'Good' over a 12 month period.

6 Ecotoxicology

6.1 Introduction

This chapter introduces chemical risk assessment and some of the possible effects of chemicals on biota of the river. Chemical pollution is one of the major threats to global freshwater biodiversity (Dudgeon *et al*., 2006). The adverse biological impacts of chemical pollution are exacerbated through changes in temperature and rainfall patterns, acid–base chemistry, and reduced freshwater availability due to climate change (Pinheiro *et al*., 2021; Canedo-Arguelles *et al*., 2016). This is a major challenge for protecting biodiversity in UK rivers (Johnson *et al*., 2009; Wilby *et al*., 2010).

Many human activities, including agriculture, mining, waste water treatment and industrial discharges can increase the total concentration of dissolved inorganic salts in freshwaters (Canedo-Arguelles *et al*., 2016; Griffith, 2017). Yet water quality legislation that targets salinity tends to focus on drinking water and irrigation and does not automatically protect biodiversity (Canedo-Arguelles *et al*., 2016). In Europe, for example the Water Framework Directive seeks to address this critical issue by use of the Environmental Quality Standards for a wide range of chemical contaminants (Crane & Babut, 2007; European Commission, 2018).

The scientific environmental assessment of natural and synthetic chemicals needs to address exposure pathways integrated with information on their short term (acute) and long-term (chronic) hazardous properties. Where environmental exposure concentrations are below the biologically adverse concentrations for a chemical, this is termed a contamination (Chapman, 2007). Environmental quality standards for inorganic and organic chemicals are one management tool used to minimise chemical risks to ecosystems and to avoid indirect human health problems (eg food webs pollution by Persistent Bioaccumulative and Toxic (PBT) chemicals). However, of the 5000 new high-production volume chemicals synthesised since the 1950s, it is estimated that less than 50% have undergone robust environmental safety assessments (Pinheiro *et al*., 2021). The situation is even more challenging when addressing the risks of multiple environmental stressors (eg climate change) (Johnson *et al*., 2009; Pinheiro *et al*., 2021; Wilby *et al*., 2010).

One key aspect of water quality protection relating to chemical contamination relates to salinisation. In contrast to extensive risk assessments for inorganic trace metals, our scientific understanding of mechanisms by which increasing salinisation damages freshwater ecosystems is in its infancy (Canedo-Arguelles *et al*., 2016).

As this study on the River Inny catchment developed, measurements of water chemistry within the catchment showed significant changes in composition from Na, K and Cl concentrations. Invertebrate surveys recorded lower counts of *Gammarus pulex* numbers downstream of the discharge compared to upstream. Based on this, the need to undertake ecotoxicological trials on some of the measured elements within the test river system became apparent. The need was further emphasised as UK waters do not have statutory limits for Na, K and Cl. Ecotoxicology trials were undertaken to determine the 96 hr EC50 of *G. pulex* to Na, K and Cl. The approach taken was consistent with the updated European Commission scientific guidance for developing EQS values (European Commission, 2018).Work contained in this chapter fulfils objectives 4 and 5 of the study (Figure 1.1).

6.2 Ecotoxicology of non-statutory chemicals

Reflecting widespread concern over fish kills due to chemical pollution in many countries, the science of ecotoxicology can be traced back to the June 1969

Committee of the International Council of Scientific Unions (ICSU) in Stockholm. The objective of the developing branch of toxicology was to study the harmful effects to the various constituents of ecosystems of chemical pollution of the environment for which humankind is to a large extent responsible (Truhaut, 1977). Physico-chemical features of natural fresh waters, including pH, temperature, oxygen, carbon dioxide, divalent cations, anions, carbonate alkalinity, salinity and dissolved organic matter, can affect the environmental risk to aquatic wildlife of pollutant chemicals (Pinheiro *et al*., 2021).

With physico-chemical monitoring of ecosystems, this can provide information on chemical contamination, which is the presence of a synthetic chemical where it should not be, or a natural chemical (e.g. trace metals or nutrients) at concentrations above background (Chapman, 2007). Ecotoxicology is able to add value to monitoring activities as it allows the measurement of adverse biological effects. Hence chemical contamination is regarded as a pollutant when its presence results in adverse biological effects to wildlife such as fish, invertebrates and aquatic plants (Chapman, 2007). Increasingly, published evidence suggests that these pollution effects are likely to be exacerbated due to changes in water temperature and atypical rainfall patterns associated with global climate change (Pinheiro *et al.*, 2021). When designing biological methods to measure pollution effects, the route of exposure, life stage, health status and sex of the organism are highly important, together with the ability to metabolise and excrete chemical toxicants (Pinheiro *et al*., 2021).

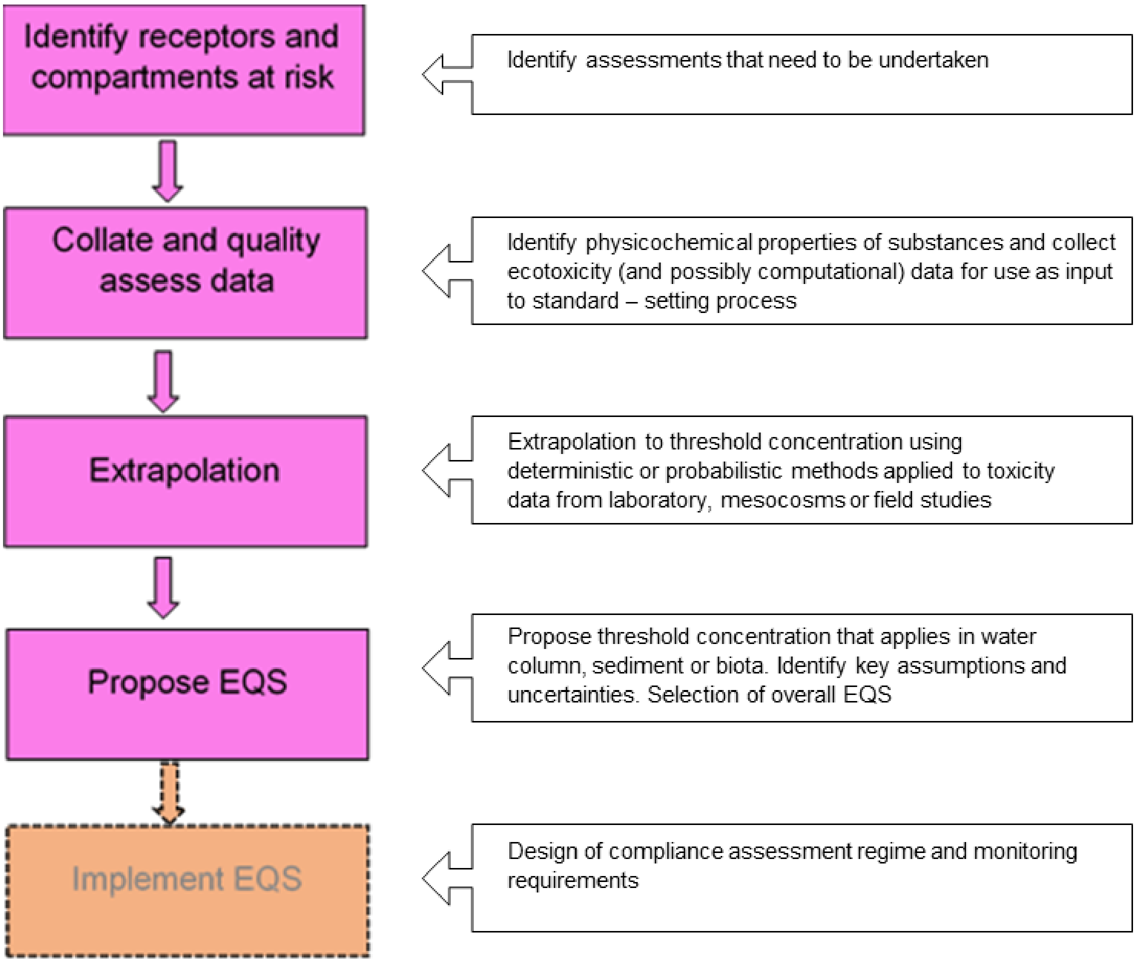


Figure 6.1 Key steps involved in deriving an EQS. Reproduced from European Commission, (2018)

In order to determine the effects of a chemical on biota, the laboratory, tests can be conducted under controlled conditions, to establish at what concentration a substance shows a level of toxicity. This might be acute, or chronic, where an acute test is measured by survival and a chronic test by growth and fecundity (Chapman, 2007). As a result of the laboratory experiments, an effective concentration, EC50 is determined, where 50 percent mortality occurs in a specified time period such as 48 or 96 hours. This forms one of the key steps in determining an EQS (Figure 6.1). The EC50 concentration requires extrapolation to estimate a threshold that takes account of uncertainties such as inter and intra species variations and laboratory to field extrapolation (European Commission, 2018). The factors used to extrapolate are referred to as ‘safety’ or ‘assessment’ factors (Chapman *et al*., 1998; European Commission, 2018) Where an acute test is undertaken and direct measurements are lacking, an acute to chronic ratio (ACR) of 10 is often applied to the EC50 value to predict chronic toxicity (Chapman *et al*., 1998). This assumption allows uncertainty to be included within the data that will mitigate any potential chemical risk, by dividing the acute concentration of the chemical by 10. Further assessment factors can be introduced, for example to adapt from laboratory to field or to account for the presence of more sensitive organisations. Wider detail of the assessment factors used, following an EU review in 2018 are reproduced in Table 6.1. Explanatory notes referenced in the Assessment factor column can be found in Appendix 1.

Table 6.1 Assessment factors to be applied to aquatic toxicity data for deriving an Environmental Quality Standard. Reproduced from (European Commission, 2018)

Available data	Assessment factor
At least one short-term L(E)C50 from each of three trophic levels (fish, invertebrates (preferred *Daphnia*[2]) and algae) (i.e. base set)	1000 [a)]
One long-term EC10 or NOEC (either fish or *Daphnia*)	100 [b)]
Two long-term results (e.g. EC10 or NOECs) from species representing two trophic levels (fish and/or *Daphnia* and/or algae)	50 [c)]
Long-term results (e.g. EC10 or NOECs) from at least three species (normally fish, *Daphnia* and algae) representing three trophic levels	10 [d)]

[2] “Daphnia” is generally used to mean small crustaceans

Available data	Assessment factor
Species sensitivity distribution (SSD) method	5-1 (to be fully justified case by case) [e)]
Field data or model ecosystems	Reviewed on a case by case basis [f)]

However, further challenges in extrapolating between chemical effects from laboratory-based exposures and wildlife populations relate to possible differences across the life stages of the animals used, the limited concentration ranges normally tested and the interaction of other contaminants (Pinheiro *et al*., 2021) that might be found outside of the laboratory controlled testing environment. Through the ecotoxicological trial, a predicted no-effect concentration (PNEC) and predicted environmental concentration (PEC) can be determined. The PNEC is derived by applying the assessment factor to the EC50. The ecotoxicology assessment and determination of PEC and PNEC are elements of a suite of available risk assessment tools. It should be stated that an EQS is a legally binding limit value, whilst a PNEC is one of the suite of risk assessment tools (Godoy *et al*., 2018).

Within industry, agreed permits to discharge will state an EQS which is a legally binding concentration. This concentration is the level that when not exceeded, will not change the ecological function or community structure of the water body (European Union, 2000). If the EQS is exceeded, then the water body will be classified as ‘not achieving good status’.

Increasing salinity or ionic strength can have adverse effects on the environment, including a reduction in freshwater biodiversity. Despite this, scientific understanding of mechanisms by which increasing salinisation damages freshwater ecosystems is in its infancy (Canedo-Arguelles *et al*., 2016). Salinity can be increased by the addition of a host of different ions resultant of different activities (Table 6.2).

Table 6.2 Dominant ions associated with different anthropogenic sources of salts, reproduced with modification from Griffith, (2017).

Source	Dominant ions	Reference
Use of salt to melt ice and snow	Na^+, Cl^-, Ca^{2+}, Mg^{2+}	Forman & Alexander (1998); Kaushal *et al*. (2005); Kelting *et al*. (2012)
Weathering of concrete in urban drainage systems	K^+, Ca^{2+}, HCO_3^-	Davies *et al*. (2010); . Wright *et al*. (2011)
Produced water from traditional oil and gas production	Na^+, Cl^-, SO_4^{2-}	Boelter *et al*. (1992); Veil *et al*. (2004)
Produced water from coalbed methane production	Na^+, HCO_3^-, Cl^-,	Jackson & Reddy (2007); Brinck *et al.* (2008); Dahm *et al*. (2011)
Flowback and produced water from shale gas production (fracking)	Na^+, Cl^-, Mg^{2+}, Ca^{2+}, Br^-	Entrekin *et al*. (2011); Haluszczak *et al*. (2013)
Runoff and effluents from traditional coal mining	SO_4^{2-}, Na^+, Cl^-, Ca^{2+}, Mg^{2+}, K^+	Kennedy *et al*. (2003)' (Hopkins *et al*. (2013)
Runoff from valley fills associated with mountaintop mining	Ca^{2+}, Mg^{2+}, HCO_3^-, SO_4^{2-}	Griffith *et al*. (2012)
Coal combustion residue effluents	Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}	Ruhl *et al*. (2012)
Irrigation runoff	Na^+, Mg^{2+}, Cl^-, F^-, SO_4^{2-}	Leland *et al*. (2001); Scanlon *et al*. (2009)
Anthropogenic increases in geothermal weathering	Ca^{2+}, HCO_3^-, SO_4^{2-}	Raymond & Oh (2009); Kaushal *et al*. (2013)
Industrial sources (inc food production)	Na^+, Cl^-, K^+, Ca^{2+}, Mg^{2+}	Echols *et al.* (2009)
Wastewater treatment plants	Na^+, Cl^-, K^+, SO_4^{2-}	Andersen *et al.* (2004); (Hur *et al*. (2007); Gardner et al. (2012)
Agricultural sources from crops and livestock	Na^+, Cl^-, K^+, Mg^{2+}, SO_4^{2-}, Ca^{2+}, HCO_3^-	(Evans et al., 2019); Mateo-Sagasta *et al*. (2017)

6.2.1 Ecotoxicological effects of sodium

Freshwater salinisation, defined as an increase in concentration of major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, and $HCO_3^-/CO^2{}_3^-$) is now recognised as one of the top stressors on freshwater biodiversity (Cañedo-Argüelles *et al*., 2013; Po & Wood, 2021). Since Na^+ is often considered relatively non-toxic, historically there has been more emphasis on the anions than on the cations (Po & Wood, 2021). Salinisation can affect organisms in different ways, from increasing stress, to causing outright mortality and impacting on the viability of populations (Cañedo-Argüelles *et al*., 2013). Sodium is an important component of osmoregulation within freshwater organisms and they need to maintain an internal osmotic pressure relative to the media of their environment (Cañedo-Argüelles *et al*., 2013). The concentration of hemolymph (the organisms bodily fluid) solutes in freshwater animals is generally lower than 16 g L^{-1} and they rarely survive salinities above 25 g L^{-1} (Withers 1992 and Pinder *et al* 2005, cited in Cañedo-Argüelles *et al*., 2013).

Colby, cited in (Griffith, 2017) concluded that the Plecoptera *Pteronarcys californica* actively transports Na^+ against a concentration gradient. Sutcliffe (1961), cited in Griffith (2017), found that *Limnephilus affinis, a* Trichoptera, of both freshwater and estuarine habitats, has a body wall relatively impermeable to Na^+ and more permeable to water. At lower external Na^+ (<100 mM), hemolymph Na^+, was held at greater concentrations (75−100 mM), whilst at higher external Na^+ (up to 400 mM), hemolymph Na^+ was held at less than the external concentrations. Not all freshwater invertebrates rely on Na^+ uptake from water. The freshwater diving beetle *Dytiscus verticalis* obtains its Na^+ from the diet (Frisbie & Dunson, 1988, cited in Griffith, 2017). Whilst Shaw (1955), concluded that the megalopteran, *Sialis lutaria* absorbed Na^+, K^+, and Cl^- from ingested water through the gut.

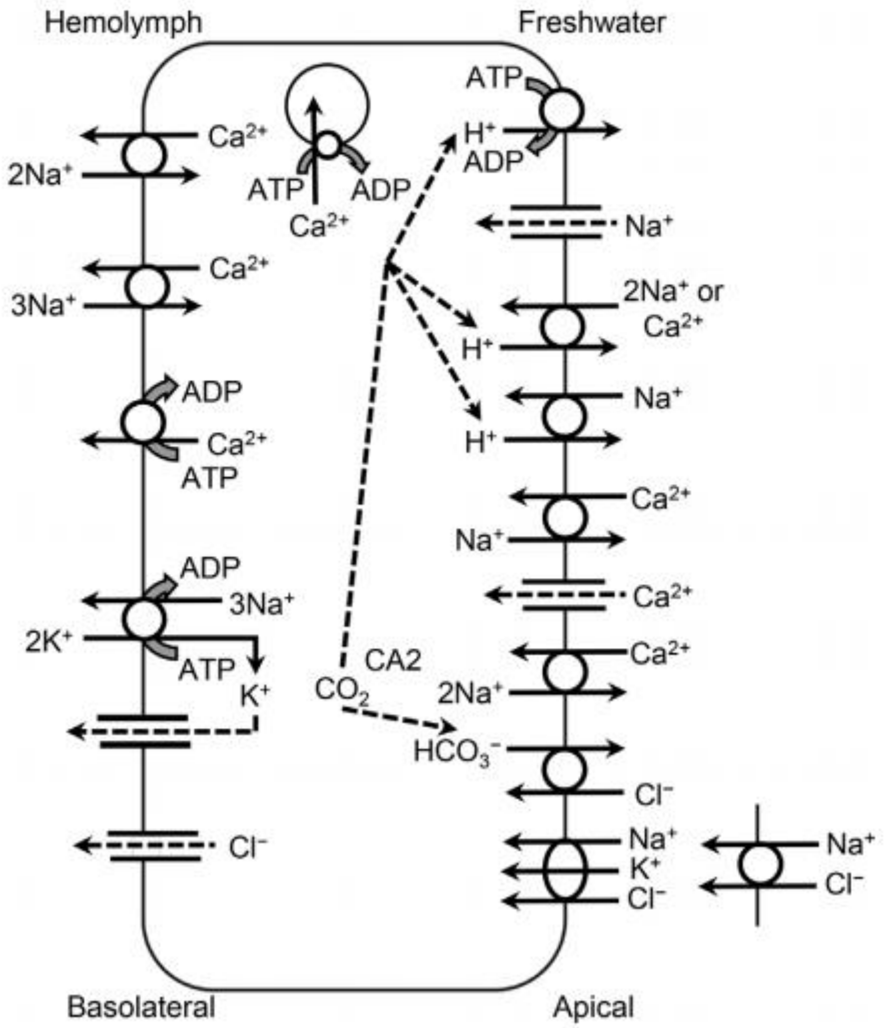


Figure 6.2 Generalised model for ion transporters on gill cells of freshwater Crustacean (Griffith, 2017).

Relationships and interactions with other elements can impact on the ionic balance within invertebrates. Figure 6.2 provides a simplification of the relationship between the ions associated with osmoregulation within freshwater Crustacean. A competitive inhibition of Na^+ uptake by elevated Ca^{2+} has been observed in the crayfish *Austropotamobius pallipes* (Shaw, 1960). With a lowering in pH to <5.5, net uptake of Na^+ is inhibited among crayfish. This results from competitive inhibition with the counter ion H+, which is elevated in the water. However, it is not known whether it is individual ions, some function of several ions or the total ions that are setting the upper (and lower) salinity limits of species (Cañedo-Argüelles *et al*., 2013)

6.2.2 Ecotoxicological effects of potassium

Like Na^+, K^+ is an important factor in osmoregulation within freshwater organisms and a major component of hemolymph. K^+ is required in the transportation of Na^+ across the basal membrane into the intracellular fluids (Griffith, 2017). In a comparison of hemolymph K^+ of starved Plecoptera nymphs in stream water and deionised water, Colby, cited in (Griffith, 2017) concluded that *Pteronarcys californica* actively transported K^+ from the water against a concentration gradient. Croghan *et al*. (1965), cited in Griffith (2017), experimented with isolated gills of the crustacean *Austropotamobius pallipes*. The electrochemical potential of K^+ was greater than that in the perfusion medium, indicating that K^+ is actively transported across the gill epithelium into the hemolymph (Figure 6.2).

Molluscs are particularly sensitive to elevated water K^+, to the extent that it is used as a molluscicide in water intake structures. Toxicity to molluscs is thought to be related to ion regulation disturbances associated with the role of K^+ in Na^+ transport and homeostasis and in volume regulation (Griffith, 2017). Of all the major ions, K^+ has been shown to be most toxic to crustaceans (e.g. *Ceriodaphnia dubia* and *Daphnia magna*) and fish (*Pimephales promelas*) (Griffith, 2017).

6.2.3 Ecotoxicological effects of increased salinity

Increased salinity kills freshwater species owing to toxic levels of sodium and chloride ions in their cells and reduced capacity to take in essential ions and water (Reid *et al*., 2019). Numerous anthropogenic impacts have resulted in impairments of the fluvial system of the River Werra, Germany. Since the beginning of the last century, the massive introduction of salt wastewater from potash mining into the river, in particular, has resulted in an extensive biological degradation of the middle and lower River Werra (Coring & Bäthe, 2011). At the peak of mining activity, concentrations of more than 30 g Cl^{-} L^{-1} were measured. Mining has now stopped and the river system is undergoing recovery from its former hyper saline conditions. Once absent aquatic vascular plants have returned together with a more representative diatom community structure.

A large proportion of macrophytes are sensitive to salinity concentrations between 1.5 and 3 mS cm^{-1} although several freshwater species (e.g. *Ranunculus circinatus*) have been reported to be unaffected by salinities higher than that. Salinisation can affect the photosynthetic rate of aquatic plants too, for example, Canadian waterweed (*Elodea canadensis*) reduces its net photo-synthesis production at such levels of salt as 100 mg Cl L^{-1} (Cañedo-Argüelles *et al*., 2013).

Regarding phytobenthos, it is known that salinity can reduce the number of planktonic algae and photosynthetic efficiency of epilithic algae. Diatoms react to changes in Cl as low as 100 mg L^{-1} (≡ 0.14 mS cm^{-1}). Ziemann *et al*. (2001) cited in Cañedo-Argüelles et al. (2013), registered a shift in the composition of the diatom assemblages of the River Wipper, Germany, after salt pollution and established that a maximum chloride concentration of 400 mg L^{-1} (≡ 0.6 mS cm^{-1}) should not be exceeded to ensure the dominance of freshwater diatom species.

Whilst tolerances to individual ions is lacking, given their wide use as indicators of water quality and ecosystem health, there is much information concerning the salinity tolerances of stream invertebrates. Cañedo-Argüelles *et al*. (2013), cite Ephemeroptera, Plecoptera and Pulmonate snails as being the most salinity sensitive taxa. They show 48-h and 72-h LC50 around 5 to 20 mS cm^{-1} and they have been rarely registered in salinities higher than 3 mS cm^{-1}. Ephemeroptera, Plecoptera and Trichoptera species richness decreases over the entire salinity range. Crustacea, Coleoptera and certain Diptera (e.g. Ceratopogonidae) and Odonata are among the most tolerant families. Shifts from salinity-sensitive taxa to communities with more tolerant taxa have been registered to occur between 0.8 and 1.0 mS cm^{-1} and a significant reduction in species richness has been observed above 1.5 mS cm^{-1}.

In most areas across Europe, salinity has not been perceived as a major problem, however, there are important exceptions including most of southern Europe with a Mediterranean climate, northern and alpine regions where road de-icing is extensive and regions with salt mining (Cañedo-Argüelles *et al*., 2013).

An impact assessment methodology is usually developed at a regional level by the responsible authorities in regions where saline discharges are recognised as an important ecological issue. In Germany the reference concentration referring to "good" condition for WFD is considered to be 200 mg Cl L^{-1} (≡ 333 g NaCl g L^{-1}) (Cañedo-Argüelles *et al*., 2013).

6.3 Acute toxicity test methodology

As a first step, a robust experimental approach was devised (Rowett *et al*., 2016, OECD 202, OECD, 2004, Harris *et al*., 2014) to determine the acute toxicity of both K as KCl and Na as NaCl using the freshwater crustacean *G. pulex*.

G. pulex were chosen as the test organism as they are ubiquitous and observations had been made in the study river that lower numbers of individuals were present downstream compared to upstream of the discharge. Macroinvertebrates such as *G.*

pulex have been successfully used as bioindicators of water quality in many freshwater ecosystems (Dudgeon *et al*., 2006; Wilby *et al*., 2010).

Experimental organisms were collected from a small tributary of the River Dart, at Newbridge (NGR SX 71152 71035), a soft water river that flows off Dartmoor, south Devon. Firstly, 10L of river water was transferred into the holding tanks at the University of Plymouth, maintained to constant temperature room (15± 2°C) in which the stock population of organisms were held and where subsequently the toxicity tests were conducted. Fallen leaves of beech, alder and oak were collected from the same location of the River Dart tributary to feed the *G. pulex* whilst in the holding tank.

Once in the holding tanks containing aerated River Dart water, the *G. pulex* were left to acclimatise. After 24 hours, 50% of the water was syphoned off to waste and replaced with a standardised artificial river water made up according to soft water recipe (ASTM, 1980) in order to avoid the potential risks of undefined trace metal contaminants known to occur in many Dartmoor rivers. Batches of 50 L artificial river water were prepared with deionised water from the University of Plymouth (Davy Building) as follows: 12 g / 200 mL $NaHCO_3$; 500 mg / 100 mL KCl; 8.125g / 100 mL $CaCl_2 .2H_20$; and 7.5g / 100 mL $MgSO_4 .7H_2O$. After a further 48 hours, 50% of the holding tanks water was again removed to waste and replaced with artificial soft river water. Both the river from where the test animals were collected and the study river exhibit naturally soft water.

Organisms were held in the holding tank for at least 7 days before tests were undertaken. The constant temperature room was held at a temperature of 15 ± 2°C with lighting set to 12h light 12h dark.

Mean concentrations of K, Na and Cl within the discharge into the River Inny were 832 ± 265, 2875 ± 836 and 5755 ± 2651 mg L^{-1}, respectively. Range finding experiments for KCl and NaCl were planned across a range of nominal test concentrations: 0, 100, 250, 500, 750 and 1000 mg KCl L^{-1}, and 0, 1000, 2500, 3500, 5000 and 10,000 mg NaCl L^{-1} in order to determine the precise range of concentrations at which the definitive experiments would be performed over a 96 hour period. For the range-finding tests, two 250 mL acid washed beakers were prepared with 200 mL of each concentration made up with stock solution and dilution water. Three additional beakers contained 10 mg L^{-1} ZnSO4 for use as a positive control (Rowett *et al*., 2016).

To start the 96 hr range-finding tests, five adult (size 8-10 mm) *G.pulex* individuals were gently transferred to the test solutions held within 250 ml beakers (with replicate beakers being set at the same time to monitor the physico-chemical water quality parameters). Conductivity, dissolved oxygen, pH, salinity and temperature measurements were taken at the start of the test and at 24, 48 and 96 hours. In those exposure concentrations where full mortality was observed before 96 hours, the monitoring of water quality values was also ended earlier.

On completion of the range-finding tests, definitive toxicity tests were carried out according to the same methodology over a 96 hour period. The selection of the definitive test concentrations was based on five nominal concentrations reflecting the range where there was between zero to 100% immobilisation of adult *G.pulex* in the range-finding test.

To start the definitive test, four adult organisms were gently added into seven 250 mL beakers, with five replicates per test concentration, one of dilution water control and one of zinc sulphate positive control. The 96 hour definitive test for KCl used nominal exposure concentrations of 0, 10, 25, 50, 100 and 250 mg KCl L^{-1}, while the subsequent definitive test for NaCl used nominal exposure concentrations of 0, 3500, 3875, 4250, 4625 and 5000 mg NaCl L^{-1}. For both tests, water quality measurements were taken as before (0, 24, 48 and 96 hours) and at the same time a 100 µL subsample from beakers containing no test animals was collected into acid washed 15mL centrifuge tubes for chemical analysis. These 100 µL subsamples were then made up to 5mL with high purity water for subsequent confirmation of the measured ion concentrations using ICP OES and ion chromatography.

6.4 Ecotoxicology results

6.4.1 Results of KCl bioassay

Positive control tests of the test specimens resulted in 33% immobilisation at 24h, 87% immobilisation at 48h and 100% immobilisation at 96h. Concentrations were plotted against percentage cumulative response at 96h to produce the plot shown in Figure 6.3.

Based on the 96h toxicity experiment with KCl, an EC50 (with 95% CIs) was determined by binomial interpolation as (Stephan, 1977) 70 mg K^{+} L^{-1} (54 to 130).

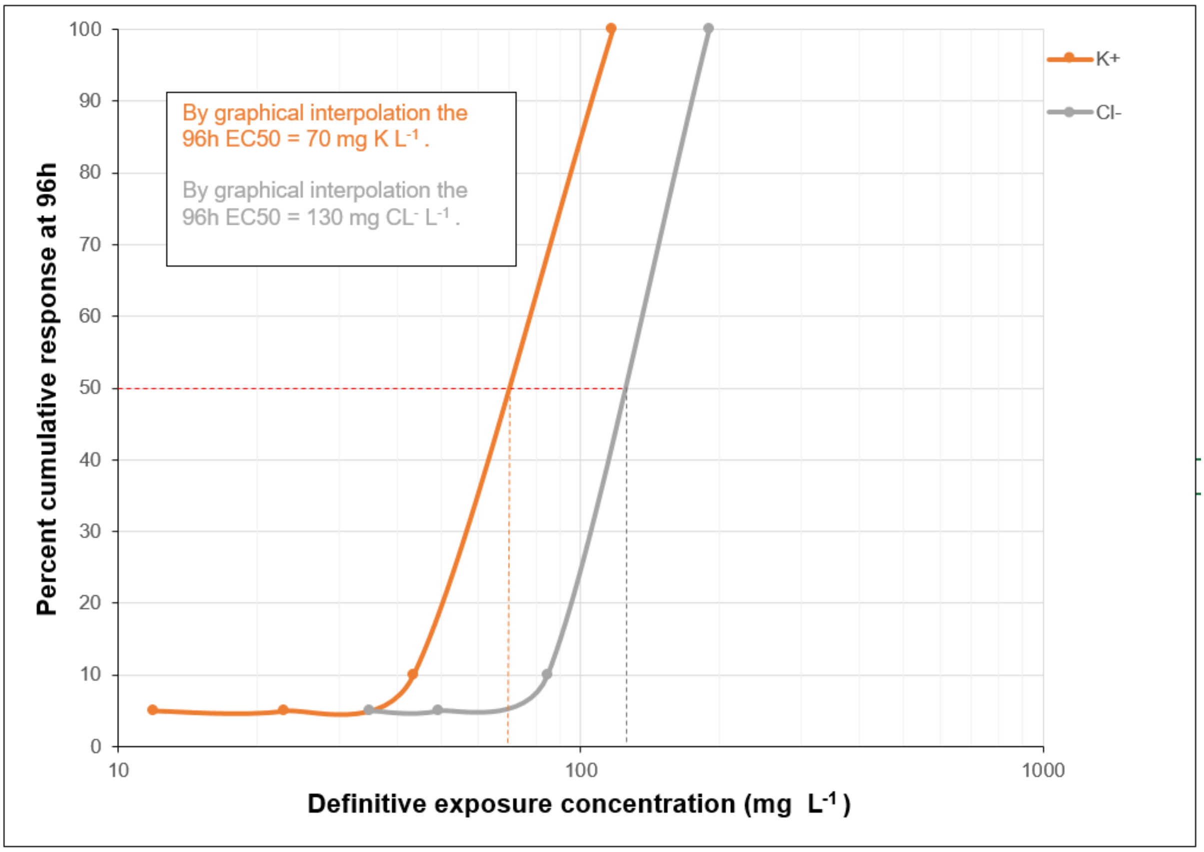


Figure 6.3 Exposure response curves based on immobilisation of *Gammarus pulex* following 96h exposures to KCl at 15 ± 1°C (with corresponding curves for K^+ and Cl^- included).

From the same experiment with KCl, an EC50 (with 95% CIs) was determined as 130 mg Cl^- L^{-1} (85 to 190). These experimental values represent a 96h EC50 for the species *Gammarus pulex*, in artificial soft river water at 15 ± 2°C. Following established methods for deriving an Environmental Quality Standard concentration, an assessment factor was applied to the EC50 values (European Commission, 2018). The use of assessment factors (sometimes termed 'safety factors') is a pragmatic approach where there are limited toxicity data for a chemical (Table 6.1).

The use of assessment factors aims to take into account that within the natural environment, there may be organisms more sensitive to the test chemicals than the experimental species; there is a need to consider short-term (acute) versus potential long-term (chronic) effects and there is a need to consider potential interactions with other chemicals or mixtures (which may lead cumulative toxic effects). Applying the recommended assessment factor approach to the acute toxicity data for *G.pulex* is as follows for K^+,

$$70 / 1000 = 0.07 \text{ mg } K^+ \text{ L}^{-1}$$

and for Cl^-,

$$130 / 1000 = 0.13 \text{ mg } Cl^- \text{ L}^{-1}.$$

6.4.2 Results of NaCl bioassay

Using the same methodology as above, NaCl trials took place. The range test informed a definitive test of 0 to 5000 mg NaCl L^{-1}. A definitive test was undertaken with test solutions of nominal concentrations 0, 3500, 3875, 4250, 4625 and 5000 mg NaCl L^{-1}. Concentrations of the test solutions were determined using ICP-OES for Na and ion chromatography for Cl. Positive control tests of the test specimens resulted in 100% immobilisation at 48h. Concentrations were plotted against percentage cumulative response at 96h to produce the plot shown in Figure 6.4.

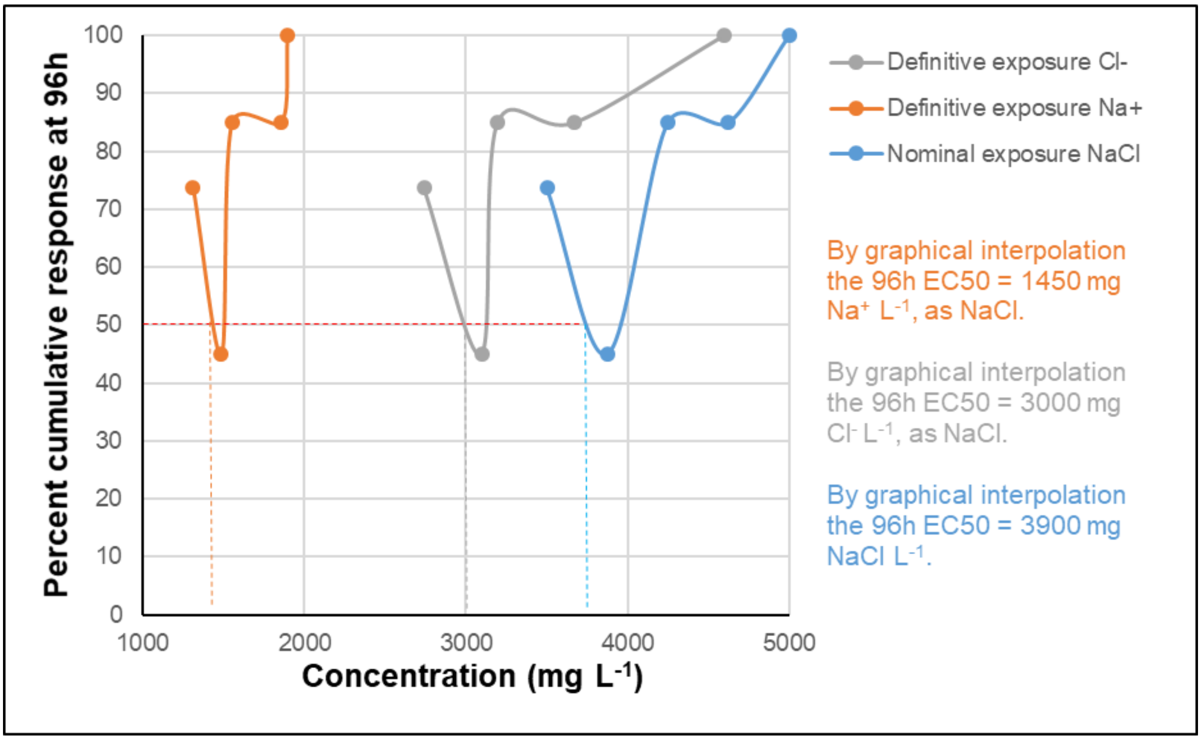


Figure 6.4 Exposure response curve based on immobilisation of *Gammarus pulex* following 96h exposure to NaCl at 14 ± 1.1°C (with corresponding curves for Na+ and Cl- included).

Based on the 96h toxicity experiment with NaCl and *G. pulex* as test organism, an EC50 (with 95% CIs) of 1450 mg Na^{+} L^{-1} (1309 to 1550) was determined through binomial interpolation (Stephan, 1977). From the same experiment with NaCl, an EC50 (with 95% CIs) of 3000 mg Cl^{-} L^{-1} (2742 to 3197) was determined. These values represent a 96h EC50 for the species, determined under laboratory conditions. Using the recently updated regulatory approach to deriving EQS values (European Commission, 2018) gives the following values:

$$1450/\ 1000 = 1.45 \text{ mg } Na^{+}\ L^{-1} \text{ for } Na^{+}$$

and

$$3000/1000 = 3.0 \text{ mg } Cl^{-}\ L^{-1} \text{ for } Cl^{-}.$$

6.5 Discussion

6.5.1 Comparison with proposed and established EQS

The application of safety factors reduces the probability of causing harm to the environment (Chapman *et al*., 1998; European Commission, 2018). These methods to ameliorate potential degradation are a conservative approach, based on policy rather than science and may often overestimate the risk.

6.5.2 Potassium

At the time of writing, an EQS for protection of aquatic life has not been set for potassium. Literature describing the potential impacts of KCl on aquatic life is not extensive (Densmore, *et al*., 2018). However, its use as a molluscide (100 mg KCl L^{-1}) [by atomic weight proportions, 52.5 mg K^+ L^{-1}, 47.55 mg CL^- L^{-1}], particularly against invasive zebra mussels is being evaluated. Toxicity testing of KCl to selected species of salmonid fish indicated a 96 hr lethal concentration (LC50) >800 mg KCl L^{-1}(Densmore, *et al*. 2018) [by atomic weight proportions, >419 mg K^+ L^{-1}, >380 mg CL^- L^{-1}]. Further acute toxicity tests were conducted with invertebrate species at exposure concentrations of 0–3,200 mg KCl L^{-1}. Daphnid exposure trials resulted in differences in mortality among the test groups with higher mortality evident among the higher KCl exposure concentrations with a calculated LC50 value of 196 mg KCl L^{-1} for a 48 hr exposure. Crayfish exposed to higher concentrations of KCl at or above 800 mg L^{-1} exhibited death or reversible paralysis. Due to cannibalistic behaviour among the various test groups, Chironomid larvae exposures were largely inconclusive (Densmore *et al*., 2018).

In their study of aquatic invertebrates of Lake Michigan, (Hamilton *et al*., 1975) observed lethal levels (100% mortality) at 48h of 204 mg KCl L^{-1} for the oligochaete *Nais variabilis*, 4896 mg KCl L^{-1} for the chironomid *Cricotopus trifascia*, and 6317 mg KCl L^{-1} for the caddisfly *Hydroptila* angusta.

In this study, the established 96hr EC50 (immobilisation) of 70 mg $K^{+}L^{-1}$ for wild *G. pulex* compares well with the lower LC 50 concentrations observed in the studies discussed. The EQS derived by application of /1000 assessment factors is just 0.07 mg K^{+} L^{-1}, with no recognised EQS to compare with.

6.5.3 Sodium

Hamilton *et al*., (1975) observed 100% mortalities for NaCl concentrations calculated from a regression line at 3735 mg L^{-1} for the oligochaete *Nais variabilis*, 8865 mg L^{-1} for the chironomid *Cricotopus trifascia*, and 10,136 mg L^{-1} for the caddisfly *Hydroptila angusta*. Studies since 1989 suggest that the toxicity of sodium is insignificant compared to that of corresponding ions such as chloride and sulphate (Fittall *et al*., 2002, Canadian Council of Ministers of the Environment, 1999).

Based on available data, a threshold EQS of 170 mg Na^{+} L^{-1} (annual average) was proposed in 1990 (Gardiner and Smith, 1992). In a revised report of 2002 (Fittall *et al*., 2002), it was suggested that an EQS for sodium is not necessary when sodium is present alongside chloride and sulphate as the toxicity of sodium is not significant compared to chloride and sulphate when present together.

In this study, the established 96hr EC50 (immobilisation) of 1450 mg $Na^{+}L^{-1}$ for wild *G. pulex* was much less than cited studies. The EQS derived by application of /1000 assessment factors is 1.45 mg Na^{+} L^{-1}, compared to the proposed value from Gardiner and Smith (1992) of 170 mg L^{-1}.

6.5.4 Chloride

The two experiments undertaken returned very different 96hr EC50 values for Cl^{-}, 130 mg Cl^{-} L^{-1} as KCl and 3000 mg Cl^{-} L^{-1}as NaCl. The Canadian Council of Ministers of the Environment (1999) report a short term (24 to 96 hr) exposure of 640 mg Cl^{-} L^{-1}. Based on Figure 6.2 reproduced from the review by Griffith (2017), it is clear that Cl, K and Na are all of fundamental importance to the biological health of crustaceans. In the two experiments undertaken here, there was a marked variation in the predicted concentration of Cl associated with the two ions. Reasons are unclear but may relate to the inherent variability of using wild caught organisms for ecotoxicology studies, which is the reason why the OECD recommend cultured populations of organisms (e.g. *Daphnia magna*) where feasible. Due to laboratory constraints it was not possible to work on these OECD recommended species at the University of Plymouth. Positive control results suggest that the test specimens utilised in the NaCl experiment were more sensitive (100% immobilisation @ 48h) than those used in the KCl experiment 100% immobilisation @ 96h). Chloride has an established non-statutory EQS of 250 mg $Cl^- L^{-1}$ (Gardiner and Smith, 1992) expressed as an annual average for freshwater, compared with a chloride EQS derived by application of assessment factors and concentrations determined in this study of 3 mg $Cl^- L^1$, as NaCl or 0.13 mg $Cl^- L^{-1}$ as KCl.

Suitability of the calculated EQS concentrations for sodium, potassium and chloride will be discussed further in Chapter 8.

7 Modelling river flow and discharge composition within the receiving waters

7.1 River Inny Catchment

The River Inny rises close to the A395 trunk road at Davidstow, north east of the main dairy facility (see Chapter 2). The EA Catchment explorer (Environment Agency, 2021) divides the River Inny catchment into two sub catchments, Upper River Inny and Lower River Inny. The Upper describes a channel length of 19.4 km and covers a catchment area of 38.9 km^2 and extends downstream to the A30 trunk road at Two Bridges. The Lower extends from the exit of the Upper River Inny downstream to the confluence with the River Tamar near Bealsmill, a channel length of 15.8 km and catchment area of 40.1 km^2 (https://environment.data.gov.uk/catchment-planning/WaterBody/GB108047007890). Within the two sub catchments exists just one gauging station at Bealsmill, measuring flow for the whole of the Inny catchment.

Chemical concentrations and loadings associated with discharge permits have been calculated using flow described at Bealsmill and apportioned for the position it lies within the catchment. The Saputo discharge is approximately 21 km straight line distance from Bealsmill gauging station. Saputo hold a permit to discharge up to 2,600 m^3 day^{-1} treated effluent into the River Inny. In the upper reaches of the Inny, a considerable number of springs issue and feed into the Inny, suggesting that the discharge in the upper Inny could be proportionately higher than that in the lower reaches. Upstream of the outfall, at Inny Vale, (Figure 3.3) the company abstracts water under license from springs that feed a leat, to a maximum of 654 m^3 day^{-1}. When the springs are not supplying sufficient water to the leat, additional volume is made up from river abstraction. Abstraction feeds a tank which is pumped to the main Saputo factory for production and washing uses. At times, tank volume is in exceedance of requirements and water overflows back to the river.

In order to more accurately understand the flow at a more defined level, the upper Inny catchment, downloaded from EA Catchment Explorer was subdivided into smaller operational catchments. Ordnance Survey Watercourse networks and 5m data downloaded from Edina Digimap was used to build raster tiles for each sub-catchment of interest using the QGIS Upslope area tool and elevation data. Data was resampled at 20 metres using bilinear interpolation. For each sub catchment of interest, a layer was created with the exit coordinates of the catchment. The Hydrology-Catchment area tool within the SAGA Terrain Analysis kit was run to check that the river location had been mapped in the correct place. Using the Hydrology – Upslope area tool, a raster of the subcatchment above the exit point was drawn. This was converted to a shapefile (Figure 7.1) for use in further modelling.

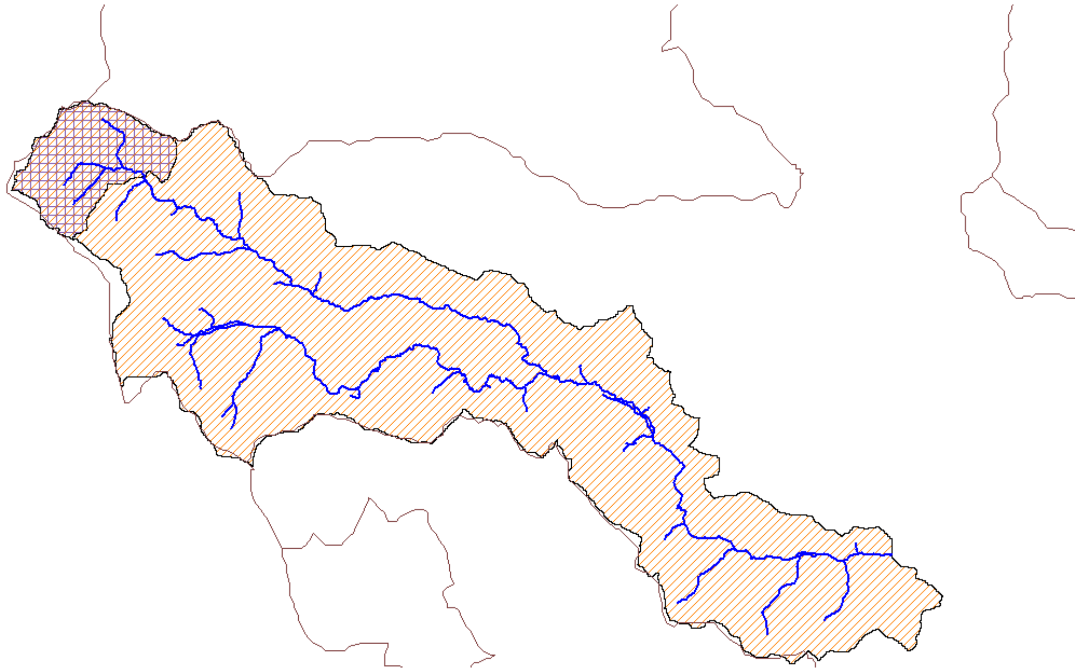


Figure 7.1 Upper River Inny catchment showing QGIS created sub catchment (double hashed area) to point of Saputo discharge

The created sub catchments were imported into LowFlows2 (Wallingford Hydro Solutions) to calculate the discharge generated from that sub-catchment. LowFlows2 is a software system that has been developed to enable river flows to be estimated from ungauged catchments in the UK. These discharges can then be used to determine concentrations and loadings within the SIMCAT model.

Channel discharge measured during fieldwork on the River Inny at sample point 'US' was compared with apportioned discharge from Bealsmill, derived via a linear regression from Bealsmill gauged flow and discharge generated from the QGIS sub-catchment (Figure 7.1) and modelled using LowFlows2 gave a range in Q95 flow of 0.045 to 0.062 $m^3 s^{-1}$ (Table 7.1), with the LowFlows2 value being very conservative owing to the abstraction value, some of which would be returned to the river as tank overflow. The apportioned flow from Bealsmill gauged data being the most generous for dilution of discharge. The Q95 value is the lowest 5% flow that will occur on the hydrograph and is used by the regulator for monitoring purposes as this represents the lowest (ecologically worst) flow

From 2019, Saputo installed a flow meter upstream of their discharge to ascertain an accurate measure of local river discharge (Figure 7.2). A 235 day data set spanning 22 August 2019 to 25 August 2020 was generated, with gaps in February, March, April and May (due to changes in the channel that affected the quality of the data) and July 2020 (due to battery failure). Analysis of all the Saputo Flow monitoring data[3] (August 2019 to August 2020) generated a Q95 of 0.061 $m^3 s^{-1}$ (5357 $m^3 day^{-1}$).

[3] Data management and modelling associated with flow meter and correlation with Bealsmill flow data undertaken by WSP as a part of Saputo project to model outputs associated with planned expansion of the facility.

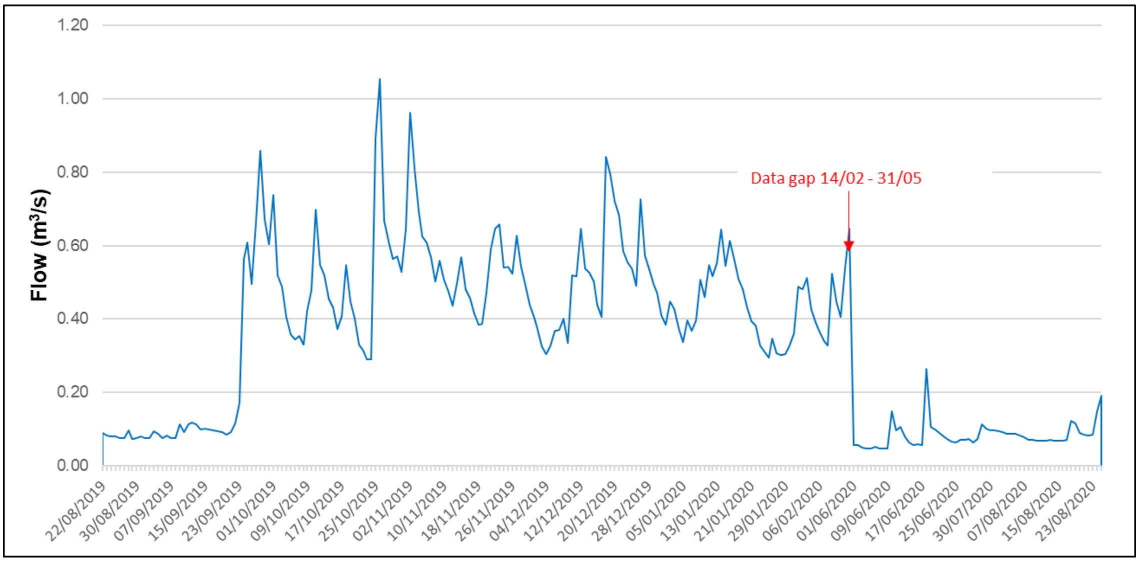


Figure 7.2 River Inny upstream of Saputo discharge point, daily mean flow (m^3 s^{-1}, Aug 2019 - Aug 2020).

This data allows an accurate prediction of chemical concentrations and loading into the channel from the discharge using the SIMCAT model.

Table 7.1 Comparison of modelled and measured flow for US site

Site	Mean Flow (m^3 s^{-1})	Standard deviation (m^3 s^{-1})	Q95 (m^3 s^{-1})
River Inny at Bealsmill (n=10788)	3.52	3.80	0.53
Bealsmill extrapolation to upstream of Saputo discharge (n=10788)	0.27	0.19	0.062
LowFlows2 modelled flow for constructed catchment above discharge, with Saputo abstraction accounted for	0.26	0.12	0.045
Flow measured (n=6) upstream of discharge	0.21	0.30	0.050*
Saputo measured flow upstream of Saputo discharge (n=235)	0.34	0.23	0.061

*Determined by graphical interpolation

7.2 SIMulation of water quality in river CATchments (SIMCAT)

SIMCAT is a Monte Carlo based catchment simulation model that calculates the water quality throughout a defined catchment. Observations of flow and water quality, together with features such as effluent flows and quality are used by the model to produce predictions of river flow and water quality.

Where effluent from a process meets the receiving waterbody, mixing of the effluent with the receiving waters can be affected by a number of factors that can impact on the accuracy of modelled scenario.

- Effluent entering on one side of the channel can remain on that side for some distance.
- If the effluent is warmer than the receiving water it may rise to the surface.
- Sediment within the effluent may settle on the bed during low flows to be resuspended as flow increases.
- If the effluent is denser than water, it can remain at the bottom of the channel unmixed (Chubb *et al*., 2014).

These factors can be ignored if a mixing zone is assumed immediately downstream of the discharge. The mixing of a discharge with a river can be described by the following Mass balance Equation:

$$T = \frac{FC + fc}{F + f}$$

where T is the concentration downstream of the discharge

F is the river flow upstream of the discharge

C is the concentration of the pollutant in the river upstream of the discharge

f is the flow of the discharge

c is the concentration of the pollutant in the discharge

If F, C, f and c refer to the same instant in time, then T can be calculated at that time. River standards and discharges are stated as annual means or percentiles and the Mass Balance Equation does not work with summary statistics. This can be overcome by using a Monte-Carlo Simulation which creates thousands of different sets of values for F,C, f and C to calculate thousands of values of T (Chubb *et al*., 2014). This is the basis of how SIMCAT generates results.

To use SIMCAT, a data file is generated to define with as much accuracy as is available all characteristics of water quality, inputs and outputs for the catchment. Upstream and downstream boundaries of the catchment are defined and data for their river flow and water quality are noted. Individual reaches within the catchment are defined by marking an upstream boundary on the catchment map and tracing downstream until meeting a confluence with another river. This reach is allocated a unique numerical code and name, together with the length of the reach and the reach into which it flows. Each reach has features defined on it, which have a specific code for the type of feature: 1 representing a monitoring station; 2 represents a stream or tributary, 4 a river flow gauge; 5 an industrial effluent discharge. The distance from the head of the reach is entered, together with associated flow data sets and water quality data sets. The determinands being investigated are entered, with a descriptor, units and definition of good quality. A section for water quality allows measurements of the defined determinants (up to 12) to be entered. This data set generates unique codes which link the water quality to flow and river feature specifics. Any effluent sources are similarly defined, together with their quality in terms of the quality determinands already set. Finally a section for targets allows the user to enter river quality targets such as WFD class boundaries for the different determinands. These targets have a unique number which can be linked to the features.

7.2.1 Meeting Good water quality status for reactive phosphorus

As previously discussed (Chapter 4.2), the EQS for phosphorus (reactive) is site specific owing to how it is calculated with altitude and alkalinity as proxy values. Through the field work aspect of this study TRP was measured at US, DS and TB and within the effluent (Table 7.2). Entering the data (Table 7.2) into SIMCAT, together with river and discharge flow data, the concentration of TRP within the discharge needed to meet the downstream EQS can be modelled. In the first instance, running the model forecasts concentrations based on forward and back calculations, calculating the discharge quality needed to achieve a downstream target from an upstream quality. These are associated with the concentrations at the top and bottom of the catchment and the concentration of the discharge. Observation of the modelled flow data (Figure 7.3) shows a close relationship with observed data. Calibration with the observed flow data will ensure an accurate measure of flow against which to model concentrations (Figure 7.4).

Table 7.2 Mean concentration of total reactive phosphorus (TRP) December 2017 – November 2019 and site specific EQS for 'good'.

Site	Concentration TRP (μg P L^{-1})	EQS ('Good/Moderate' boundary) (μg P L^{-1})
Top of catchment (TP)	71±102, n=24	28
Upstream (US)	47±36, n=24	30
Effluent (WwTW3)	508±443, n=21	N/A
Downstream (DS)	171±207, n=24	41
Trewinnow Bridge (TB)	124±146, n=24	30
St Clether Bridge (StC)	52±46, n=23	42
Two Bridges, Inny (2BI)	50±36, n=24	46

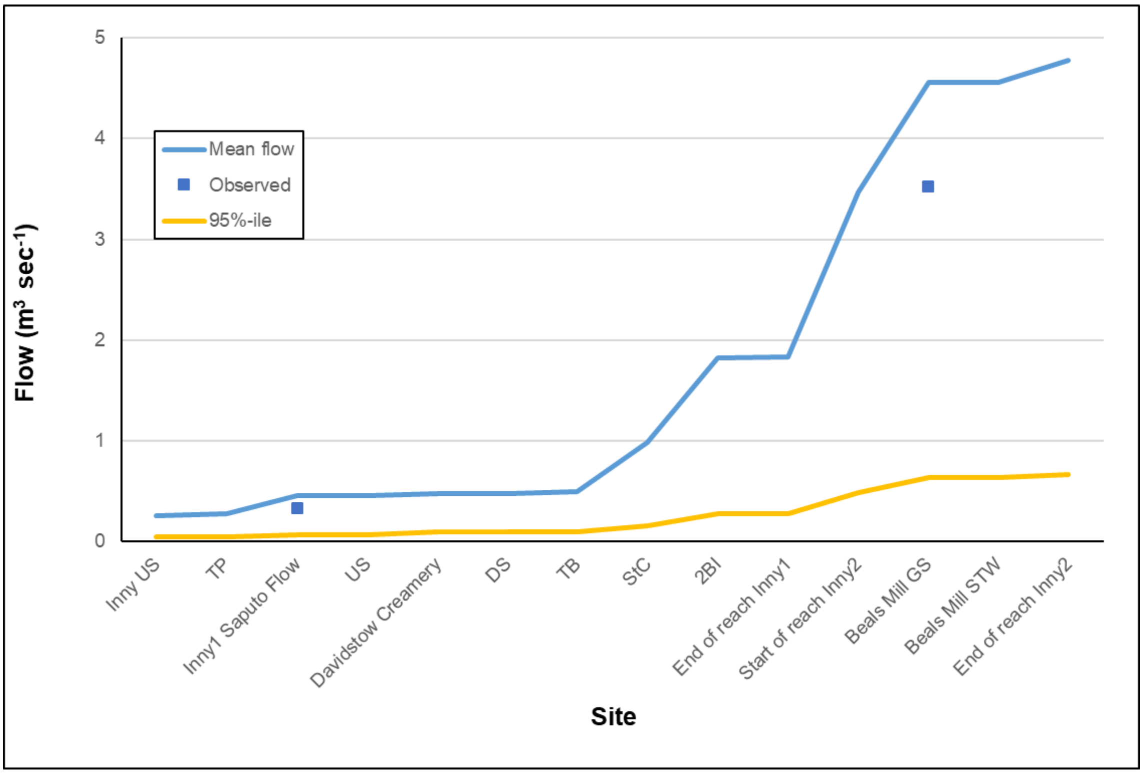


Figure 7.3 SIMCAT river flow output without calibration.

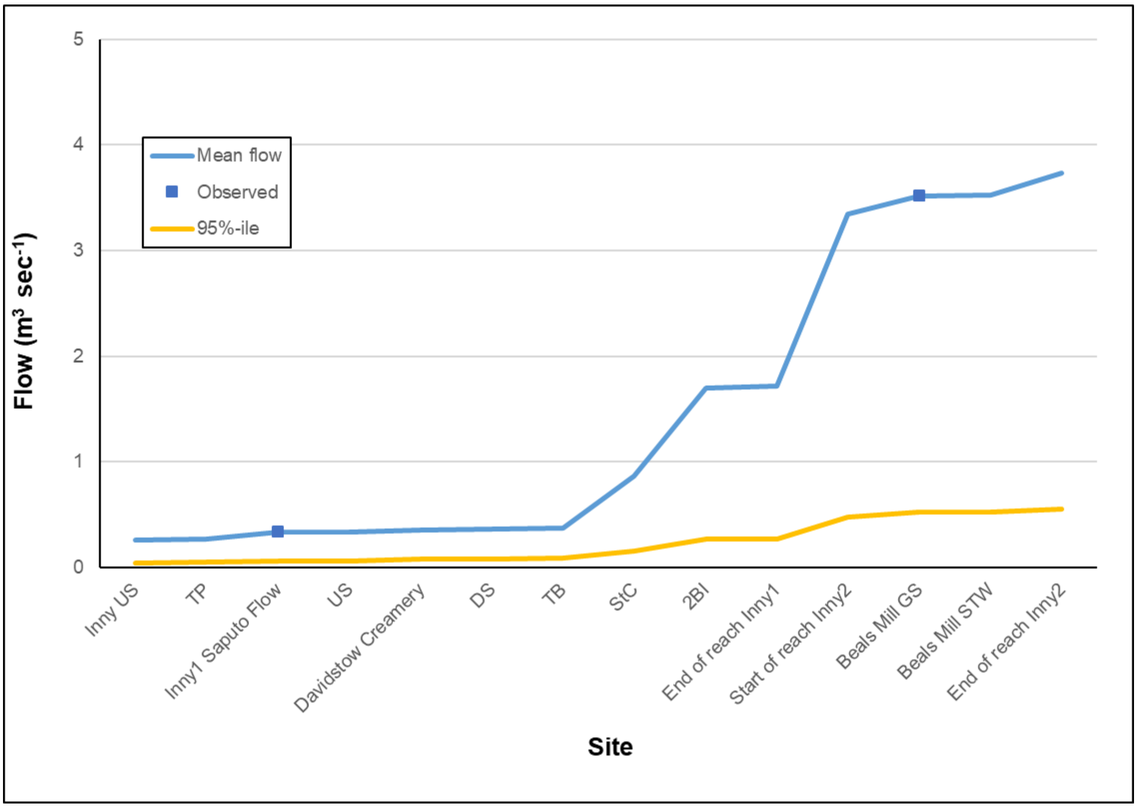


Figure 7.4 SIMCAT river flow output calibrated against Saputo flow data and Bealsmill gauging station.

Once a good fit for flow has been established, chemical parameters can be investigated. In this instance, the modelled mean TRP output is lower than the observed mean (Figure 7.5). Accuracy can be improved by calibrating the model against these observed mean concentrations measured from the monitoring points along the reach (Figure 7.6).

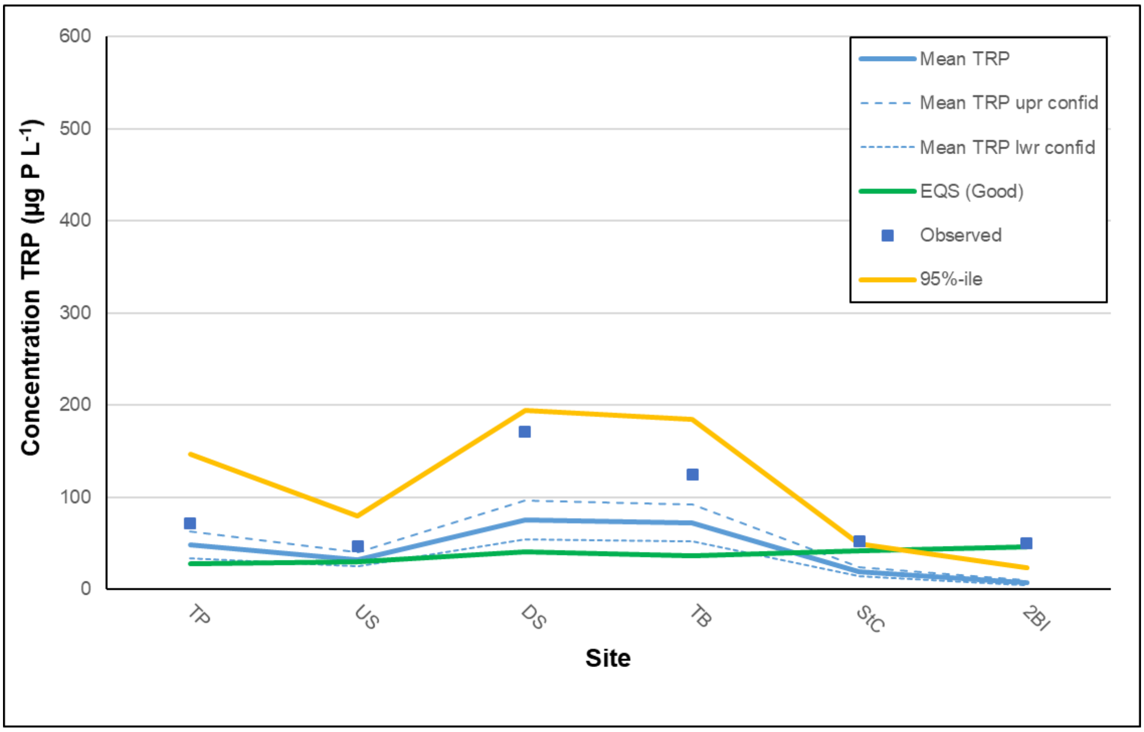


Figure 7.5 SIMCAT output without river water quality calibration.

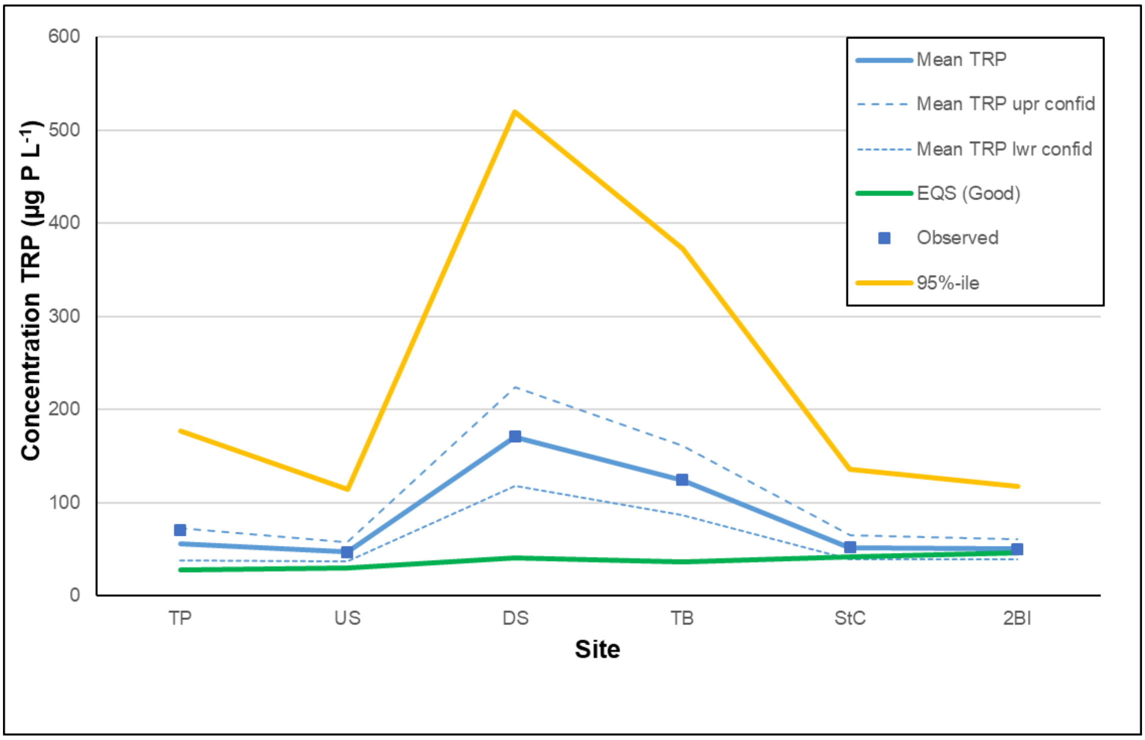


Figure 7.6 SIMCAT output calibrated river water quality

The EQS for phosphorus in rivers is given as reactive phosphorus (≡ total reactive phosphorus) but the permit under which the WwTW operates is given as total phosphorus. Using concentration data collected from the outfall, a linear regression of TP and TRP yielded a significant positive linear regression ($F (1, 19) = 44.15$; *p=2.35E-06*). The relationship can be described as

$$TP = TRP/0.4469 - 103.58 \ (R^2 = 0.699).$$

This can be used to calculate the concentration of TP within the effluent that would correspond to the modelled TRP. The observed mean concentrations of TRP measured within the River Inny, particularly those upstream, exceeded the EQS of good at (green line, Figure 7.6). Trewinnow Bridge (TB) is seen as the end of the effluent mixing zone and has an EQS (good) of 30 µg P L^{-1}. The exceedance of the target 30 µg P L^{-1} EQS upstream of the discharge prevents SIMCAT from giving a meaningful modelled concentration that would achieve the downstream EQS. The EQS for site DS is 41 µg P L^{-1} (lower boundary of 'good') but this site is within the mixing zone and still exceeded by the upstream concentration. If SIMCAT is forced with a downstream EQS of 65 µg P L^{-1} (within 'moderate' class, and above lower boundary of moderate of 116 µg P L^{-1}), it models a concentration of TRP within the effluent of 61.2 µg P L^{1}. Using the above regression equation would suggest a required TP concentration within the effluent of

$$61.2/0.4469 - 103.58 = 33.9 \ \mu g \ P \ L^{-1}$$

to meet the downstream forced EQS of 65 µg P L^{-1}. An effluent concentration of 61.2 µg P L^{-1} is less than the TRP concentration at the top of the catchment and would not be achievable under the current processes within the dairy. The modelled 33.9 µg P L^{1} (Total P) is 97% of the existing permit and considerably less than the wastewater treatment industry target of 100 μg P L^{1}, which is based on Best Available Technology (Saputo 2019, pers. com.)

At the start of fieldwork monitoring, the P concentration within the discharge showed greater variability than was observed in the last 12 months of monitoring (Table 7.3). Thus, the 2 year average concentrations showed greater variation than the last 12 months ($t(8)=1.754$; $p=0.117$). These observations align with engineering changes to the treatment process, with installation of more efficient filtration equipment.

Table 7.3 Comparison between full data set (24 month) and final 12 month average for Total reactive phosphorus and Total phosphorus.

Site	TRP 12 MTH MEAN(μg P L^{-1})	TRP 24 MTH MEAN(μg P L^{-1})	TP 12 MTH MEAN(μg P L^{-1})	TP 24 MTH MEAN(μg P L^{-1})
TP	80±111	71±102	177±349	134±251
T2	51±57	51±48	1003±165	83±119
US	43±42	47±36	63±68	78±61
WWTW3	292±182	508±443	739±310	1107±647
DS	89±57	171±207	162±128	333±392
T1	26±38	22±28	105±149	76±109
TB	66±40	124±146	166±106	241±238
StC	33±11	52±46	109±145	127±130
2BI	37±15	50±36	124±134	119±114

Using the 12 month mean concentration data gives more of a snap shot of the current situation so this data is now used for the modelling.

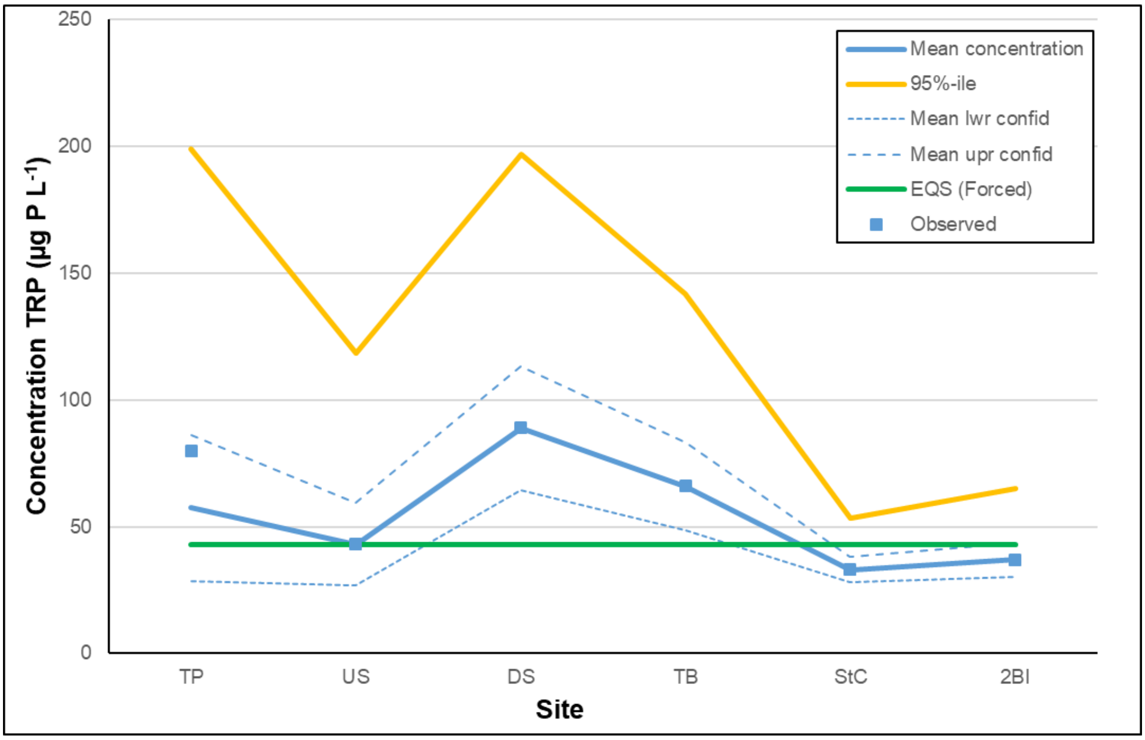


Figure 7.7 SIMCAT output calibrated river water quality for the period December 2018 to November 2019. EQS represents forced concentration of 43 µg P L^{-1}.

Comparison of the output in Figure 7.7 with Figure 7.6 shows a much improved situation with all observed concentrations falling below 100 µg P L^{-1}.The EQS in Figure 7.7, has been forced at 43 µg P L^{-1}. This was needed to allow SIMCAT to successfully return a concentration of TRP within the effluent that would meet the downstream EQS, as the upstream TRP concentrations still exceeded the downstream EQS of 41 µg P L^{-1}. SIMCAT's modelled concentration of TRP within the discharge for compliance with a 43 µg P L^{-1} EQS target was 23.7 µg P L^{-1}.

7.2.2 Modelling K^+

The output shown in Figure 7.8 is generated using data from the entire monitoring period (n=21 to 24) and shows the modelled concentration of potassium within the River Inny presenting above the laboratory derived EQS of 0.07 mg L^{-1} at the top of the catchment (TP) and upstream of the discharge. The 95%-ile plot for potassium is above the EQS, which results in the model being unable to return a potassium concentration within the discharge that could meet the EQS.

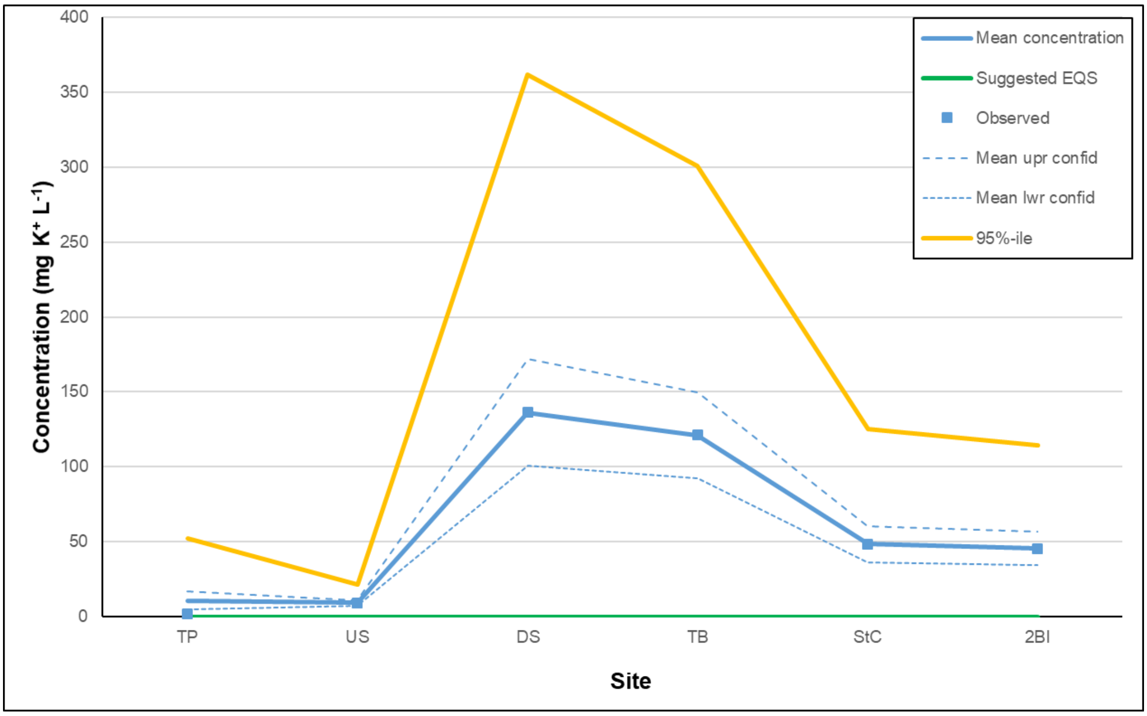


Figure 7.8 SIMCAT output calibrated against flow and observed potassium concentration.

By forcing the suggested EQS to 30 mg K L^{-1} the model is able to successfully run and return a predicted discharge output of 45 mg K L^{-1} which would meet the forced EQS of 30 mg L^{-1}. However this substantially exceeds the EQS of 0.07 mg L^{-1}, derived in the laboratory from the 96 hr EC50 of 70 mg L^{-1}, generated in Chapter 6. The forced EQS of 30 mg L^{-1} compares well with 96hr EC5 of 23 mg L K^{-1} (Figure 6.3).

Replotting using data measured from the 12 month period to November 2019 showed little difference, but modelled a reduced K concentration requirement within the outfall of 39.9 mg K L^{-1} to meet the forced EQS (See Appendix 7 for model data).

7.2.3 Modelling Na^+

Figure 7.9 shows the SIMCAT output for modelled concentrations of sodium within the River Inny for the full monitoring period. Calibration against measured flow and observed concentrations of sodium have been undertaken. Although not an established EQS, Gardiner *et al*., (1992) have suggested a sodium EQS of 170 mg L^{-1}. However, they stress that the toxicity of sodium cations is insignificant in comparison to that of the corresponding chloride or sulphate anion. For modelling purposes, the laboratory derived sodium EQS (1.45 mg Na L^{-1}), reported in chapter 6 is being used. As the chart shows, the derived EQS is exceeded at all monitoring sites. A no effect concentration could not be derived from this assay, but the range test conducted over 72 h returned a no effect concentration of =< 983 mg Na L^{-1}, as NaCl.

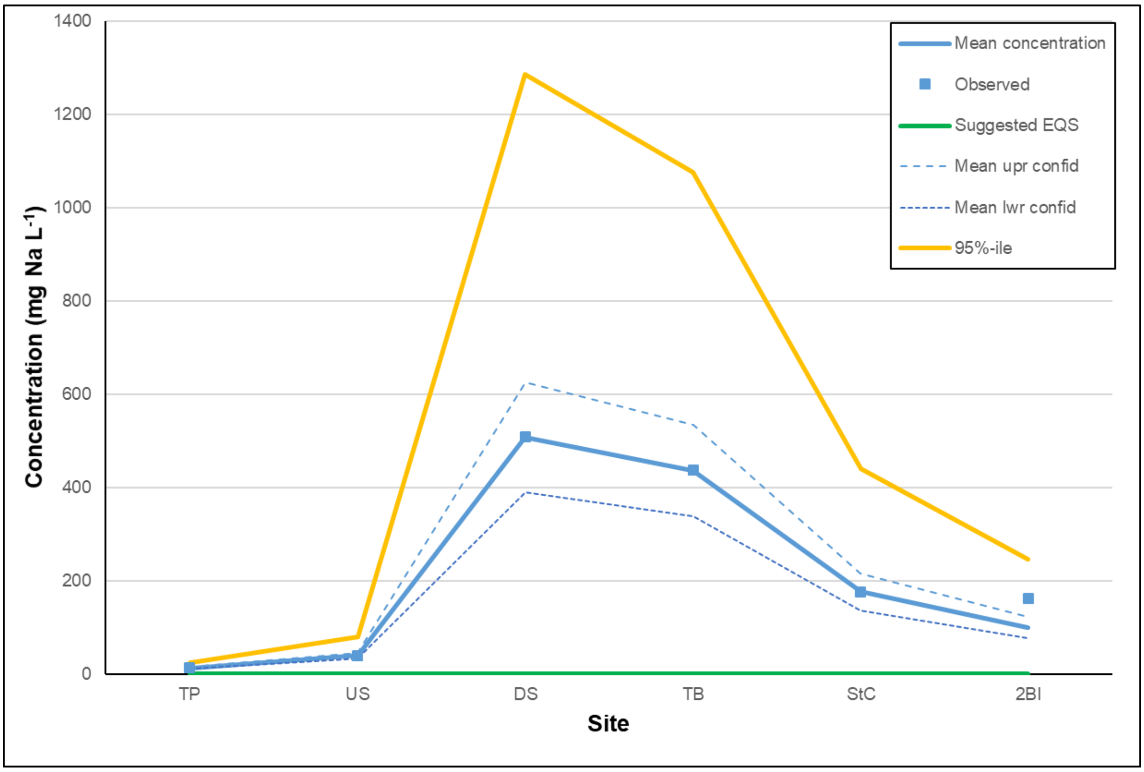


Figure 7.9 SIMCAT output calibrated against flow and observed mean sodium concentration (flow not plotted).

With the derived EQS exceeded at the top of the catchment, it was not possible to model a concentration of Na within the discharge that would meet the EQS. Again, using just the last 12 months of sodium monitoring data (December 2018 – November 2019), SIMCAT was unable to return a modelled a discharge concentration that would be compliant with the derived EQS, because the concentration at the top of the catchment was higher than the derived EQS.

7.2.4 Modelling Cl^-

Concentrations of chloride were modelled by SIMCAT using mean concentrations (n=6 to 7) of chloride determined by ion chromatography (Chapter 4). After data checking the model, chloride and flow were calibrated with observed measurements to produce Figure 7.10.

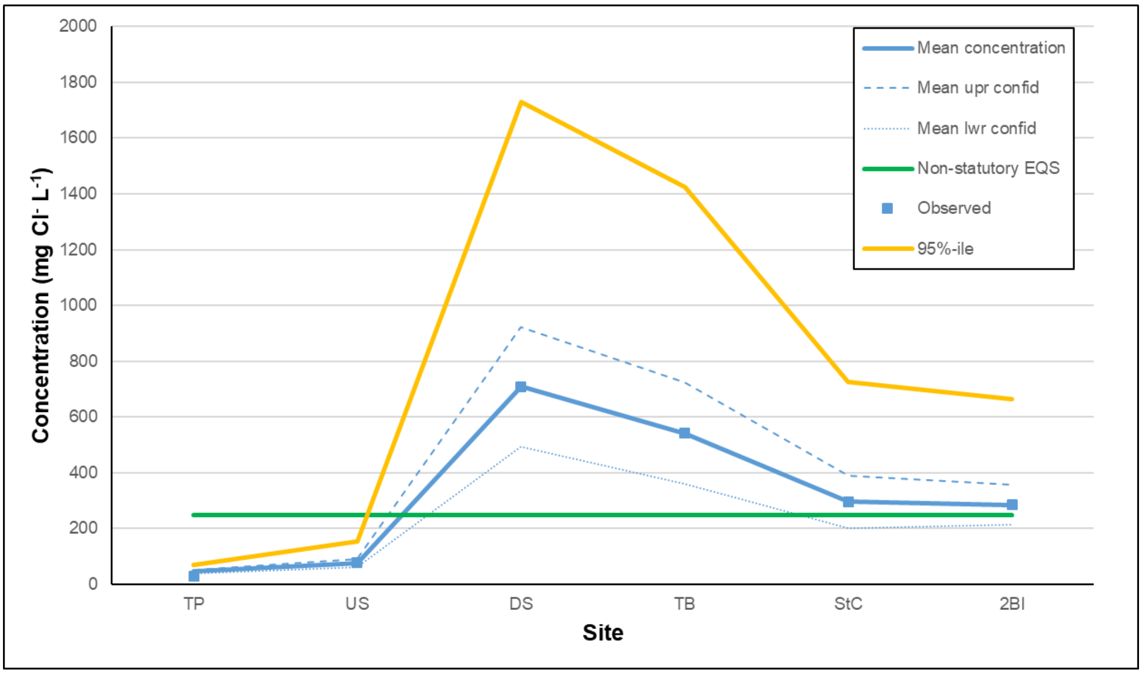


Figure 7.10 SIMCAT output calibrated against flow and observed mean chloride concentration (flow not plotted)

An established EQS for chloride in UK waters does not exist but a non-statutory EQS of 250 mg L^{-1} is accepted by the regulator. In order to meet this level, the concentration of chloride within the discharge would need to be 1698 mg L^{-1} ± 782, a drop of 339%

from the current mean concentration of 5760 mg L^{-1} ± 2650. Further modelling with the last year of monitoring data was not undertaken due to the small data set (n=3).

7.2.5 Modelling Fe^{+}

Concentrations of total iron were modelled by SIMCAT using mean concentrations of total iron determined by ICP-MS (Chapter 4). After data checking the model, mean total iron and flow were calibrated with observed measurements to produce (Figure 7.11).

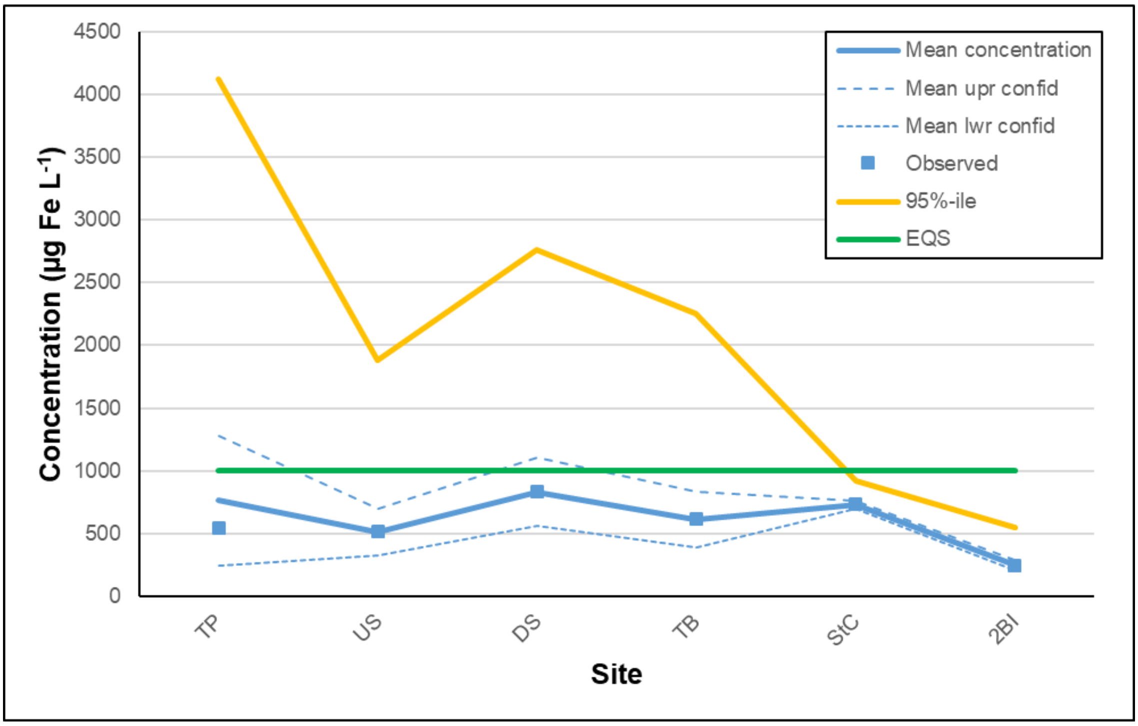


Figure 7.11 SIMCAT output calibrated against flow and observed mean total iron concentration.

The current EQS for iron in UK waters is 1000 µg Fe L^{-1}, as dissolved iron (Environment Agency, 2007), however Peters *et al*., (2012) have proposed a threshold of 0.73 mg L^{-1} total iron for the protection of sensitive taxa, and a threshold of 1.84 mg L^{-1} total iron for the protection of the whole community. The mean concentration downstream of the outfall was calculated as 830 µg L^{-1} ± 1268 and at Trewinnow Bridge as 612 µg Fe L^{-1} ± 1358. All observed concentrations fell below the EQS and the SIMCAT modelled concentration of Fe required to meet the DS EQS was not changed from the observed concentration of 1528 µg Fe L^{-1} measured in the discharge.

Remodelling using data from the 12 month period to November 2019 yielded the plot shown in Figure 7.12, with lower observed values of total iron at all sites except 2BI. The modelled concentration of total iron within the discharge remained at 1528 µg Fe L^{-1}.

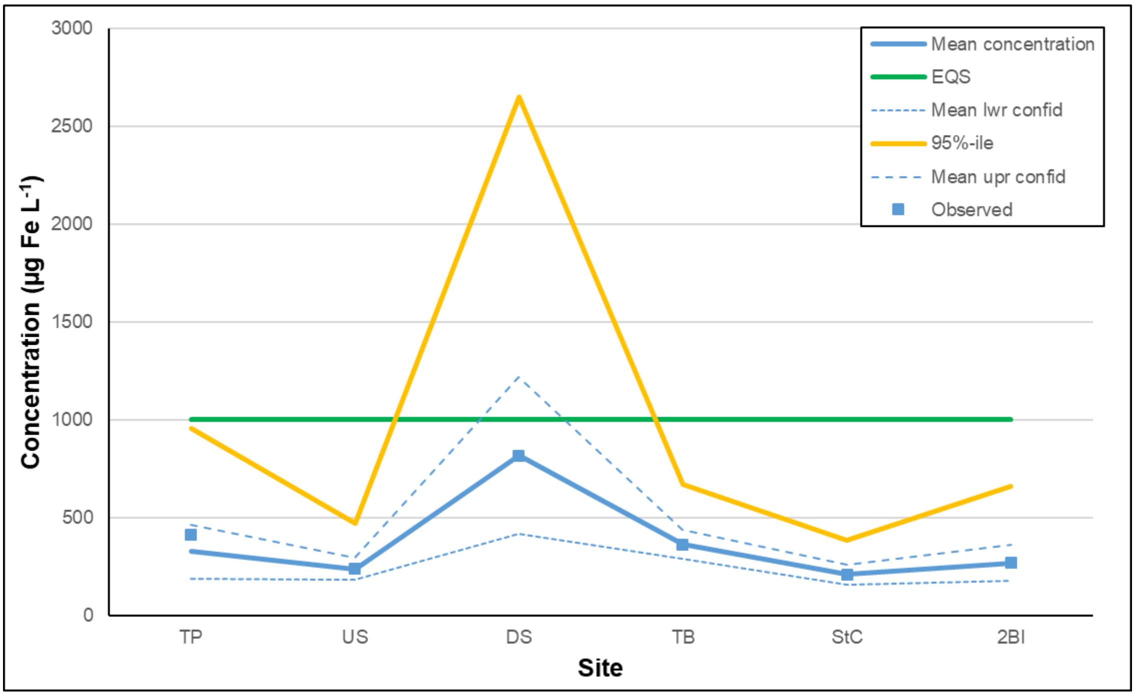


Figure 7.12 SIMCAT output for total iron for the period December 2018 to November 2019.

7.3 Discussion

In order for accurate chemical concentrations and loads to be modelled, accurate data must first be inputted to establish the model before scenarios can be run. The SIMCAT model is now set up with good spatial data around the Saputo discharge to the River Inny. Hypothetical values have been used to force SIMCAT to return concentrations that would meet downstream EQS concentrations. The model structure can now be used in any permitting discussions for the parameters outlined above to help the WwTW to meet the targets as well as highlighting the issues with high US concentrations. EQSs will be discussed further in the final chapter.

Table 7.1 shows flow rates for the River Inny that have been used historically by the Environment Agency within SIMCAT modelling to determine discharge permits. A walk over of the fields around the outfall showed numerous springs and seasonal overland flow which may not have been picked up through using the extrapolation method to determine a simulated flow. The LowFlows simulated flow returned a mean flow of 0.26 $m^3 s^{-1}$. Field measurements within this study returned a mean flow of 0.21 $m^3 s^{-1}$, compared with 0.34 $m^3 s^{-1}$ measured by Saputo's installed flow meter. Thus, the simulated flows under estimated the River Inny flow at the point of discharge. With a higher flow, discharge will be more readily diluted by the receiving waters.

Without a local gauging station, the flow at Bealsmill was extrapolated by linear regression to the position of the outfall, giving a simulated flow of 0.27 $m^3 s^{-1}$. Extrapolation of Bealsmill flow data upstream to the Saputo discharge gave a good estimation of river flow (Q95 0.062 $m^3 s^{-1}$ vs Q95 0.061 $m^3 s^{-1}$), compared with the estimated upstream flow from onsite measurements ((n=6) Q95 0.050 $m^3 s^{-1}$) and the modelled catchment upstream flow (Q95 0.045 $m^3 s^{-1}$) Using the flow measurement from Bealsmill would have resulted in more lenient estimations of concentrations, whilst the upstream calculated catchment river flow data would have led to much stricter concentrations being generated.

Owing to the Saputo drainage overflow observed at Inny Vale (Figure 3.3), at the former discharge point, US exceedances of the EQS cannot be apportioned solely to sources other than Saputo without further study. However, the model was unable to calibrate with the observed concentration of TRP at the top of the catchment (Figure 7.6) and the observed value here was in excess of the EQS, suggesting that the catchment has been enriched by nutrients other than those from Saputo.

Within the SIMCAT modelling, variance was observed in the DS measurements between observed and predicted pre-calibration concentrations. SIMCAT uses the concentration parameters entered by the user then applies forward and backward concentrations to generate 'whatif' scenarios. Data undergoes Monte-Carlo simulation modelling using 365 'hits' to generate the modelled concentrations. This results in a pre-calibration data set which can be corrected by calibrating with observed values.

The Environment Agency currently reports river quality based on three yearly rolling mean data. This can give an inaccurate view of the river health as changes within industry can make improvements far quicker than this. For example, the River Inny is currently (2019) graded as 'Poor' for phosphate status however the last two years of nutrient data show substantial improvement compared to 2017. Of course, the measurement of the concentration of a pollutant will decrease downstream of the point of discharge, being influenced by the increase in dilution from additional flow inputs – overland flow or joining tributaries. Hence, in terms of compliance monitoring, a specified distance downstream of the discharge might be considered appropriate to report concentrations within the water body against any EQS. That said the WFD used not to apply any information on the spatial application of EQS values (Jirka *et al*., 2004). This was amended in 2008 and introduced the concept of mixing zones (Directive 2008/105/EC Article 4) (Bleninger & Jirka, 2011). This allowed Member States to designate a mixing zone adjacent to the point of discharge where the EQS can be exceeded. Details of any mixing zone are included within the River Basin Management Plan.

The modelling developed within this chapter has illustrated that chemical concentrations upstream of a discharge can have an impact on setting the EQS downstream of a discharge. With that in mind, hypothetical values have been utilised in an attempt to calculate required concentrations within the discharge that would meet downstream EQS values.

8 Summary/ Final Discussion / Conclusions

This study has undertaken a scientifically rigorous investigation to elucidate the environmental risk associated with a significant industrial discharge into the head-waters of a river. Within both the historic data set and the data recorded during this study, pollution events have occurred which resulted in fish kills. A part of this study has therefore been able to look at how well the river system has recovered following chemical pollution of the river.

This chapter will proceed though discussion sections related to the original objectives of the thesis. The overall content of this section fulfils objective 6 of the study (Figure 1.1).

8.1 To review temporal water quality as assessed through regular monitoring by the Environment Agency

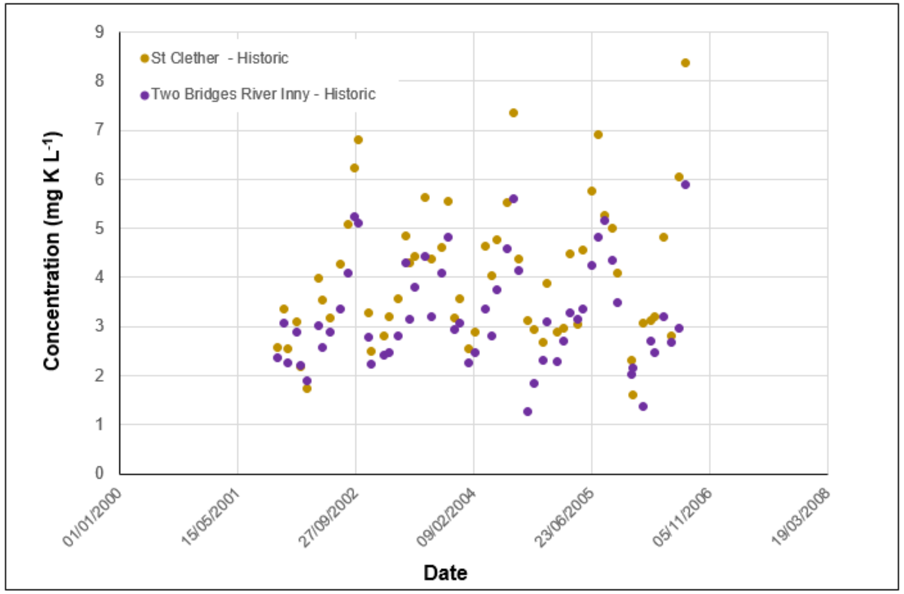
Water quality data downloaded from the Environment Agency WIMS repository has been reviewed to determine water quality characteristics over the period of review, 2000 to 2019. Data were not available for the whole period for each of the monitored sites for each of the parameters of interest but a good picture of the state of the River Inny has been determined.

Orthophosphate concentrations were lower in the latter part of the review period than the start, with the EQS being met or close to being met at most sites. Total Iron concentrations within the discharge were three times higher than the receiving waters. Mean concentration of iron within the receiving waters, DS of the outfall was below the proposed EQS of 0.73 mg L^{-1} total iron. Historic mean concentration of chloride was below 100 mg L^{-1} upstream of the discharge, whilst downstream, mean concentrations exceeded the non-statutory EQS of 250 mg L^{-1} chloride, being in the range 394 to 756 mg L^{-1} (Gardiner & Smith, 1992). Sodium data were only available for 2019 for River Inny sites. Upstream of the discharge, concentrations were in the range from 17 mg L^{-1} to 64 mg L^{-1}, whilst downstream they had increased to a range of 97 mg L^{-1} to 1300 mg L^{-1}. During the range finding experiment for, the 72h EC50 983 mg Na L^{-1}, as NaCl. There is no UK adopted EQS for sodium in freshwater but this study suggests a laboratory derived EQS of 1.45 mg Na L^{-1} when applying assessment factors in accordance with the European Commission's Technical Guidance for Deriving Environmental Quality Standards (European Commission, 2018). Mean potassium concentrations for 2019, upstream of the discharge was measured at 7.13 mg L^{-1}, compared with the downstream mean concentration of 147 mg L^{-1}. During the ecotoxicology assay, the 96 hr EC5 returned a concentration of 23 mg K L^{-1}, as KCl. Currently, no EQS exists for potassium in freshwater, although this study has suggested a laboratory derived (worst-case) EQS of 0.07 mg K L^{-1}. Mean saturated dissolved oxygen concentrations were above the EQS requirement of a minimum of 75% saturation across the monitoring period. Temperature is elevated downstream of the discharge, with mean summer water temperatures up to 20.7 ^{o}C, compared with upstream summer temperatures of 18.5 ^{o}C.

Temporal changes in water quality in the River Inny associated with the Saputo discharge are evident in historical data. Of note are the effects of lower summer river flows and DS water temperature and the increase in concentration of potassium, sodium and chloride downstream, where non-statutory EQS are exceeded, or a statutory EQS has not been established.

This study has monitored a range of water quality parameters over a period of two years. Comparison with the historic Environment Agency data (from a period of 20 years) gives an indication of the current water quality condition. Monitoring points utilised by the Environment Agency were less spatially distributed than those within this study so direct comparison has only been made on sites that share both historic and current data. Comparison of the 95 % confidence intervals illustrates a significant difference where the confidence intervals are not overlapping. Table 8.1 summarises the comparisons between historic and current data for fourteen water quality parameters measured at sites on the River Inny and Penpont Water at Two Bridges. Overall, water quality shows a statistically significant deterioration at the lower reaches of the study river for potassium and a statistically significant improvement for phosphorus, as both TRP and TP within the WwTW effluent and in-river at 2BI. Of some concern is the statistically significant decline in dissolved oxygen observed within the discharge, DS and at 2BI. Viewing this data to determine temporal trends (Figure 8.1) confirms that over the time period of this project, there has been an increase in the concentration of potassium at StC and 2BI, with concentrations, over that period orders of magnitude higher than those observed in historic data (note y-axis). Current TRP (assumed to be orthophosphate in historic data) concentrations are statistically significantly lower within the effluent, DS, StC and 2BI compared with historic data (Figure 8.2) Total phosphorus has been plotted with $\log_{10}$ y-axis in order to show the large spread of concentration data (Figure 8.3). The general trend shows a fall in concentration of TP from historic to current data.

Overtime, changes in treatment methods have reduced the concentration of TP within the treated wastewater by an order of magnitude. Data resolution does not allow this pattern to be seen within the discharge. In contrast, the concentration of TP in the River Inny at Two bridges shows an upward trend, compared with the historic data, albeit of much lower concentration.



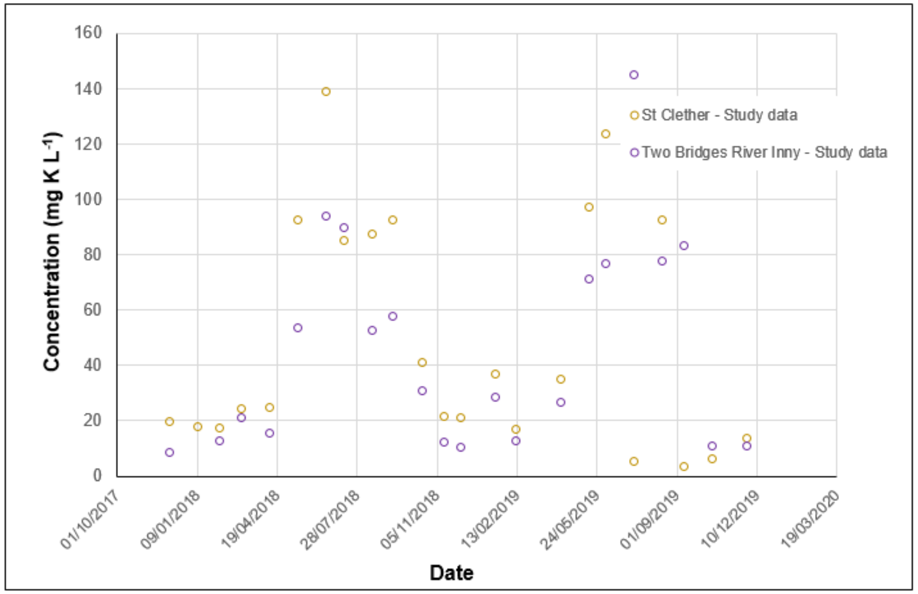


Figure 8.1 Temporal data showing historic and current concentrations of potassium at St Clether Bridge and Two Bridges Inny. Solid fill = historic data, open circles= current data. St Clether Bridge and River Inny at Two Bridges, statistically significant difference between Environment Agency and current datasets.

Table 8.1 Comparison of Environment Agency data with current water quality data. 'ns' indicates not significant, 'Sig' indicates significant difference between historic and current data, '+' indicates increase, '-' indicates decrease in mean concentration. Red indicates decline in quality green indicates improvement.

	Ca (mg L^{-1})	Mg (mg L^{-1})	Si (mg L^{-1})	K (mg L^{-1})	Na (mg L^{-1})	Cl^- (mg L^{-1})	SRP (µg L^{-1})	TRP (µg L^{-1})	TP (µg L^{-1})	Fe(dis) (µg L^{-1})	Fe(tot) (µg L^{-1})	TSS (mg L^{-1})	DO (mg L^{-1})	Temp (^{O}C)
US	ns	ns	Sig -	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
WwTW1	ns	Sig +	Sig -			ns		Sig -	Sig -			Sig +		ns
WwTW3	Sig -	ns	Sig -		ns	ns	ns	ns	Sig -	ns	ns	ns	Sig -	ns
DS	ns	ns	Sig -	ns	ns	ns	ns	Sig -	ns	ns	ns	ns	Sig-	ns
StC				Sig +		ns		Sig -	ns			ns		ns
2BPP	ns	ns		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2BI		Sig +		Sig +		ns		Sig -	Sig -		Sig +	Sig -	Sig -	ns

There is a decline in concentrations of dissolved oxygen (Figure 8.4) across the period of study and it is now lower than those measured in historic data.

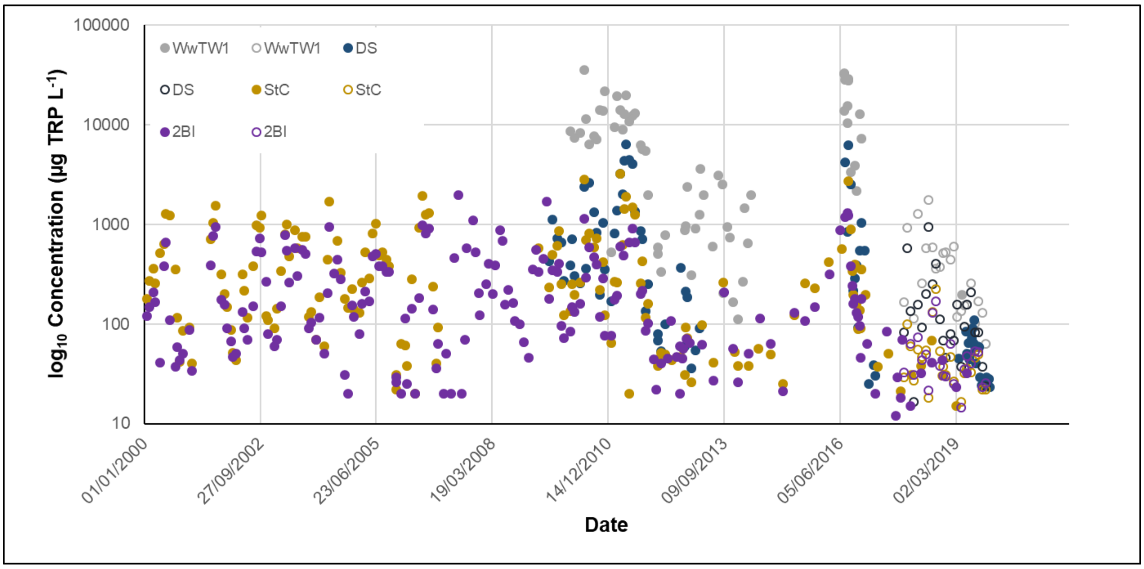


Figure 8.2 Temporal concentrations (log) of TRP. Solid fill = historic data, open circles= current data. Post treatment (WwTW1), Downstream (DS) St Clether Bridge (StC) and Two Bridges (2BPP), showed statistically significant difference between Environment Agency and current data.

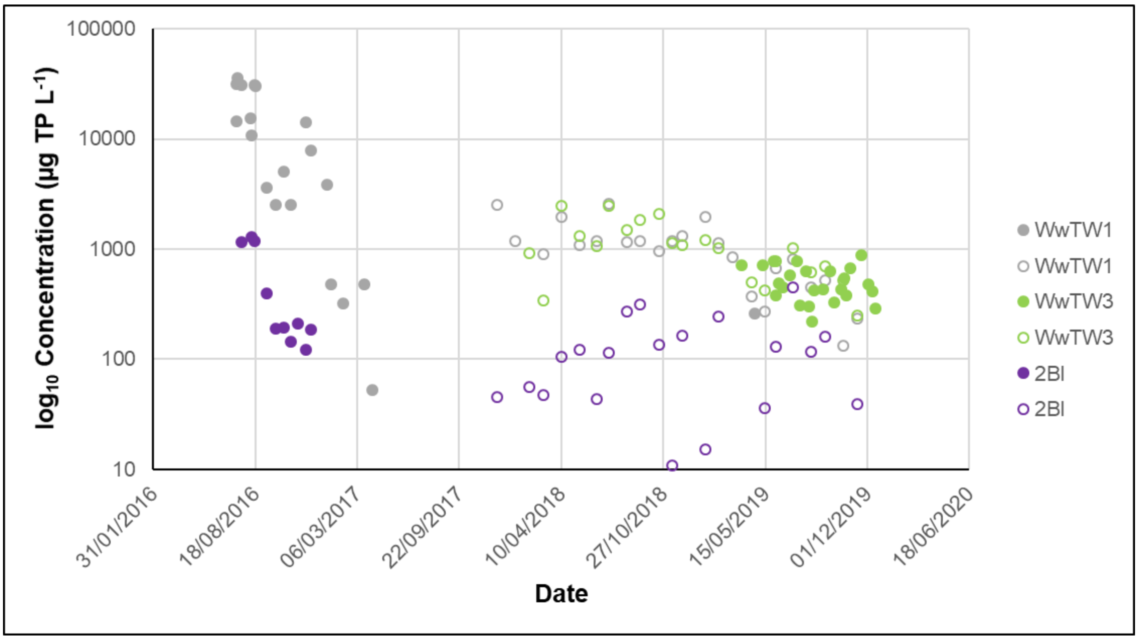


Figure 8.3 Temporal concentrations (log) of TP Solid fill = Environment Agency data, open circles= current data. Post treatment (WwTW1), Outfall (WwTW3) and Two Bridges (2BPP), showed statistically significant difference between historic and current data.

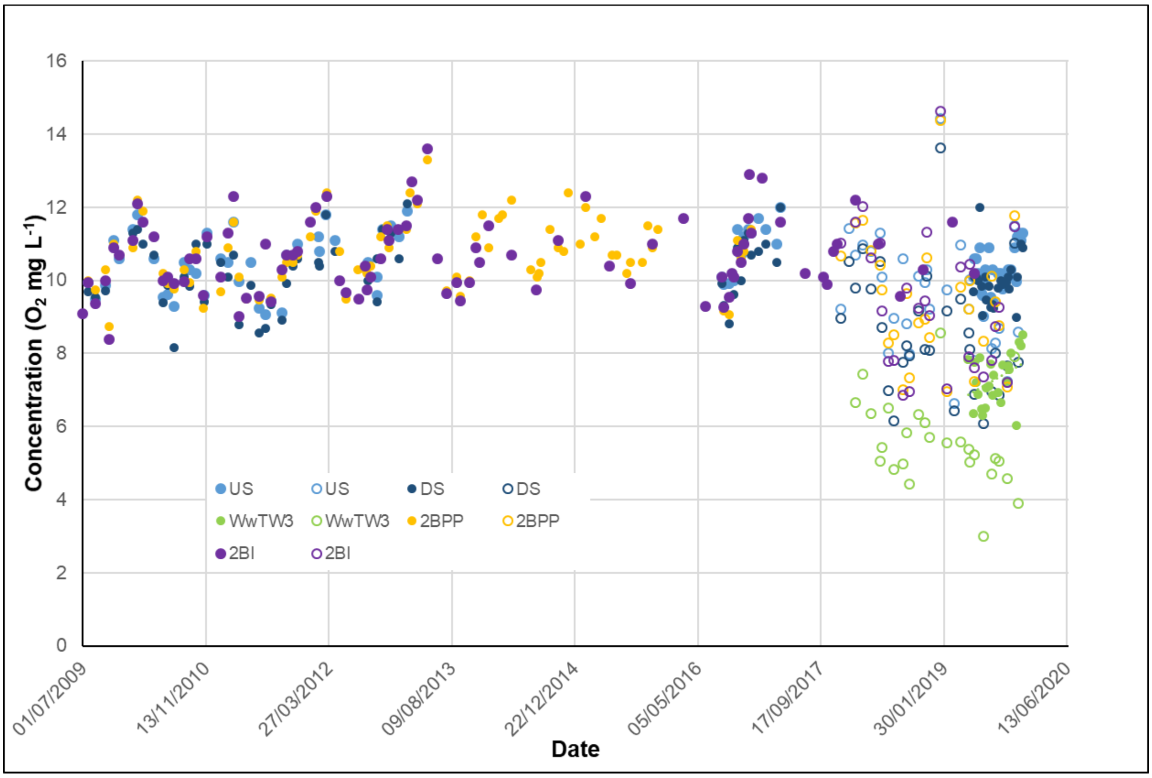


Figure 8.4 Temporal concentrations of dissolved oxygen. Solid fill = historic data, open circles= current data. Upstream (US) and Penpont Water at Two Bridges (2BPP), no significant difference between historic and current datasets. Outfall (WwTW3), Downstream (DS) and River Inny at Two Bridges (2BI) showed statistically significant difference between historic and current data.

Historic temporal data sets have been of mixed resolution, making a definitive review challenging. When compared with current data, there were insignificant changes in concentration for the majority of parameters, owing to variation in concentrations associated with changes in effluent quality, seasonality (dilution) and varying sources of chemicals to the catchment. Of the 14 determinands reviewed, 9 showed significant change (Table 8.1), with 5 indicating an improvement in environmental conditions from at least one monitored site. Just two of the monitored parameters are currently subject to permitted discharge conditions from the Regulator; Total phosphorus and total suspended sediments. Owing to the resolution of monitoring data, it is not possible to determine the impact of the permitted discharge on the receiving waters, suffice to say that the concentration of total phosphorus has fallen significantly (Figure 8.3). Regarding TSS, a significant difference between historic and current concentrations was observed at Two Bridges on the River Inny. Owing to the distance downstream from dairy operations and the lack of significant differences between historic and current data at sites between the outfall and 2BI, it is unlikely that the significant difference is associated with the dairy. Two Bridges River Inny samples are taken downstream of the A30, whilst immediately upstream of the A30 are two abandoned quarries which may, although no evidence is presented, have an influence on total suspended solids.

Nutrient water quality (phosphorus) has improved compared with the historic data. However the ionic composition of potassium, sodium and chloride is higher downstream, with potassium significantly higher at Two Bridges than observed in the historic data.

8.2 To conduct a comprehensive physico-chemical monitoring programme of water quality within the freshwater ecosystem receiving dairy processing waste.

8.2.1 Relationship between TP, TRP and SRP

Within chapters 1 and 3, discussions centred around the historic measurements of phosphorus species in river water, particularly about the lack of clarity in how sample preparation was undertaken. This results in difficulty in data comparison when there is inadequate certainty over what is being compared – is orthophosphate SRP or TRP – is there consistency and does it matter? The UKTAG river assessment method for phosphorus states that:

‘*Where necessary to ensure the accuracy of the method, samples are recommended to be filtered using a filter not smaller than 0.45 µm pore size to remove gross particulate matter.’* (UKTAG, 2014b). ‘Where necessary’ is at the discretion of the analyst, although the Method suggests that in practice, the difference between RP and SRP is usually minor.

River Inny datasets have been combined to show more comprehensively the relationship between SRP and TRP and SRP and TP, in line with that produced in Goddard *et al* (2020). Following (Environment Agency, 2016) previously discussed, Figure 8.5 shows that plotting the observed river sample values (i.e. not the WwTW samples) results in a trend line that approaches a 1:1 relationship, for both SRP and TRP. However, as shown in Figure 8.5, the majority of the data points fall below the 1:1 line, indicating that not all of the total reactive phosphorus is soluble.

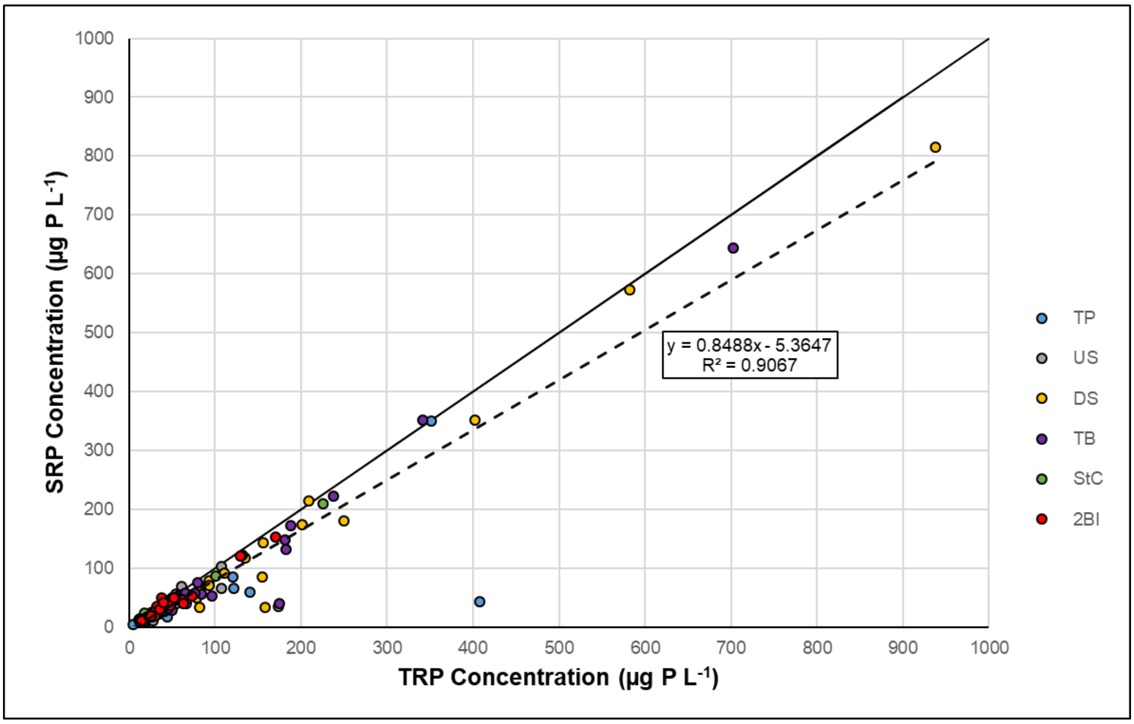


Figure 8.5 Total reactive phosphorus plotted against Soluble reactive phosphorus for the River Inny sampling sites Black line represents 1:1 relationship and dashed line the trend.

Therefore the assumption made that SRP is an equivalent measure to TRP (European Commission, (2013); UKTAG, (2013)) is clearly not validated with this data set. Focussing on the concentration range that is of relevance regarding ecological standards and replotting only data <300 µg P L^{-1} accentuates the degree of scatter observed, with SRP concentrations significantly less than TRP or TP in the majority of samples (Figures 8.6 and 8.8).

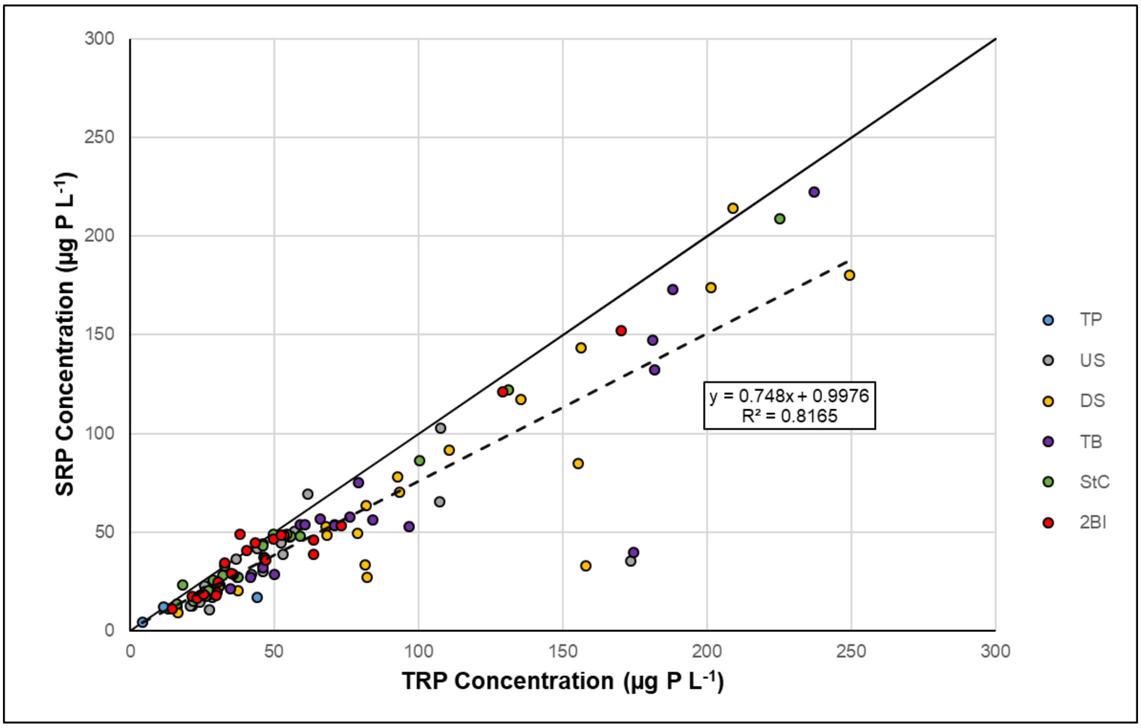


Figure 8.6 Concentrations <300 µg P L^{-1} of Total reactive phosphorus plotted against Soluble reactive phosphorus for the River Inny sampling sites. Black line represents 1:1 relationship and dashed line the trend.

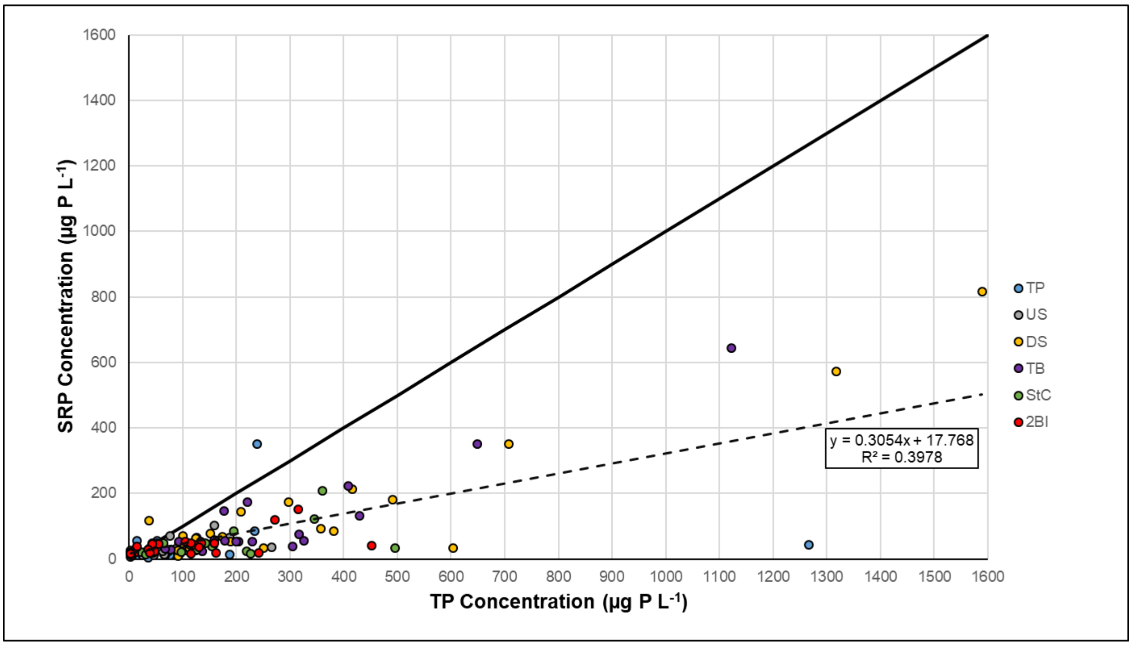


Figure 8.7 Total phosphorus plotted against Soluble reactive phosphorus for the River Inny sampling sites. Black line represents 1:1 relationship and dashed line the trend.

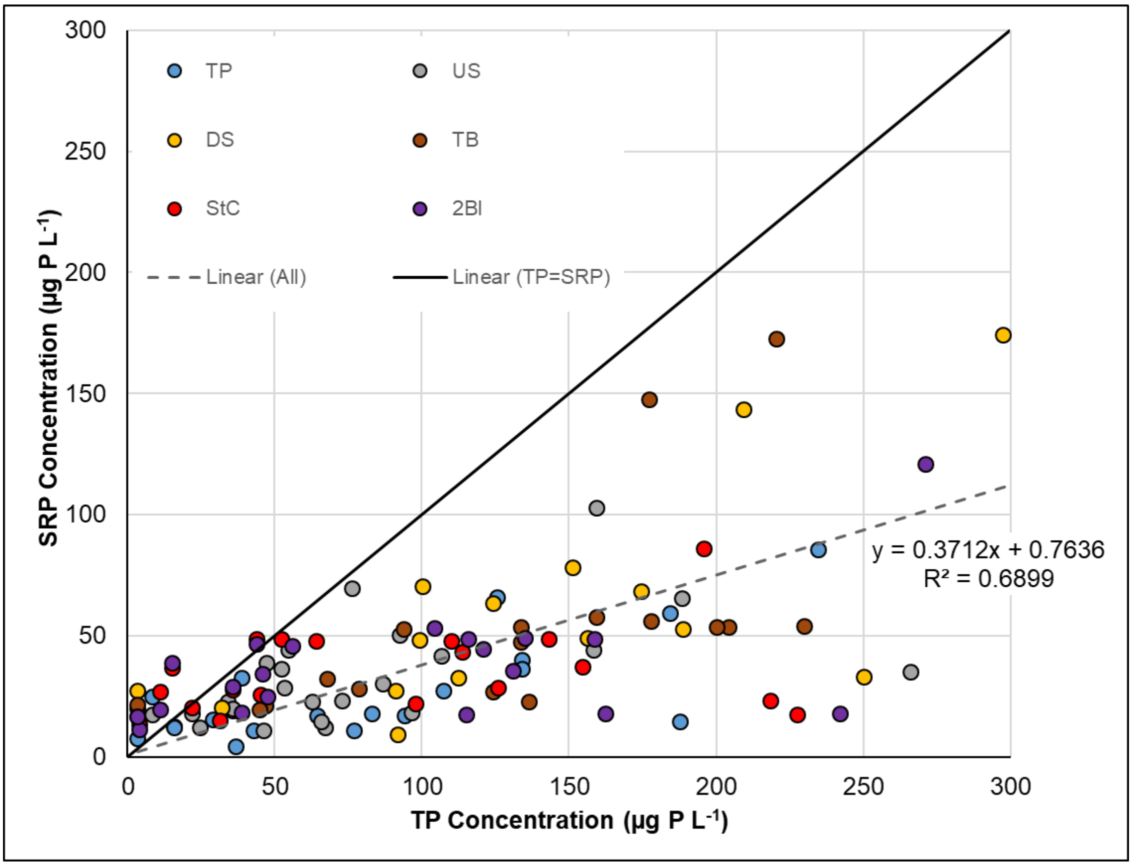


Figure 8.8 Concentrations <300 µg P L^{-1} of Total phosphorus plotted against Soluble reactive phosphorus for the River Inny sampling sites Black line represents 1:1 relationship and dashed line the trend.

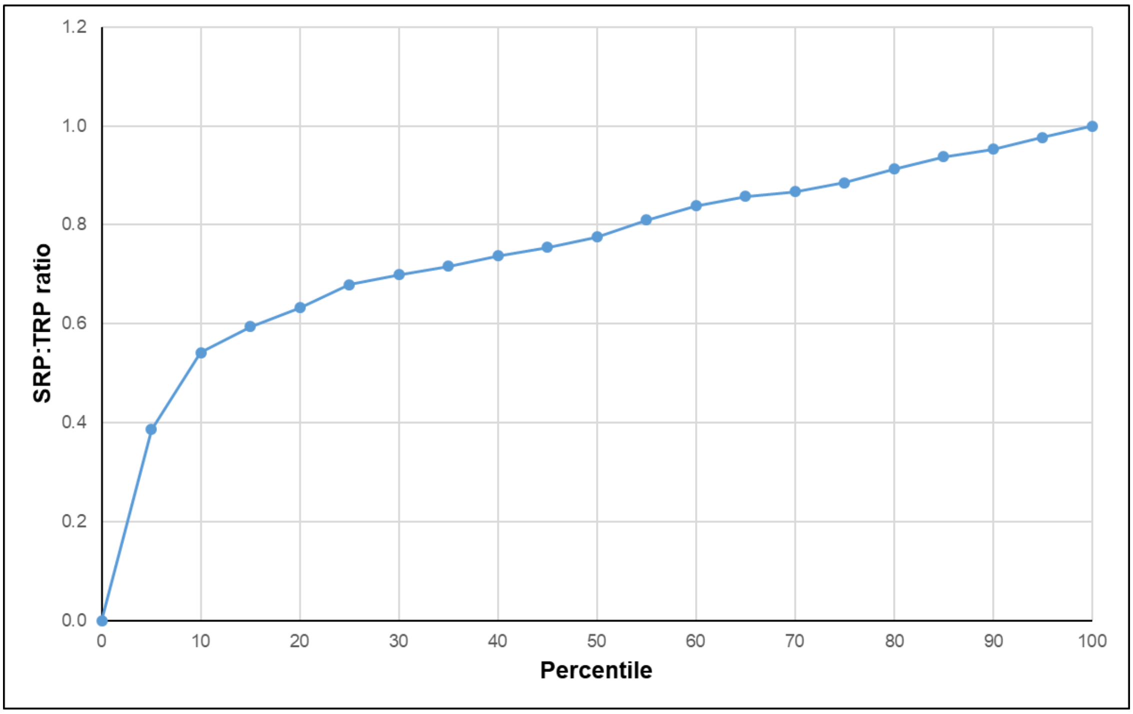


Figure 8.9 Cumulative frequency chart of the SRP:TRP ratio

Examining the data in more detail using a cumulative frequency distribution (Figure 8.9) shows that 70% of the SRP:TRP data have a ratio of <0.87 (i.e. SRP is 87% of TRP) and 30% of data have a ratio of <0.7, suggesting the presence of significant amounts of non-filterable RP. Regarding the SRP:TP ratio, a cumulative frequency chart (Figure 8.10) shows that 70% has a SRP:TP ratio <0.51, suggesting a significant portion of the TP present is non-reactive as well as non-filterable.

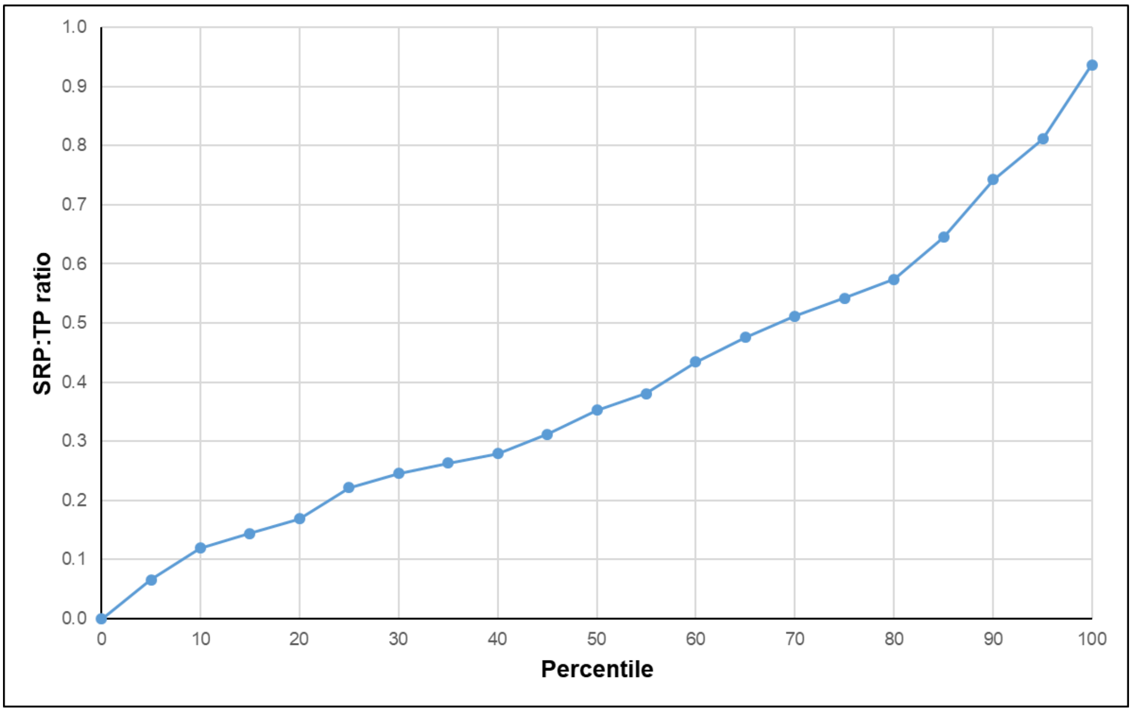


Figure 8.10 Cumulative frequency chart of the SRP:TP ratio

The confusion that exists between filtered / unfiltered or settled samples was investigated by Tappin *et al* (2016) and reported in Goddard *et al*., (2020). Higher concentrations (55 µg P L^{-1}) of phosphorus occurred most frequently in the settled/decanted samples (85% of sites, (n=13)). 71% had mean concentrations of phosphorus that were significantly different for the two sample treatments. Similar results have been shown previously for WwTW effluent (Comber *et al*., 2015). The data therefore suggest a systematic difference in measured phosphorus concentrations occurring when samples are not filtered prior to analysis (i.e. defined as TRP). Although it may be argued that this is a conservative measurement when considering phosphorus potential bioavailability, the degree of bias between filtered and settled then decanted samples will not be consistent. This has the impact of making comparison of phosphorus concentrations between sites and between sampling occasions challenging owing to the presence of varying concentrations of suspended solids and colloidal phosphorus.

8.2.2 Impact of suspended solids concentrations on SRP presence

Given the potential influence of suspended solids and colloidal material on the observed phosphorus concentrations, the datasets were further interrogated to seek any relationships or impacts of the presence and magnitude of suspended solids on the observed SRP concentrations. Higher river flows experienced during sample collection on some occasions when rivers were under spate conditions (e.g. >20 mg L^{-1}) would have led to enhanced concentrations of fine suspended solids and colloidal phosphorus in the water column (for example, from bed sediment resuspension and runoff from adjacent fields). Fine suspended solids and colloids (defined as particles ≤1μm in any one dimension) are slow to settle under gravity and would have been present in the collected samples. Owing to slow settling, they would have also been decanted with the sample prior to phosphorus determination for TRP but would have been filtered out to <0.45 μm for SRP. Under the acidic conditions of the colorimetric analytical procedure, a proportion of the fine suspended solids and colloidal phosphorus would have contributed to the measured phosphorus concentration.

Plotting the ratio of SRP to TRP/TP shows no clear trend, but suggests that where suspended solids are elevated, SRP tends to be low (Figure 8.11). The concentration of phosphorus distributed between the dissolved and particulate phase will ultimately be a function of partitioning and kinetics. Any phosphorus adsorbed to suspended solids has been suggested to be of lower reactivity and may therefore also impact on its immediate bioavailability (Banaszuk & Wysocka-Czubaszek, 2005). The amount of suspended solids present in a catchment will be a function of catchment typology and land use (i.e. likelihood of soil being lost from land), seasonal variation in flow (i.e. typically low flows in summer and high flows in winter) or the occurrence of unseasonal weather patterns, e.g. heavy summer rainfall episodes. Overlaying these physico-chemical processes, it should also be noted that a decrease in SRP concentration would be expected in summer due to higher plant productivity and uptake by phytoplankton.

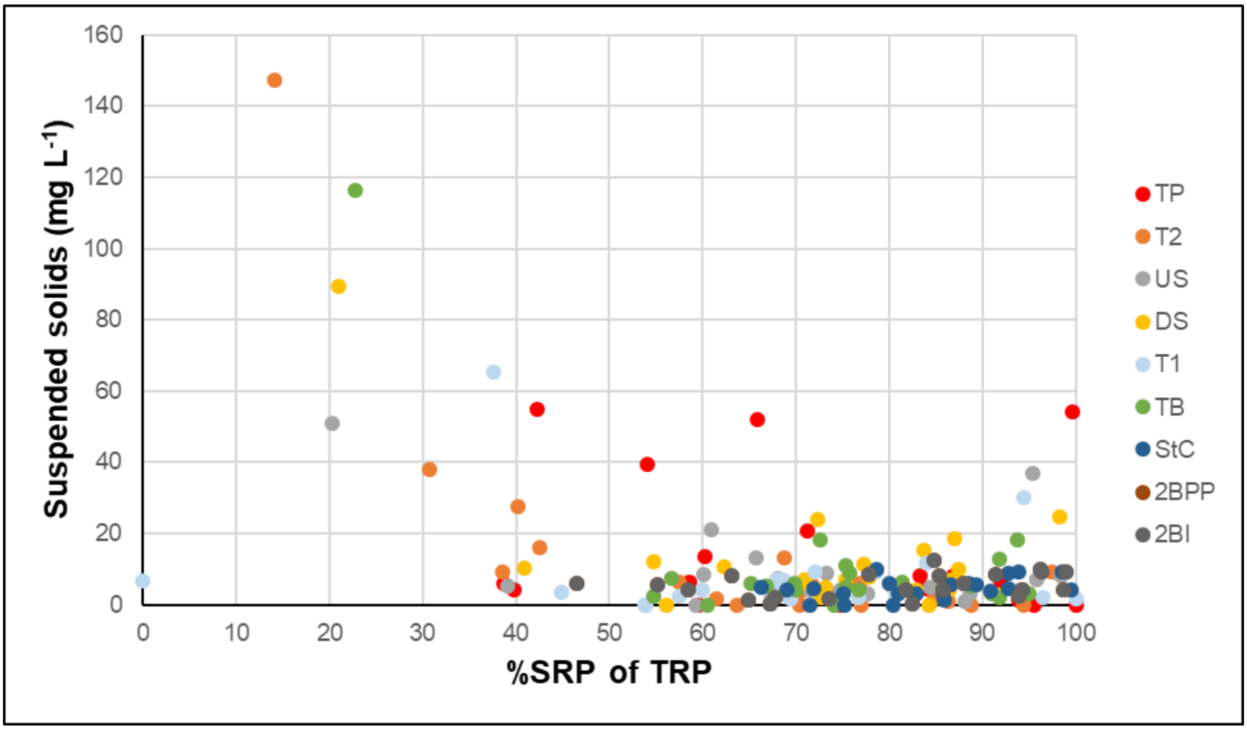


Figure 8.11 % Soluble reactive phosphorus of total reactive phosphorus vs total suspended solids, based on samples collected from River Inny, 2018-2019.

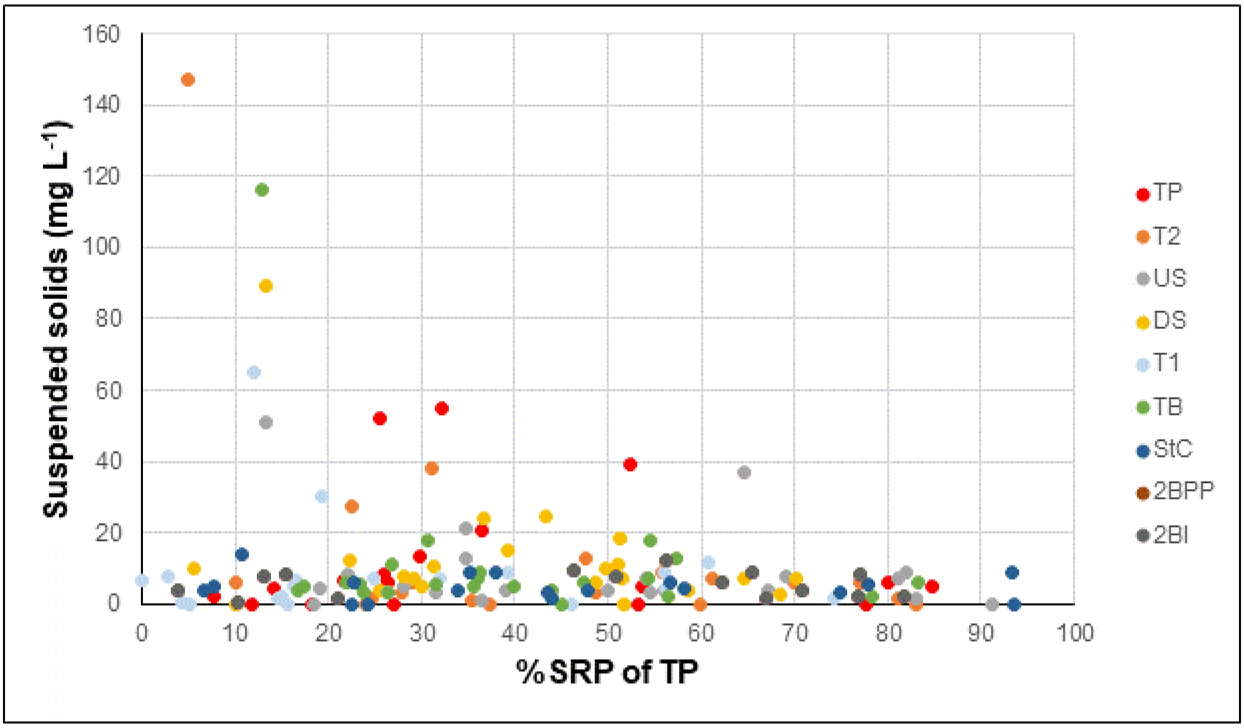


Figure 8.12 % Soluble reactive phosphorus of total phosphorus vs total suspended solids, based on samples collected from River Inny, 2018-2019.

Jarvie *et al*., (2006) established that point sources (effluent) rather than diffuse sources (agricultural) of phosphorus provide the most significant risk for river eutrophication. They found that SRP was the dominant phosphorus fraction in all UK rivers monitored (n=7) (sample sites, n=54), averaging 67% of TP. Again, considerably less than the assumed 1:1 ratio. They noted that in times of low flow, this percentage increased. The time of this study should be noted as it occurred prior to many WwTW installing phosphorus stripping, following requirements of the EU Urban Wastewater Directive and WFD.

During higher winter flows, PP can form a significant proportion of phosphorus load to a river, but owing to the timing of such events – i.e. lower phyto-productivity, its relevance to eutrophication is questionable (Jarvie *et al*., 2006). The significance of phosphorus cycling within the channel should not be understated. Withers & Jarvie (2008), cite sediment uptake rates of phosphorus of 0.16 g m^2 day^{-1} calculated by

House and Casey (1989), i.e. twice the rate of phosphorus assimilation by algae. Thus, a higher concentration of total suspended solids within the channel would be associated with a lower concentration of SRP (Figures 8.11 and 8.12); that is unless suspended sediments or resuspended bed sediments resulted in changed redox conditions or were sufficiently contaminated to drive the partitioning of phosphorus from the particulate to the dissolved phase (Burns *et al*., 2015). However, Jarvie *et al*., (2006), have undertaken experiments to assess the significance of bed sediment as a source or sink of SRP using equilibrium phosphorus concentrations (EPC_0). They found that over 80% of the 84 riverbed samples had potential for net SRP uptake from the water column under low flow conditions, where SRP in the water column exceeded the EPC_0 of the bed sediment. Release of SRP from the sediment back to the water column generally occurred where river water concentrations of SRP were low (<c.50 μg P L^{-1}). This is a further mechanism that will impact on the concentration of SRP within the river.

8.2.3 Iron as a controlling factor for observed SRP concentrations

Iron plays a key role in the biogeochemistry of phosphorus and as previously postulated (Withers & Jarvie, 2008) the presence of excess iron within the water column would be expected to form either non-filterable and/or non-reactive colloids. Plotting % SRP of TRP and % SRP of TP versus filtered (<0.45 μm filtered) iron concentrations shows no obvious trend, but as with suspended solids, high iron concentrations lead to suppressed SRP:TRP/TP ratios. Where % SRP of TP, or of TRP is 100%, all P is SRP. In a high Fe concentration situation, where a low % SRP of TP results, the difference between SRP and TP is accounted for by unreactive phosphorus or particulate bound phosphorus being present. In a high Fe concentration situation where the % SRP of TRP is low, the difference between SRP and TRP is accounted for by particulate bound phosphorus. The suppression of SRP by high concentrations of iron is the process utilised within WwTW to reduce the concentration of SRP, where, for example, iron chloride is added during the treatment process to precipitate out SRP as iron phosphate.

e.g. $FeCl_3 + Na_3PO_4 \rightarrow FePO_4 + 3NaCl$

In (Goddard *et al*., 2020), this P:Fe relationship was shown in the natural environment where rivers with Fe concentration >200 µg L^{-1} have a lower %SRP of TRP.

Comparison of the Saputo WwTW discharge composition with EA historic water quality data and that within a conventional WwTW (Table 3.2) shows a significant reduction in TP and SRP (at Saputo), but a significant increase in chloride, sodium and potassium, resulting from the stochastic removal of SRP and the demineralisation of whey.

Under oxic conditions, ferric iron (Fe (III)) forms insoluble oxyhydroxides that have a high affinity for phosphorus anions through sorption or precipitation reactions, thereby limiting phosphorus solubility (Banaszuk & Wysocka-Czubaszek, 2005; Smolders *et al*., 2017). Seasonal or spatial changes in iron speciation can change the phosphorus solubility (Smolders *et al*., 2017). Spatially, such changes can occur, for example, around industrial discharges or seasonally, for example associated with iron-rich greensand geology in times of lower flow (Shand *et al*., 2003; Goddard *et al*., 2020).

Overall the presence of SRP in the water column is a product of a complex series of biogeochemical processes, not easily disentangled, nor easily predicted with a high degree of certainty. The data presented here, however, suggests that elevated suspended solids can influence the proportion of SRP present in a sample.

The use of scientifically robust and consistent phosphorus speciation terminology in river systems is essential for scientists, regulators and industrial dischargers. A recognised standardised approach needs to be set out using a robust methodology to ensure clear future regulation and that compliance monitoring is free from any ambiguity. The existing set of guidance and regulation prevents consistent determination of P in rivers in terms of trend analysis, seasonal cycling and compliance assessment; the ability to coherently replicate tests that are free from bias and subjectivity is essential for regulators and regulated alike (Goddard *et al.*, 2020).

8.2.4 Ecological toxicity of iron

Debate continues about the effects and toxicity of iron (Peters *et al*., 2012). Typically, the dissolved form of metals are considered most relevant to ecological effects. However, water chemistry can change the form of iron present and precipitate it as insoluble Fe (III), leading to organisms being smothered, whereas Fe toxicity is often experienced at a much higher concentration. The proposed EQS threshold of 0.73 mg L^{-1} total iron has been derived to be protective of the most sensitive invertebrate taxa (Peters *et al*., 2012). At the time of writing, Saputo are not subject to a permit for iron concentrations, however the measured concentrations within the discharge and receiving waters would fail under the proposed EQS threshold of 0.73 mg L^{-1} total iron. At TB and subsequent sites further downstream of the discharge, dilution has ensured that the EQS would not have been exceeded.

8.2.5 Ecological toxicity of principal anions and cations

Salinity is significantly increased within the River Inny from upstream of the discharge to downstream. This is a result of the waste input to the treatment works from the demineralisation process. Increases in salinity from various anthropogenic origin (secondary sources) (Table 6.2) pose a growing global risk of causing severe losses in biodiversity and compromising the ecosystem services provided by the river (Cañedo-Argüelles *et al*., 2013). The concentration of hemolymph solutes in freshwater animals is generally less than 16 g NaCl L^{-1} (Withers, 1992) and they rarely survive concentrations in excess of 25 g L^{-1} (Pinder *et al*., 2005). Upstream of the discharge, Na concentrations equated to 0.04 g L^{-1}, whilst downstream they equated to 0.5 g L^{-1}, suggesting that Na concentrations are not an issue to the river's freshwater animals. High salt concentrations have been reported to adversely affect macrophyte cover and reduce macroinvertebrate and diatom species density (Cañedo-Argüelles *et al*., 2013). For example, diatoms can react to changes in Cl^- as low as 100 mg L^{-1} (Zimmermann-Timm, 2007). Increased salinity has also been associated with a reduction in the grazer and shredder species, in favour of predators, filter and deposit feeders (Marshall & Bailey, 2004) and this has been observed with *Gammarus* at the Upstream / Downstream sites, although concentrations studied by Marshall & Bailey (2004) were in the order 2000 mg L^{-1}. Knowledge is limited about whether individual ions, cumulative impacts from a combination of ions or the total ions are responsible for setting the upper and lower salinity limits of a species (Cañedo-Argüelles *et al*., 2013).

8.3 To monitor the ecological patterns of diatom and invertebrate biodiversity using established regulatory protocols for water quality protection

Within a river, SRP concentration is not always equal to TRP. Biogeochemical processes including reactions between iron and SRP and total suspended solids and SRP can alter and change the speciation of phosphorus (Withers & Jarvie, 2008). This variation in physico-chemical state controlled by ambient conditions may go some way towards explaining the mismatch observed between the ecology and chemistry within WFD waterbodies where RP is used for the determining the chemical status (UKTAG, 2013b). The UKTAG found (UKTAG, 2013b) that for samples collected in England for example, 68% out of the 221 sites have an ecological status that is either better or worse than predicted based on RP values alone. For the 29% of sites where the ecological status is better than the reported RP concentrations predict, it may be a case that the phosphorus present (measured as RP) is not necessarily 100% bioavailable. Under these conditions comparing the ecological status with SRP could result in a better agreement (See chapter 5). That is not suggesting that all chemically non-reactive P is biologically unavailable, just that using a procedurally consistent method for pre-treating and reporting of phosphorus concentrations may provide a more scientifically robust approach. UKTAG (2013) considers the major reason for the difference between derived phosphorus standard and ecological status is the influence to the biological response of phosphorus from other factors. These include, but may not be limited to site alkalinity and altitude, specific site conditions such as shade, river flow, river bed composition, grazing and the effects of other plant nutrients.

Overall, the bioavailability of different phosphorus species, particularly the particulate and non-filterable reactive species, is not fully understood and further work in this area is needed; but switching to SRP for regulatory purposes would help.

8.4 To address critical knowledge gaps on the directly harmful effects of anions and cations present in treated dairy processing waste through laboratory ecotoxicity studies

Through attempts to address the dairy waste stream, liquid whey can be further processed into marketable products; buttermilk, probiotic compounds for the food industry and formula milk, with a resulting solid waste product of nutrient rich calcium phosphate cake. This increases the financial revenue that can be generated within the dairy but depending on the subsequent processes involved, can result in a final liquid waste stream which can exhibit a different set of issues. Specifically, at Saputo Davidstow, Cl^-, K^+ and Na^+ have increased within the discharge in an attempt to manage the waste stream by processing using ionic precipitation. Adopted EQSs are not available for these salts and this study has undertaken limited toxicology experiments to determine EQS values in freshwater for Cl^-, K^+, and Na^+. However, following the strict WFD methodology, having only 1 dataset leads to the application of a 1000x safety factor, driving the derived EQS below background concentrations and considerably lower than the concentrations that the dairy could comply with if the current whey processing is to continue. No effect concentrations determined within the laboratory indicate a 72 hr EC0 =< 983 mg Na L^{-1} as NaCl and =<1517 mg Cl L^{-1} as NaCl and 96 hr EC5 =< 23 mg K L^{-1} as KCl and =<50 mg Cl L^{-1}, as KCl. That said, there is rationale to use a less stringent assessment factor and further study could reduce the assessment factor further. Literature on the biotoxic effects of ions is from research associated with salination of water courses from brines, salt mining or potash works (Canedo-Arguelles *et al*., 2016; Cañedo-Argüelles *et al*., 2013; Zimmermann-Timm, 2007). Ionic concentrations associated with these sources are considerably higher than those observed within the River Inny. However, potassium is identified as an ion with toxic effects, yet an assay to consider specific effects is yet to be determined (Ziemann & Schulz, 2011).

8.5 To conduct a deterministic risk assessment of anion and cation exposures versus laboratory ecotoxicology data, supported by ecological monitoring indicators of water quality

The methods of risk assessment on which the EQS derivation are based rely on a worst case assumption (European Commission, 2018). This is a legitimate approach to ensure environmental protection through the precautionary principle but may lead to unworkable or unrealistic target EQS concentrations. Within the River Inny, at the top of the catchment, potassium concentrations were measured far in excess of the laboratory derived EQS (mean concentration of 2.1 mg L^{-1} vs EQS $_{calculated}$ 0.07 mg K L^{-1}) (See Section 8.4 for No effect Concentrations).

The general regulatory approach to EQS is designed for a wide range of chemicals with potential developmental and reproductive toxicity as per (Table 6.1) (from EC 2018 Guidance document 27). This applies an assessment factor of 1000 to an acute EC50 value, based on limited tests and trophic levels. This assessment factor of 1000 is used by regulators to include a factor of 10 for acute to chronic effects, plus a factor of 10 for extrapolating from one species to multiple species, plus a factor of 10 for a single chemical exposure study under optimal laboratory conditions versus a complex environment (which would include multiple physico-chemical stressors and chemical mixtures), for example sodium in the presence of chloride (Gardiner & Smith., 1992). Given the essential requirements of sodium and potassium and their mode of action in relation to osmoregulation in crustaceans (Griffith, 2017), then acute to chronic effects due to developmental or reproductive toxicity are physiologically unlikely and thus the acute-chronic factor of 10 is therefore not justified for these ions. Hence this means for the River Inny EQS for the ions of interest, an overall factor of 100 is more environmentally realistic (adapting Table 6.1).This would change the EQS to be 0.7 mg K L^{-1}, 14.5 mg Na L^{-1} and 1.3 mg Cl^{-} L^{-1} (as KCL) and 30 mg Cl^{-} L^{-1} (as NaCl), Still far below the top of catchment concentration of 2 mg K L^{-1}, but comparable to the top of catchment mean concentration of 14 mg Na L^{-1} and 20 mg Cl^{-} L^{-1}. Longer term toxicity studies using multiple trophic levels could potentially reduce the EQS further to factors of 50 or even 10. *Daphnia pulex* would ordinarily be used as a crustacean test organism and for consistency with other tests should be considered, however in the case of discharges into fast flowing rivers, such as the River Inny, *D.pulex* would not be representative of the organisms present. Despite a more robustly determined EQS concentration, discharge of a strong ionic composition waste into the upper reaches of a river is likely to remain of concern to the regulator. The undertaking of ecotoxicological tests of Na, K and Cl were driven by the ecological and chemical monitoring of the River Inny which showed a significant decrease in the Gammarus count downstream of the discharge believed to be associated with significant increases in K, Na and Cl concentrations.

8.6 To provide a clear impact study to be used in any future negotiation of revision of consent to discharge treated dairy waste into a river

This thesis provides an in-depth assessment of the impacts of a dairy processing unit on the receiving waters of a head water river. SIMCAT modelling of concentrations of the discharge components provides a platform from where discussions on permit setting can proceed (Chapter 7). Generally, effective treatment and discharge control can keep the impact on the headwaters to an acceptable level where freshwater invertebrate communities meet or are close to a quality condition level classed as 'good' status under WFD classification. However, more detailed community structure and species diversity is not accounted for within the assessment. With ever increasing public and political pressure on water industries to improve river water quality, the regulator will continue to monitor, revise down and strengthen permits. Nonetheless, this stability is predicted on seasonal river flows providing adequate dilution and the threat from drier summers and increased upstream demand for water abstraction resulting from climate change. The spatial monitoring provided within this study has captured chemical and ecological changes to the watercourse associated with a pollution event. Subsequent to this event, recovery in the invertebrate community was observed. However, minimal impact was observed from the diatom data.

Through this study it has been shown that the historic ecological condition (nutrients and ecology) status of the river varied between 'Poor' and 'High'. Current regulatory assessment, based on the previous three year's data have modelled the status as 'Moderate' and the monitoring conducted as a part of this study also as 'Moderate'.

8.7 Final Conclusions

This study has shown that a small upper catchment river is challenged to receive treated dairy waste with a high ionic concentration without affecting the biota of the water body. With sufficient flow, dilution allows for a functioning biotic community, but with low flows and factors such as treatment malfunction, the river becomes stressed beyond its healthy threshold. The thesis brings to light issues of the impact of wastewater treatment on biota where no EQS exists. It illustrates the lack of consistency between quality monitoring of water chemistry and ecology and demonstrates how an upper catchment river can recover from a pollution incident of industrial source. This study has for the first time monitored the spatial and temporal behaviour of water chemistry and ecology, and the associated upstream / downstream changes in relation to a point source discharge from a dairy processing unit into upper catchment receiving waters. Further to the preliminary study, ecotoxicological trials have been undertaken in an attempt to derive Environmental Quality Standards for chemicals within the treated waste stream that do not currently have any environmental controls.

8.8 Recommendations for further research

With the availability of further time and financial resources, a deeper understanding of some of the issues uncovered in this study could be achieved through:

- A more in depth long term toxicity investigation of 1) locally sourced *Gammarus* and molluscs to determine any population adaptation to the increased ionic concentrations affecting environmental conditions, coupled with investigation of the ions of concern using multi-trophic levels of organism with longer duration ecotoxicology experiments This would potentially allow less stringent assessment factors to be applied in the derivation of an EQS.
- A further study immediately upstream of Inny Vale to determine impact of drainage overflow on the River Inny.
- Replication of point source discharges to the upper river catchment from similar wastewater processing plants.
- A wider spatial study from St Clether Bridge, the Environment Agency's monitoring point for catchment status, to the top of the catchment to determine

further significant point and diffuse discharge of nutrient and saline sources not related to the Saputo activities.

- A further study of macrophyte condition over a wider stretch of the catchment, outside of the direct influence of the discharge, coupled with detailed water quality sampling to provide more detailed understanding of the association of water chemistry with macrophyte diversity.

8.9 Limitations of the study

This study has suffered some impact from restrictions imposed through the COVID pandemic. Diatom samples could not be processed due to time constraints resulting from laboratory closures. This was overcome by engaging with an external contractor to undertake this element.

One of the waste products of the demineralisation process is a calcium phosphate cake which has potential for use as a nutrient rich fertiliser (Urbanowicz, 2018). This has been applied to land in the local area, possibly the Inny catchment. Wider study could have determined potential nutrient diffuse inputs to the River Inny from this source.

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Appendices

Appendix 1

Explanatory notes associated with Table 6.1

a) The use of a factor of 1000 on short-term toxicity data is a conservative and protective factor and is designed to ensure that substances with the potential to cause adverse effects are identified. It assumes that the uncertainties identified above make a significant contribution to the overall uncertainty. For any given substance there may be evidence that this is not so, or that one particular component of the uncertainty is more important than any other. In these circumstances, it may be necessary to vary this factor. This variation may lead to a raised or lowered assessment factor depending on the available evidence. A factor lower than 100 should not be used in deriving a $QS_{fw, eco}$ from short-term toxicity data. The use of a factor different from 1000 on short-term toxicity data should not be regarded as normal and should be fully supported by accompanying evidence.

b) An assessment factor of 100 is applied to a single long-term result (e.g. EC10 or NOECs) (fish or Daphnia) if this result was generated for the trophic level showing the lowest L(E)C50 in the short term tests. If the only available long-term result (e.g. EC10 or NOECs) is from a species (standard or nonstandard organism) which does not have the lowest L(E)C50 from the short-term tests, applying an assessment factor of 100 is not considered as protective of other more sensitive species. Thus, the hazard assessment is based on the short-term data and an assessment factor of 1000 applied. However, the resulting QS based on short-term data may not be higher than the QS based on the long-term result available.
An assessment factor of 100 can also be applied to the lowest of two long-term results (e.g. EC10 or NOECs) covering two trophic levels when such results have not been generated from that showing the lowest L(E)C50 of the short-term tests. This should, however, not apply in cases where the acutely most sensitive species has an L(E)C50 value lower than the lowest long-term result (e.g. EC10 or NOECs) value. In such cases the QS might be derived by using an assessment factor of 100 to the lowest L(E)C50 of the short-term tests

c) An assessment factor of 50 applies to the lowest of **two** long term results (e.g. EC10 or NOECs) covering two trophic levels when such results have been generated covering that level showing the lowest L(E)C50 in the short-term tests. It also applies to the lowest of **three** long term results (e.g. EC10 or NOECs) covering three trophic levels when such results have not been generated from that trophic level showing the lowest L(E)C50 in the short-term tests. This should however not apply in cases where the acutely most sensitive species has an L(E)C50 value lower than the lowest longterm result (e.g. EC10 or NOECs) value. In such cases the QS might be derived by using an assessment factor of 100 to the lowest L(E)C50 of the short-term tests.

d) An assessment factor of 10 will normally only be applied when long-term toxicity results (e.g. EC10 or NOECs) are available from at least three species across three trophic levels (e.g. fish, Daphnia, and algae or a non-standard organism instead of a standard organism). When examining the results of long-term toxicity studies, the $QS_{fw, eco}$ should be calculated from the lowest available long-term result. Extrapolation to the ecosystem can be made with much greater confidence, and thus a reduction of the assessment factor to 10 is possible. This is only sufficient, however, if the species tested can be considered to represent one of the more sensitive groups. This would normally only be possible to determine if data were available on at least three species across three trophic levels. It may sometimes be possible to determine with high probability that the most sensitive species has been examined, i.e. that a further long-term result (e.g. EC10 or NOECs) from a different taxonomic group would not be lower than the data already available. In those circumstances, a factor of 10 applied to the lowest long-term result (e.g. EC10 or NOECs) from only two species would also be appropriate. This is particularly important if the substance does not have a potential to bioaccumulate. If it is not possible to make this judgment, then an assessment factor of 50 should be applied to take into account any interspecies variation in sensitivity. A factor of 10 cannot be decreased on the basis of laboratory studies.

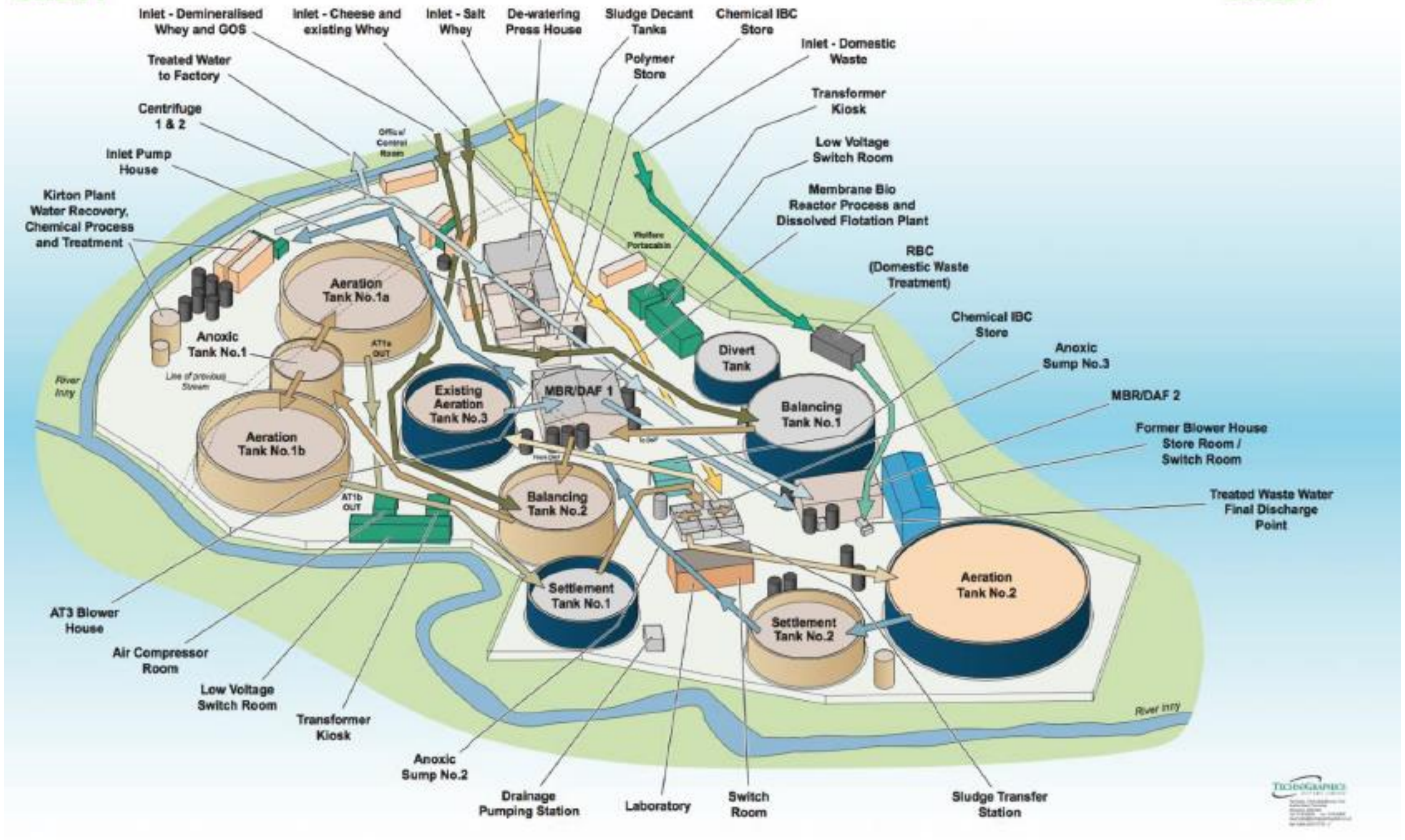
e) Basic considerations and minimum requirements.

f) The assessment factor to be used on mesocosm studies or (semi-) field data will need to be reviewed on a case-by-case basis.

Appendix 2

Appendix 2

Davidstow
Waste Water Treatment Plant



Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (µs cm^{-1})	DO ppm	% DO	Temp °C	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
1WTP	Top	SX14934 87137	256	06/12/2017	10:04	1027	0.81	0.1	6.56	142.4	11.36		9.6	8	
1WT2	Plant surface water	SX15203 87003	244	06/12/2017			2.9	0.18	6.71	175	10.82		10.3	6	
1WUS	U/S discharge	SX16904 86696	214	06/12/2017	13:54				6.66	190.8	9.22		10.5	3	
1WwTW1	Dairy WWTW	SX14881 86584		06/12/2017					7.51	7480	9		14.5	25	
1WDS	D/S discharge	SX16898 86659	219	06/12/2017					6.7	810	8.96		10.8	10	
1WT	Trib	SX16930 86588	216	06/12/2017					6.65	134.9	10.13		10.5	9	
1WTB	Trewinnow Bridge	SX16999 86520	232	06/12/2017					6.72	876	8.78		10.8	7	
1WSTC	St Clether Bridge	SX20589 84144	167	06/12/2017					6.61	557	10.83		10.6	6	
1W2BPP	Two Bridges-PenPoint	SX27039 81662	116	06/12/2017					6.67	123.2	10.67		10.1	9	
1W2BI	Two Bridges - Inny	SX27081 81738	110	06/12/2017					6.71	306	11.01		10.2	9	
01_I_US	Upstream			20/11/2017	14:25		2.05	0.31	5.31		10.31		11.4		
01_I_DS	Downstream			30/11/2017	09:40	1017	2	0.45	6.66	276	12		7.8		
01_I_t	Trib1			20/11/2017	13:21		1.9	0.26	5.76		10.81		11.2		
01_I_TB	Trewinnow Bridge		232m	20/11/2017	11:52		3.8	0.39	7.51		10.31		12		
01_I_2BPP	TwoBridges PP		116m	20/11/2017	09:26	1018	13	0.3	6.54		10.9		10.6		
2WTP	Top			09/01/2018	10:07	1005			5.88	167.4	9.78		8.4	0	
2WT2	Plant surface water			09/01/2018	11:18				6.92	263	10.65		7.8	24	
2WUS	U/S discharge			09/01/2018	14:06				5.78	442	11.43		8.9	47	
2WwTW1	Dairy WWTW			09/01/2018					7.46	8930	6.75		16.7	18	
2WDS	D/S discharge			09/01/2018	14:29				5.74	987	10.53		8	24	
2WT	Trib			09/01/2018	13:49				6.59	138.8	11.12		8.75	0	
2WTB	Trewinnow Bridge			09/01/2018	13:22				6.86	895	11.21		9.4	18	
2WSTC	St Clether Bridge			09/01/2018	15:54				5.56	462	11.21		9.8	3	
2W2BPP	Two Bridges-PenPoint			09/01/2018	Too dark to sample safely										
2W2BI	Two Bridges - Inny			09/01/2018											
3WTP	Top			06/02/2018	10:02	1020			5.64	145.4	10.34		6.9	7	
3WT2	Plant surface water			06/02/2018	12:44				6.75	195.8	10.71		6.3	21	
3WUS	U/S discharge			06/02/2018	14:08				6.76	366	10.7		7.6	10	
3WWwTW1	Dairy WWTW								na	na	#N/A		na	na	
3WWwTW2	Composite sample			06/02/2018	11:25				7.93	7680	9.79		8.4	11	
3WWwTW3	Outfall	SX16899 86669	223	06/02/2018	14:40				7.55	10790	6.66		16.5	8	
3WDS	D/S discharge			06/02/2018	14:23				6.88	106.7	9.8		7.9	7	
3WT	Trib			06/02/2018	13:53				6.74	140	10.64		7.1	0	
3WTB	Trewinnow Bridge			06/02/2018	13:22				7.01	777	9.9		7.3	2	
3WSTC	St Clether Bridge			06/02/2018	15:30				7.61	452	11.2		7.5	4	
3W2BPP	Two Bridges-PenPoint			06/02/2018	16:09				7.13	129.6	11.57		6.7	2	
3W2BI	Two Bridges - Inny			06/02/2018	16:27				7.06	375	11.6		6.8	4	
4WTP	Top			06/03/2018	09:39	988			6.18	153.8	12.53		6.9	0	
4WT2	Plant surface water			06/03/2018	12:53				6.45	221	10.94		8.7	0	
4WUS	U/S discharge			06/03/2018	13:55			0.24	6.74	233	10.98		10.2	0	
4WWWTW	Dairy WWTW			06/03/2018	11:16				7.39	7150	8.33		14.5	17	
4WWTW2	WWTW Composite			06/03/2018	11:30				8.06	9290	11.95		9.5	32	
4WWTW3	Outfall to Inny			06/03/2018	14:30				7.91	12980	7.43		16.6	1	
4WDS	D/S discharge			06/03/2018	14:15			0.22	6.85	324	10.87		10	0	
4WT	Trib			06/03/2018	13:40			0.22	6.72	138.2	11.46		9.2	2	
4WTB	Trewinnow Bridge			06/03/2018	13:16				7.09	1260	12.48		10.01	0	
4WSTC	St Clether Bridge			06/03/2018	15:27				7.31	546	11.87		9.2	0	
4W2BPP	Two Bridges-PenPoint			06/03/2018	16:04				7	113.5	11.64		7.7	3	
4W2BI	Two Bridges - Inny			06/03/2018	16:17				7.44	490	12.03		8	11	

Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (µs cm^{-1})	DO ppm	% DO	Temp ^oC	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
5WTP	Top			10/04/2018	09:12	995		0.07	6.46	149.2	12.75	103.8	9.8	7	6
5WT2	Plant surface water			10/04/2018	11:45			0.1	6.35	238	9.36	86.7	9.8	10	9.33
5WUS	U/S discharge			10/04/2018	13:20			0.25	6.09	269	10.79	95.7	10.7	2	3
5WWWTW	Dairy WWTW			10/04/2018	10:36				7.26	10050	5.05	61.5	21.3	35	35.33
5WWTW2	WWTW Composite			10/04/2018	10:36				7.56	7680	12.09	86.4	7.5	26	38.33
5WWTW3	Outfall to Inny			10/04/2018	14:00				7.3	9750	6.35	67.3	20.3	12	11
5WDS	D/S discharge			10/04/2018	13:40			0.23	6.13	1237	9.77	93.6	12	5	2.67
5WT1	Trib			10/04/2018	13:00			0.32	6.57	136.2	10.51	94.8	10.2	2	6.67
5WTB	Trewinnow Bridge			10/04/2018	12:30			0.30	6.95	1096	10.3	90.2	11	7	6.33
5WSTC	St Clether Bridge			10/04/2018	15:00			0.24	7.39	649	9.84	93.2	11.7	0	3
5W2BPP	Two Bridges-PenPoint			10/04/2018	15:40			na	7.26	128.6	10.81	95.4	11	8	8.33
5W2BI	Two Bridges - Inny			10/04/2018	15:57			0.34	7.26	46.9	10.63	98.9	11.3	4	3
6WTP	Top			15/05/2018	09:44	1024		0.07	6.41	169	10.05	90.7	10.9	2.5	0
6WT2	Plant surface water			15/05/2018	11:50			0.10	6.55	219	10.7	102.8	12.9	5	0
6WUS	U/S discharge			15/05/2018	13:25			0.21	6.84	347	11.29	113.1	14.4	3.7	4.3
6WwTW	Dairy WWTW			15/05/2018	11:09			na	8.15	16493	6.58	77.7	21.7	11	7.3
6WwTW2	WWTW Composite			15/05/2018	11:15			na	8.87	10630	12.87	111.5	9.5	36	28.5
6WwTW3	Outfall to Inny			15/05/2018	13:49			na	8.17	10347	5.06	60.1	23.7	16	11
6WDS	D/S discharge			15/05/2018	13:38			0.14	7.65	2230	10.52	106.2	16.5	2	0
6WT1	Trib			15/05/2018	13:08			0.25	6.82	156	10.45	97.8	13.8	2	0
6WTB	Trewinnow Bridge			15/05/2018	12:50			0.19	7.75	2957	11.25	106.5	15.5	2	3
6WSTC	St Clether Bridge			15/05/2018	14:22			0.15	8.28	1414	10.66	102.4	14.8	7	0
6W2BPP	Two Bridges-PenPoint			15/05/2018	15:18			0.4	7.64	138	10.41	102.1	13.2	3	0.3
6W2BI	Two Bridges - Inny			15/05/2018	15:35			0.305	7.75	928	11.02	104.3	13.9	5	4
2ITP	Top			24/05/2018	13:21		0.8	0.065	7.48	148.5	11.12	109.2	16.6		
2IT2	Plant surface water			24/05/2018	14:20		na	na	6.93	192.4	11.7	114.6	18.8		
2IUS	U/S discharge			24/05/2018	09:30		2.88	0.092	7.21	344	10.1	94.3	14.5		
WTW1	Dairy WWTW			24/05/2018	12:33		na	na	8.35	1684	6.66	71.2	22.1		
WTW2	WWTW Composite			24/05/2018	12:33		na	na	8.9	2140	10.08	105	12.9		
WTW3	Outfall to Inny			24/05/2018	11:25		#N/A	#N/A	8.18	8650	5.43	82.6	28.2		
2IDS	D/S discharge			24/05/2018	10:50		3.45	0.194	8.01	4270	8.71	94.3	19.4		
2IT1	Trib			24/05/2018	14:41		2	0.2	6.66	147.1	10.5	105.7	16.4		
2IT1	Trib			24/05/2018	09:22		na	na	7.29	145.1	11.27	104.7	14.3		
2ITB	Trewinnow Bridge			24/05/2018	13:29		3.65	0.256	7.27	850	10.48	115	18.1		
2ITB	Trewinnow Bridge			24/05/2018			na	na	7.83	3111	9.44	102.8	16.9		
2IStC	St Clether Bridge			24/05/2018	14:55		6.4	0.169	8.04	1489	10.05	91.1	17.5		
2I2BPP	Two Bridges-PenPoint			24/05/2018	09:00	1019	12.8	0.286	6.19	119.8	10.76	105.5	12.5		
2I2BPP	Two Bridges-PenPoint			24/05/2018	08:46		na	na	6.72	128.2	9.75	105.8	13.9		
2I2BI	Two Bridges - Inny			24/05/2018	11:13		8.6	0.246	7.7	1645	9.88	107.2	13.5		
2I2BI	Two Bridges - Inny			24/05/2018	08:37	1020	na	na	7.24	957	9.17	97.5	14.4		
7WTP	Top			19/06/2018	09:20	1025		0.035	6.45	191	8.02	77.2	14.3	44	52
7WT2	Plant surface water			19/06/2018	11:32			0.08	5.12	327	8.7	90.1	15.2	2.7	7
7WUS	U/S discharge			19/06/2018	13:20			0.193	5.05	662	8.01	83.4	18.2	2	5
7WwTW1	Dairy WWTW			19/06/2018	10:30			na	8.27	9160	5.57	63.8	22	20.5	1.33
7WwTW2	WWTW Composite			19/06/2018	10:30			na	8.38	10980	7.22	73.9	15	78	67
7WwTW3	Outfall to Inny			19/06/2018	14:00			na	8.15	9240	6.5	80.7	27.1	8	9
7WDS	D/S discharge			19/06/2018	13.45			0.193	8.02	4600	6.99	78.9	22.1	6.7	4
7WT1	Trib			19/06/2018	12:50			0.17	4.71	164.2	7.99	80	16.1	17.3	30
7WTB	Trewinnow Bridge			19/06/2018	12:38			0.21	6.23	4310	7.12	77	19.5	3	2
7WSTC	St Clether Bridge			19/06/2018	14:55			0.14	8.62	1994	9.75	105.3	19.4	4	5.67
7W2BPP	Two Bridges-PenPoint			19/06/2018	15:35			na	7.04	128	8.3	84	16.7	4	2.33
7W2BI	Two Bridges - Inny			19/06/2018	15:48			0.29	8.18	1389	7.78	80.3	17.3	5	5.67

Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (µs cm^{-1})	DO ppm	% DO	Temp °C	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
8WTP	Top			12/07/2018	09:20	1022		0.03	6.72	171.6	7.45	74.7	15.6	10.3	13.3
8WT2	Plant surface water			12/07/2018	11:32			0.05	7.34	884	8.16	90.1	16.8	3.0	1
8WUS	U/S discharge			12/07/2018	13:20			0.18	6.92	386	8.97	100.7	21.6	5	4
8WwTW1	Dairy WWTW			12/07/2018	10:30			na	7.6	7890	4.19	54.5	27.7	16	10.3
8WwTW2	WWTW Composite			12/07/2018	10:30			na	8.66	12160	7.66	76.4	16.8	35.7	29.7
8WwTW3	Outfall to Inny			12/07/2018	14:00			na	8.41	18570	4.83	61.8	29.5	28	23.3
8WDS	D/S discharge			12/07/2018	13.45			0.12	8.41	5780	6.17	76.8	26.1	22.0	18.7
8WT1	Trib			12/07/2018	12:50			0.18	6.46	186.7	8.22	86.6	17.2	4.0	0
8WTB	Trewinnow Bridge			12/07/2018	12:38			0.18	8.05	4640	7.26	82.3	24.4	14	12.7
8WSTC	St Clether Bridge			12/07/2018	14:55			0.10	8.89	1594	7.32	78.9	18.6	14	14.00
8W2BPP	Two Bridges-PenPoint			12/07/2018	15:35			na	7.03	144.5	8.52	86.4	17.1	10	9.00
8W2BI	Two Bridges - Inny			12/07/2018	15:48			0.26	8.43	1697	7.8	81.8	17.7	14	13.00
9WTP	Top			16/08/2018	09:17	1014		0.02	6.75	187.1	7.49	75.7	15	36.3	20.7
9WT2	Captures DC surface water			16/08/2018	10:49			0.08	6.11	262	7.48	75	15.4	12	13
9WUS	U/S discharge			16/08/2018	11:37			0.10	6.71	223	10.6	106	16.9	22.7	21
9WwTW1	Dairy WWTW			16/08/2018	10:00			na	8.35	10222	5.7	68.5	24.2	28.3	13.3
9WwTW2	WWTW Composite			16/08/2018	10:00			na	8.42	12180	8.34	80	13.8	82.3	77
9WwTW3	Outfall to Inny			16/08/2018	11:55			na	8.25	17180	4.98	58	26.5	17	14
9WDS	D/S discharge			16/08/2018	11:48			0.13	7.96	12480	7.77	84.1	19.3	24	24
9WT1	Trib			16/08/2018	11:26			0.64	6.14	158.5	8.9	89.2	15.8	10.7	9
9WTB	Trewinnow Bridge			16/08/2018	11:10			0.20	7.77	3410	7.54	78.5	17.6	23.3	18
9WSTC	St Clether Bridge			16/08/2018	12:31			0.18	8.1	2330	7.74	80	17.1	8	8.67
9W2BPP	Two Bridges-PenPoint			16/08/2018	08:30			na	6.41	135.5	7.01	72.6	15.7	6	4.00
9W2BI	Two Bridges - Inny			16/08/2018	08:42			0.21	8.08	695	6.85	81.5	16	11.7	10
3ITP	Top of catchment			30/08/2018	15:40:00			0.000	6.93	183.8	9.11	88.6	13.9	na	na
3IT2	Tributary 2, d/s of WwTW			30/08/2018	13:37:00		2.350	0.052	6.77	307	8.42	82	14.1	7.7	10.3
3IUS	Upstream of Outfall			31/08/2018	14:07:00		2.800	0.066	7.47	553	8.82	103	17.3	6	5
3IWWTW3	Discharge into river,sampled from from pipe			31/08/2018	15:00:00			na	8.34	14730	5.82	71.1	28.5	6	5
3IDS	Downstream of outfall			31/08/2018	13:01:00		3.300	0.062	8.4	6210	8.2	92.8	21.3	5.3	8.7
3IT1	Tributary 1, joins D/S of outfall			31/08/2018	11:20:00		1.700	0.103	6.63	170.8	11	105.8	13.5	5	7.3
3ITB	Trewinnow Bridge			31/08/2018	09:26:00		3.500	0.238	8.26	5700	6.5	66.3	17.3	26.4	25.6
3IStC	St Clether Bridge			31/05/2018	15:28:00		6.000	0.102	8.56	2640	8.59	86.9	16.4	6	5
3I2BPP	Two Bridges, Penpoint Water			30/08/2018	08:48:00		12.250	0.244	6.17	131.7	9.64	88.5	14.6	9	3.7
3I2BI	Two Bridges, River Inny			30/08/2018	11:05:00		7.050	0.128	8.23	2250	9.78	93.2	13.1	6.0	5.0
10WTP	Top			11/09/2018	08:43	1021		0.02	5.84	181.8	9.01	87.6	16.2	54	56.7
10WT2	Captures DC surface water			11/09/2018	10:10			0.06	7.1	331	6.9	68	14.7	1.7	0
10WUS	U/S discharge			11/09/2018	12:38			0.05	7.17	304	7.98	81.9	16.6	0	0
10WwTW1	Dairy WWTW			11/09/2018	09:40			na	6.67	19390	5.15	62.4	24.5	48	5.67
10WwTW2	WWTW Composite			11/09/2018	09:45			na	6.84	13350	8.49	81	14.3	21.7	18.0
10WwTW3	Outfall to Inny			11/09/2018	12:59			na	8.2	8840	4.43	56.3	27.3	27.3	15.3
10WDS	D/S discharge			11/09/2018	12:49			0.08	na	5300	7.93	86.1	20.3	10	13.0
10WT1	Trib			11/09/2018	12:15			0.04	na	191.4	8.55	89	15.6	4.33	0
10WTB	Trewinnow Bridge			11/09/2018	11:45			0.07	7.15	6240	6.42	70	19.8	7.00	14.3
10WSTC	St Clether Bridge			11/09/2018	15:10			0.07	7.12	2690	7.24	75.3	16.7	4.33	6.33
10W2BPP	Two Bridges-PenPoint			11/09/2018	15:38			na	7.11	148.4	7.33	72.3	16.1	6.00	5.33
10W2BI	Two Bridges - Inny			11/09/2018	15:58			0.18	7.04	1969	6.96	71.3	16.3	8	0

Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (µs cm^{-1})	DO ppm	% DO	Temp °C	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
11WTP	Top			18/10/2018	09:15	1027		0.03	5.75	159.1	11.11	98.9	11.3	6.67	6
11WT2	Captures DC surface water			18/10/2018	11:00			0.18	6.27	203	9.92	95.7	12.5	3	2.33
11WUS	U/S discharge			18/10/2018	12:52			0.11	6.53	192.5	10.11	93.7	12.9	3	7.33
11WwTW1	Dairy WWTW			18/10/2018	10:01			na	8.51	9610	8.21	75.1	19.9	13	12.33
11WwTW2	WWTW Composite			18/10/2018	10:01			na	8.79	13600	11.01	87.1	6.9	17.33	11.33
11WwTW3	Outfall to Inny			18/10/2018	13:25			na	8.26	18690	6.34	70.1	22.5	11	4
11WDS	D/S discharge			18/10/2018	13:05			0.14	7.59	2820	9.16	91.4	14.5	4	4.33
11WT1	Trib			18/10/2018	12:43			0.19	6.39	131.3	8.65	81.6	12.7	2.33	3
11WTB	Trewinnow Bridge			18/10/2018	11:30			0.25	7.8	196.3	8.12	76.9	13.1	5.33	3
11WSTC	St Clether Bridge			18/10/2018	14:01			0.145	7.49	923	8.59	82	13	3.67	8
11W2BPP	Two Bridges-PenPoint			18/10/2018	14:30			na	7.14	117.5	8.83	82.3	12.7	1.33	3
11W2BI	Two Bridges - Inny			18/10/2018	14:46			0.28	7.67	737	9.24	87.5	12.6	0	0
12WTP	Top			13/11/2018	09:10	1.021		0.075	5.98	171.9	11.01	97.3	10.6	0	0
12WT2	Captures DC surface water			13/11/2018	11:24			0.22	6.74	239	7.99	73.3	11.4	1.7	3
12WUS	U/S discharge		221	13/11/2018	13:03			0.24	6.43	195.9	9.94	88.6	11.9	0.0	0
12WwTW1	Dairy WWTW			13/11/2018	10:28				7.39	9070	6.12	66.2	18.3	8.0	7
12WwTW2	WWTW Composite			13/11/2018	10:28				7.99	9520	11	97	9.8	15.7	15.67
12WwTW3	Outfall to Inny			13/11/2018	13:30				7.72	9200	6.12	65.1	19.2	14.0	10.67
12WDS	D/S discharge			13/11/2018	13:15			0.20	7.11	1130	8.12	75.8	12.4	7.7	4.33
12WT1	Trib			13/11/2018	12:45			0.22	6.47	121.7	9.02	82.1	11.1	0.0	7.33
12WTB	Trewinnow Bridge			13/11/2018	11:53			0.29	7.08	856	8.84	82.1	11.9	4.7	2.67
12WSTC	St Clether Bridge			13/11/2018	14:35			0.25	7.25	547	9.34	88.1	11.6	4.3	3.67
12W2BPP	Two Bridges-PenPoint			13/11/2018	15:05				6.76	123.4	8.95	80.5	11.1	2	4.67
12W2BI	Two Bridges - Inny			13/11/2018	15:25			0.43	6.77	353	9.43	86.5	11.3	4	4.67
4ITP	Top of catchment			21/11/2018	15:22:00		1.000	0.019	na	225	10.32	88.5	8.6	4	4
4IT2	Tributary 2, d/s of WwTW			21/11/2018	14:16:00		2.600	0.063	6.56	312	9.09	78	9	3	0
4IUS	Upstream of Outfall			21/11/2018	11:30:00		2.500	0.168	6.22	405	10.29	85.6	7.9	0	2
4IDS	Downstream of outfall			21/11/2018	12:24:00		2.950	0.113	7.05	2090	10.12	87.1	8.7	4.67	4
4IT1	Tributary 1, joins D/S of outfall			21/11/2018	09:58:00		1.550	0.157	5.49	133.2	10.73	85.6	6.2	0	0
4ITB	Trewinnow Bridge			20/11/2018	14:40:00		3.400	0.282	7.21	813	9.91	85.5	8.9	7	4.33
4IStC	St Clether Bridge			20/11/2018	13:15:00		6.150	0.201	7.21	779	10.63	90	8.3	3.25	3
4I2BPP	Two Bridges, Penpoint Water			20/11/2018	09:27:00		13.000	0.150	5.82	125.8	10.62	87.8	8.2	0	0
4I2BI	Two Bridges, River Inny			20/11/2018	11:13:00		8.270	0.240	6.51	540	11.33	86.2	7.4	4	3
13WTP	Top				08:45	1022		0.10	6.1	183.4	9.28	79.1	8.9	4.7	5
13WT2	Captures DC surface water			04/12/2018	10:50			0.12	6.54	209	8.76	68	9.4	6.3	5.0
13WUS	U/S discharge			04/12/2018	12:02			0.24	6.45	203	9.21	79.8	9.6	8.3	7.0
13WwTW1	Dairy WWTW			04/12/2018	09:54				7.93	12960	5.29	57.2	18.2	18.7	14.7
13WwTW2	WWTW Composite			04/12/2018	09:54				8.1	12300	8.02	66.6	6.8	26.3	23.0
13WwTW3	Outfall to Inny			04/12/2018	12:30				8.19	9530	5.71	60.5	17.9	14.0	12.0
13WDS	D/S discharge			04/12/2018	12:15			0.25	6.89	687	8.09	71.5	10.1	7.0	5.7
13WT1	Trib			04/12/2018	11:46			0.30	6.62	122.2	9.47	83.7	9.4	6.7	5.0
13WTB	Trewinnow Bridge			04/12/2018	11:25			0.34	7.1	944	8.02	70.5	9.7	6.0	4.7
13WSTC	St Clether Bridge			04/12/2018	14:00			0.35	7.05	482	8.19	72	9.6	0.0	6.0
13W2BPP	Two Bridges-PenPoint			04/12/2018	14:53				6.48	125.6	8.45	77.5	9.4	8.0	32.0
13W2BI	Two Bridges - Inny			04/12/2018	14:59			0.37	6.87	305	9.03	79.6	9.5	7.0	9.3

Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (µs cm^{-1})	DO ppm	% DO	Temp ^{o}C	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
14WTP	Top			17/01/2019	09:12	1015		0.04	6.36	170.4	14.47	121.2	5.9	9	7
14WT2	Captures DC surface water			17/01/2019	11:03			0.09	7.66	187.7	12.86	103	7.3	16	13
14WUS	U/S discharge			17/01/2019	11:59			0.14	7.05	361	14.43	120.2	7.6	13	13
14WwTW1	Dairy WWTW			17/01/2019	10:23				7.71	12180	6.45	67.2	15.9	35	9.8
14WwTW2	WWTW Composite			17/01/2019	10:23				8.35	8560	9.2	75.3	#N/A	7	16.5
14WwTW3	Outfall to Inny			17/01/2019	17:26				8.14	12310	8.56	90	17.3	20	16
14WDS	D/S discharge			17/01/2019	12:10			0.15	7.39	1588	13.63	117	8.6	10.5	10
14WT1	Trib			17/01/2019	11:44			0.14	7.26	132.1	15.17	127.5	7.2	7	9.8
14WTB	Trewinnow Bridge			17/01/2019	11:27			0.23	7.48	1347	13.61	113.5	8.5	11	10
14WSTC	St Clether Bridge			17/01/2019	13:40			0.19	7.03	842	13.65	114.4	7.6	10	11
14W2BPP	Two Bridges-PenPoint			17/01/2019	14:13				6.65	119.4	14.37	118.4	6.9	5.6	4.4
14W2BI	Two Bridges - Inny			17/01/2019				0.30	6.81	733	14.64	120.5	7.2	16	15
15WTP	Top			12/02/2019	09:02	1032		0.07	5.99	172.6	10.79	93	9	2	3
15WT2	Captures DC surface water			12/02/2019	11:25			0.09	6.61	197.11	9.91	86.2	9.5	6	7
15WUS	U/S discharge			12/02/2019	12:20			0.24	6.61	348	9.73	86.3	10.2	5.3	5
15WwTW1	Dairy WWTW			12/02/2019	10:30				7.65	8670	6.27	66.22	17.1	14	13.5
15WwTW2	WWTW Composite	Batch no. 476179		12/02/2019	10:30				7.87	13040	2.41	21.66	10.1	56.8	41.5
15WwTW3	Outfall to Inny			12/02/2019	12:42				8.05	8880	5.56	59.2	17.5	15.7	11.7
15WDS	D/S discharge			12/02/2019	12:28			0.23	7.05	923	9.17	81.5	10.5	6	6.7
15WT1	Trib			12/02/2019	12:00			0.27	6.54	127.1	10.71	91.6	9.3	8	0
15WTB	Trewinnow Bridge			12/02/2019	11:45			0.28	6.92	774	10.36	92.3	10.2	6	5.7
15WSTC	St Clether Bridge			12/02/2019	13:54			0.30	7.2	441	7.23	63.9	10	5	5
15W2BPP	Two Bridges-PenPoint			12/02/2019	14:57				6.54	124.5	6.96	60.7	9.5	4	6
15W2BI	Two Bridges - Inny			12/02/2019	15:05			0.40	6.79	349	7.04	61.8	9.6	7	6
16WTP	Top			12/03/2019	08:56	1005		0.10	5.88	130.7	6.43	63.7	7.2	515	561
16WT2	Captures DC surface water			12/03/2019	10:50			0.19	7.03	153.7	5.85	48.1	6.6	147	152
16WUS	U/S discharge			12/03/2019	12:40			0.52	6.38	128.2	6.64	54.8	6.7	51	69.7
16WwTW1	Dairy WWTW			12/03/2019	09:55				7.67	17270	4.51	42.6	13.8	14.7	4
16WwTW2	WWTW Composite			12/03/2019	na				8.1	12680	5.36	46.2	9	8.3	5
16WwTW3	Outfall to Inny			12/03/2019					#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16WDS	D/S discharge			12/03/2019	13:00			0.43	6.24	2150	6.43	53.1	7.1	89.33	84.67
16WT1	Trib			12/03/2019	11:47			0.47	6.58	86.6	7.68	62.9	6.7	65.33	86.33
16WTB	Trewinnow Bridge			12/03/2019	11:25				6.84	309	7.56	62.3	10	116.33	112
16WSTC	St Clether Bridge			12/03/2019					#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16W2BPP	Two Bridges-PenPoint			12/03/2019					#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16W2BI	Two Bridges - Inny			12/03/2019					#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
17WTP	Top			09/04/2019	08:40	1013		0.04	6.48	154.6	9.01	78.4	9.4	4.33	5
17WT2	Captures DC surface water			09/04/2019	10:30			0.07	7.09	227	10.6	81.6	10.6	3	2.67
17WUS	U/S discharge			09/04/2019	11:26			0.23	6.96	480	10.98	100.1	12.3	4	2.67
17WwTW1	Dairy WWTW			09/04/2019	09:30				7.98	10010	6.3	68.7	19.2	10	9
17WwTW2	WWTW Composite			09/04/2019	09:30				8.31	11180	10.3	84.3	6.9	10	7
17WwTW3	Outfall to Inny			09/04/2019	12:15				7.94	10080	5.57	63.9	20.9	9.33	8.33
17WDS	D/S discharge			09/04/2019	11:45			0.14	7.49	2110	9.48	90.8	13.5	5	5
17WT1	Trib			09/04/2019	11:15			0.13	6.72	135.8	11.1	100	10.8	2	3
17WTB	Trewinnow Bridge			09/04/2019	10:53			0.23	7.52	1643	10.15	93.3	12.2	4	4
17WSTC	St Clether Bridge			09/04/2019	13:32			0.19	7.98	680	9.74	91.4	12.3	3	4
17W2BPP	Two Bridges-PenPoint			09/04/2019	14:07				7.09	116.2	9.82	89.8	11.7	4	5
17W2BI	Two Bridges - Inny			09/04/2019	14:22			0.21	7.15	657	10.37	96	12	4	4

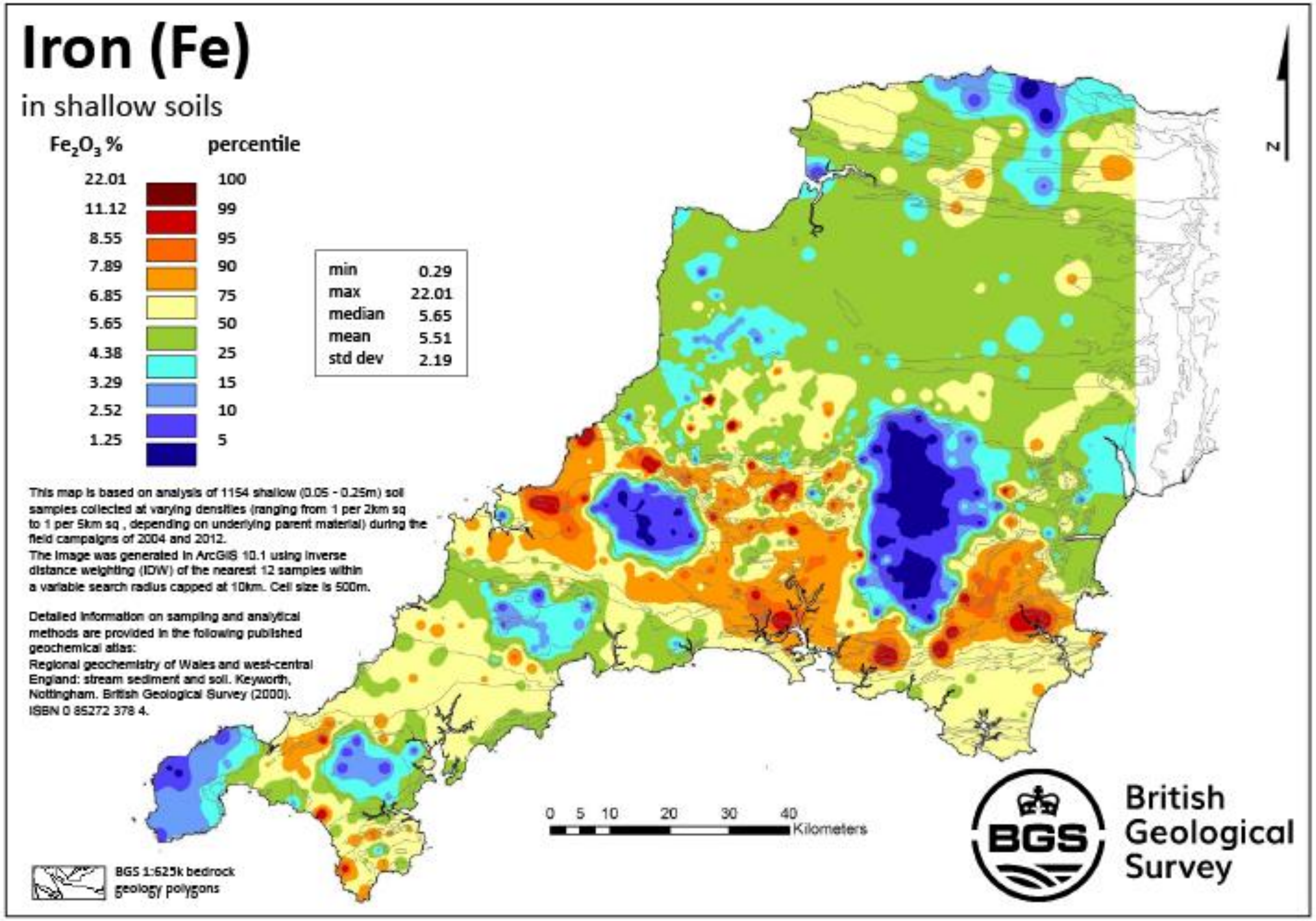
Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (µs cm^{-1})	DO ppm	% DO	Temp ^{o}C	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
5ITP	Top			10/05/2019	15:30	1.009	0.8	0.03	6.8	157.7	9.15	86.9	13.5	4	4
5IT2	Captures DC surface water			10/05/2019	14:25		1.9	0.07	6.8	229	3.42	79	13.5	5	6
5IUS	U/S discharge			10/05/2019	12:40		2.2	0.20	7.04	387	9.21	86.3	14	7	6
WwTW3	Outfall to Inny			10/05/2019	13:20		na	na	7.96	19340	53.8	4.74	21.1	7.75	6
5IDS	D/S discharge			10/05/2019	11:50		3.1	0.09	7.78	4480	8.57	85.7	16	5	4
5IT1	Trib			10/05/2019	10:45		1.55	0.14	6.58	151.4	9.8	86.3	11.1	4	3
5ITB	Trewinnow Bridge			10/05/2019	09:30		3.5	0.19	7.38	3430	10.1	95.5	12.3	4	2
5IStC	St Clether Bridge			09/05/2019	14:06		6.1	0.14	7.14	1477	9.52	89.2	12.6	3	4.6
5I2BPP	Two Bridges-PenPoint			09/05/2019	09:30		12.6	0.23	5.93	102.6	9.21	83.5	10.4	18	16.75
5I2BI	Two Bridges - Inny			09/05/2019	12:00		8.1	0.19	6.92	821	7.91	71.3	10.9	9.4	11
18WTP	Top			14/05/2019	09:05	1.032		0.04	6.62	159	9.73	87.2	10.6	5	6.7
18WT2	Captures DC surface water			14/05/2019	10:58			0.06	6.62	236	9.51	86.9	12.2	0	0
18WUS	U/S discharge			14/05/2019	12:14			0.13	7.01	436	10.02	99.6	14.9	4	4.3
18WwTW1	Dairy WWTW			14/05/2019	10:00				8.19	10500	6.6	70.2	23.7	7	6.7
18WwTW2	WWTW Composite			14/05/2019	10:00				8.37	14950	8.66	74.2	8.4	0	0
18WwTW3	Outfall to Inny			14/05/2019	12:42				8.22	10330	5.03	60.8	25.4	8.3	7.3
18WDS	D/S discharge			14/05/2019	12:33			0.10	8.1	3650	8.1	85.1	18.1	7	7
18WT1	Trib			14/05/2019	11:55			0.14	6.88	141.6	10.36	98.3	13	5	6
18WTB	Trewinnow Bridge			14/05/2019	11:30			0.16	8.14	4170	8.86	90.2	16.6	5.0	4.7
18WSTC	St Clether Bridge			14/05/2019	14:04			0.15	8.48	1958	8.96	88	14.7	5.7	4.7
18W2BPP	Two Bridges-PenPoint			14/05/2019	14:35			na	7.04	128.8	9.98	95.6	12.5	4	6
18W2BI	Two Bridges - Inny			14/05/2019	14:53			0.17	7.57	1382	10.44	103.9	13.7	7	7
19WTP	Top			04/06/2019	08:45	1003		0.03	5.96	125.2	8.1	74.2	12.2	55	50
19WT2	Captures DC surface water			04/06/2019	10:52			0.05	6.87	341	8.84	83.5	11.9	6	7.3
19WUS	U/S discharge			04/06/2019	12:05			0.21	7.01	355	7.81	73.1	12.4	7.3	3.7
19WwTW1	Dairy WWTW			04/06/2019	09:44				7.89	11700	5.36	63.1	22.8	12.3	15.3
19WwTW2	WWTW Composite			04/06/2019	09:44				8.4	13870	8.55	75.4	9.4	0	0
19WwTW3	Outfall to Inny			04/06/2019	12:35				8.17	16170	5.24	60.3	22.7	16	12
19WDS	D/S discharge			04/06/2019	12:20			0.10	8.25	6600	6.89	70.3	15.9	12	14.3
19WT1	Trib			04/06/2019	11:45			0.13	7.09	91.8	7.46	69.5	12	7	3
19WTB	Trewinnow Bridge			04/06/2019	11:28			0.16	8.1	4660	7.73	77.1	15	5.3	7.3
19WSTC	St Clether Bridge			04/06/2019	13:35			0.14	8.41	2500	7.45	72.8	13.4	6	9.3
19W2BPP	Two Bridges-PenPoint			04/06/2019	14:27				6.66	133.9	7.23	68.5	13	8	7
19W2BI	Two Bridges - Inny			04/06/2019	14:42			0.17	8	1616	7.61	73.2	13.5	7	9
20WTP	Top			09/07/2019	09:03	1022	0.45	0.01	6.49	178.7	7.6	73	13.8	0	0
20WT2	Captures DC surface water			09/07/2019	10:50		2	0.05	6.68	290	7.68	75	14.9	0	0
20WUS	U/S discharge			09/07/2019	12:00			0.13	6.95	363	9.01	88.1	17.3	1	0
20WwTW1	Dairy WWTW			09/07/2019	09:55				7.21	14000	4.31	56.6	29.9	3	2.3
20WwTW2	WWTW Composite			09/07/2019	09:55				7.93	13980	6.34	73.1	22.3	4	0
20WwTW3	Outfall to Inny			09/07/2019	12:30				7.54	14810	3.01	38.8	29.6	9	8
20WDS	D/S discharge			09/07/2019	12:15		3.2	0.1	7.7	7120	6.08	69.4	21.9	7	3.3
20WT1	Trib			09/07/2019	11:45			0.1	6.86	153.9	8.41	83.2	14.7	0.7	0.0
20WTB	Trewinnow Bridge			09/07/2019	11:14			0.1	7.79	4810	6.74	73	20.1	3.0	0.3
20WSTC	St Clether Bridge			09/07/2019	15:35			0.1	8.32	2740	6.79	72.1	11.9	4.0	2.0
20W2BPP	Two Bridges-PenPoint			09/07/2019	16:10				6.99	124.8	8.35	82.9	16.7	8.3	3.0
20W2BI	Two Bridges - Inny			09/07/2019	16:28		6.75	0.17	7.9	1703	7.37	76.9	17.2	6.0	3.0

Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (µs cm^{-1})	DO ppm	% DO	Temp °C	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
21WTP	Top			13/08/2019	09:25	1019	0.63	0.04	6.19	72.2	7.88	75.8	14.2	39.3	44.7
21WT2	Captures DC surface water			13/08/2019	10:55			0.08	7.18	253	8.08	80.2	14.4	38.0	33.3
21WUS	U/S discharge			13/08/2019	12:25			0.17	7.24	217	8.13	80.6	15.6	7.0	8.0
21WwTW1	Dairy WWTW			13/08/2019	10:03				7.9	26400	4.29	51.1	24.3	6.3	6.0
21WwTW2	WWTW Composite			13/08/2019	10:03				8.27	12160	8.15	80.2	16	8.0	4.0
21WwTW3	Outfall to Inny			13/08/2019	12:55				8.07	23700	4.71	56.3	24.3	16.3	12.7
21WDS	D/S discharge			13/08/2019	12:40			0.11	7.95	4150	6.97	72.1	17.4	15.3	12.7
21WT1	Trib			13/08/2019	12:08			0.21	7.08	134.2	7.83	77.7	15	11.7	12.0
21WTB	Trewinnow Bridge			13/08/2019	11:45			0.18	8.03	3930	7.73	77.9	16.2	8.7	8.7
21WSTC	St Clether Bridge			13/08/2019	14:30			0.13	8.21	2070	7.19	72.3	15.4	9.0	8.0
21W2BPP	Two Bridges-PenPoint			13/08/2019	15:05				6.99	122.4	10.11	105.1	15.1	12.3	10.7
21W2BI	Two Bridges - Inny			13/08/2019	15:20		7	0.22	7.93	1764	7.8	78.6	15.8	10.7	12.3
6TP	Top			29/08/2019	16:00	1020	0.42	0.04	6.98	135	7.29	72	15.6	6.25	5.75
6T2	Captures DC surface water			29/08/2019	14:29		3.3	0.125	6.81	241	8	84	16.5	6.6	7
6IUS	U/S discharge			30/08/2019	12:05		3.2	0.13	na	237	8.3	86	17.3	5	7
6IWwTW3	Outfall to Inny			30/08/2019	14:05		na	na	na	17620	5.14	58.6	26.1	6.75	6.75
6DS	D/S discharge			30/08/2019	12:15		2.97	0.1275	na	2850	8	83.9	19.3	6	6
6IT1	Trib			30/08/2019	10:50		1.6	0.208	na	130.1	7.68	75.5	15.5	6	5.6
6ITB	Trewinnow Bridge			30/08/2019	09:30		3.55	0.188	na	3970	7.6	78	16.6	5	2
6IStC	St Clether Bridge			29/08/2019	12:25		6.1	0.145	7.5	1725	9.2	88.5	14.8	4	6
6I2BPP	Two Bridges-PenPoint			29/08/2019	08:45		12.7	0.25625	5.5	116	9.42	86.8	12.8	7	7
6I2BI	Two Bridges - Inny			29/08/2019	10:36		8.15	0.1775	6.96	906	8.75	85.8	13.4	10.2	9.75
22WTP	Top			10/09/2019	08:45	1021	0.66	0.02	6.24	182.9	9.74	72.6	13.1	8.0	7.3
22WT2	Captures DC surface water			10/09/2019	10:55		2.6	0.09	6.52	241	8.95	81.4	14.1	9.0	6.0
22WUS	U/S discharge			10/09/2019	12:10			0.17	7.04	316	8.68	84.2	14.2	8.0	7.0
22WwTW1	Dairy WWTW			10/09/2019	09:50				7.7	10820	5.24	61.3	22.3	11.0	9.7
22WwTW2	WWTW Composite			10/09/2019	09:50				8.19	15170	8.31	82.8	14.3	21.0	17.3
22WwTW3	Outfall to Inny			10/09/2019	12:35				8.07	16840	5.05	59.9	23.4	10.0	9.3
22WDS	D/S discharge			10/09/2019	12:23			0.11	8.03	4030	6.87	69.7	16.6	11.3	8.7
22WT1	Trib			10/09/2019	11:53			0.17	6.96	135.4	8.3	78.5	14.9	7.0	6.0
22WTB	Trewinnow Bridge			10/09/2019	11:25			0.17	7.98	3490	8.71	86.9	15.4	5.0	7.0
22WSTC	St Clether Bridge			10/09/2019	13:55			0.14	8.27	1822	8.97	87.8	15.2	9.0	9.0
22W2BPP	Two Bridges-PenPoint			10/09/2019	14:28				6.94	120.8	8.77	86.5	14.1	10.0	9.3
22W2BI	Two Bridges - Inny			10/09/2019	14:45		6.9	0.197	8.11	1810	9.26	88.3	14.3	7.3	8.0
23WTP	Top			15/10/2019	08:58	1004	1.00	0.08	6.35	169.8	7.98	68.4	11.8	4.0	1.7
23WT2	Captures DC surface water			15/10/2019	10:48		2.76	0.1	6.56	254	6.74	62.9	12.1	0	4
23WUS	U/S discharge			15/10/2019	12:20			0.20	6.97	296	7.24	68.1	12.5	3	3
23WwTW1	Dairy WWTW			15/10/2019	09:55				7.37	8580	5.29	55.9	20.5	10	7.3
23WwTW2	WWTW Composite			15/10/2019	09:56				7.86	11640	7.34	70.2	13.1	3	2
23WwTW3	Outfall to Inny			15/10/2019	12:45				7.98	12850	4.58	52	21.5	9.7	8
23WDS	D/S discharge			15/10/2019	12:35			0.25	7.67	1189	7.67	73.6	13.5	2	3
23WT1	Trib			15/10/2019	12:00			0.32	6.93	122.9	8.59	79.5	12.8	4	1
23WTB	Trewinnow Bridge			15/10/2019	11:34			0.36	7.28	1021	7.17	68.1	12.9	0	0
23WSTC	St Clether Bridge			15/10/2019	14:25			0.305	7.19	504	6.87	63.6	13	3	2.7
23W2BPP	Two Bridges-PenPoint			15/10/2019	14:53				6.77	122	7.08	66.7	12.5	6	5.7
23W2BI	Two Bridges - Inny			15/10/2019	15:09			0.145	7.09	343	7.21	67.7	12.5	3	5

Sample	Site	NGR	Elevation (m)	Date	Time	Air Pressure (Met office forecast)	Channel Width (m)	Channel Depth (m)	pH	Conductivity (μs cm^{-1})	DO ppm	% DO	Temp ^{o}C	Turbidity (ATU)	Sus Slds in field (mg L^{-1})
24WTP	Top			12/11/2019	08:47	1.005	0.9	0.09	6.29	165.7	10.02	87.5	9.7	1.3	0
24WT2	Captures DC surface water			12/11/2019	10:40		2.65	0.09	6.8	187.6	10.47	91.1	9.1	3	1.7
24WUS	U/S discharge			12/11/2019	12:30			0.39	6.67	353	11.49	99.1	9.6	4	4.3
24WwTW1	Dairy WWTW			12/11/2019	09:55			na	7.59	7150	9.01	88.7	14.3	6	4.7
24WwTW2	WWTW Composite			12/11/2019	09:55			na	8.06	12340	11.95	95.8	5.8	4	3
24WwTW3	Outfall to Inny			12/11/2019	13:00			na	7.61	9680	7.92	82.9	16.6	1.7	3
24WDS	D/S discharge			12/11/2019	12:43			0.17	6.81	518	11.01	97	9.8	7	7
24WT1	Trib			12/11/2019	12:11			0.30	6.61	131	11.25	98.1	9.4	2	2.7
24WTB	Trewinnow Bridge			12/11/2019	11:55			0.35	6.83	702	11.24	98.5	10	4	3
24WSTC	St Clether Bridge			12/11/2019	13:53			0.3	7.41	385	10.18	89.7	9.5	4	4
24W2BPP	Two Bridges-PenPoint			12/11/2019	15:00			na	6.84	61.3	11.77	100.5	8.8	4	4
24W2BI	Two Bridges - Inny			12/11/2019	15:20			0.18	6.92	342	11.46	99.7	9.2	4	6
7ITP				28/11/2019	09:40		0.85	0.1025	5.31	164.5	9.36	85.3	10.7	9.75	5
7IT2				28/11/2019	11:45		2.7	0.105	6.76	195	9.56	84	10.4	4.4	19
7US				29/11/2019	12:25		3.25	0.264	6.74	437	8.6	76.5	9.2	4	5
7WwTW3				29/11/2019	13:15		#N/A	#N/A	7.42	10810	3.91	42.6	17.3	20	13
7DS				29/11/2019	11:20		3.23	0.2925	6.87	1011	7.75	70.4	10.4	2	3.75
7IT1				28/11/2019	13:55		1.72	0.328	6.73	122.1	8.88	80.7	10.6	8	5
7ITB				29/11/2019	09:30		3.5	0.416	5.56	828	8.11	71.8	10.3	2.75	2

Appendix 3

BGS analysis of iron in SW England soils



Appendix 4

Standard solutions, suppliers and lot numbers used within the study

Element	Concentration (µg mL^{-1})	Supplier	Lot number	Analysis
P	10,040±50	PlasmaCAL	S170220019	ICP-MS
Multi element standard (Al, Sb, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, Mn, Mo, Na, Ni, Pb, Ag, Se, Ti, Tl, V, Zn)	**100**	Labkings	1101407	ICP-MS
Ca	10,000	Labkings	147497-103	ICP-OES
Mg	10,030±40	PlasmaCal	S181114017	ICP-OES
Si	10,000±70	PlasmaCal	S14110017	ICP-OES
K	10,020±50	PlasmaCal	S161011019	ICP-OES
Na	9990±40	PlasmaCal	S180904028	ICP-OES
Potassium dihydrogen phosphate		EMSURE	No lot number	IC
Sodium nitrate		EMSURE	No lot number	IC
Sodium chloride		EMSURE	No lot number	IC
Sodium bromide		SIGMA	BCBP2429V	IC
Sodium nitrate		EMSURE	No lot number	IC
Sodium sulphate		SIGMA	BCBT2464	IC

Principal chemistry data

Set	Date	Site	SRP µg P L^{-1}	TRP µg P L^{-1}	TSP µg P L^{-1}	TP µg P L^{-1}	Fe(f) µg Fe L^{-1}	Sus Slds mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Date accurate to month Cl^- mg L^{-1}	Ca mg L^{-1}
1	06/12/2017	TP	11	13	16	43	5	8	1	13	45	13
1	06/12/2017	T2	29	37	29	41	98	6	3	24	70	14
1	06/12/2017	US	23	28	25	34	64	4	3	21	97	17
1	06/12/2017	WwTW1	50	165	508	2510	1042	136	3277	1960	3515	976
1	06/12/2017	WwTW2	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
1	06/12/2017	WwTW3	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
1	06/12/2017	DS	33	82	321	603	45	10	31	155	48	23
1	06/12/2017	T1	12	16	15	22	17	9	2	11	23	14
1	06/12/2017	TB	28	50	34	78	47	7	35	174	47	22
1	06/12/2017	StC	26	29	32	45	18	6	20	109	124	21
1	06/12/2017	2BPP	14	15	24	31	30	9	1	13	#N/A	9
1	06/12/2017	2BI	34	33	36	46	31	9	8	39	#N/A	18
2	09/01/2018	TP	4	4	5	36	12	0	1	19	#N/A	13
2	09/01/2018	T2	20	51	35	90	58	28	7	35	#N/A	16
2	09/01/2018	US	103	108	132	159	38	37	13	62	#N/A	21
2	09/01/2018	WwTW1	922	924	1068	1177	220	96	664	211	#N/A	285
2	09/01/2018	WwTW2	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
2	09/01/2018	WwTW3	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
2	09/01/2018	DS	572	582	1384	1318	115	25	52	207	#N/A	37
2	09/01/2018	T1	4	4	7	30	24	2	2	10	#N/A	14
2	09/01/2018	TB	222	237	352	408	31	18	36	155	#N/A	31
2	09/01/2018	StC	86	100	150	196	25	1	18	78	#N/A	26
2	09/01/2018	2BPP	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
2	09/01/2018	2BI	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
3	06/02/2018	TP	13	22	12	16	11	6	1	17	#N/A	14
3	06/02/2018	T2	#N/A	159	20	123	69	24	4	25	#N/A	16
3	06/02/2018	US	39	53	82	47	58	9	8	55	#N/A	20
3	06/02/2018	WwTW1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
3	06/02/2018	WwTW2	1109	1142	1323	1765	237	12	610	2279	#N/A	146
3	06/02/2018	WwTW3	534	546	654	923	301	10	927	3299	#N/A	198
3	06/02/2018	DS	117	135	234	38	80	7	54	182	#N/A	32
3	06/02/2018	T1	17	25	16	23	42	2	2	13	#N/A	15
3	06/02/2018	TB	53	97	55	94	70	2	37	151	#N/A	26
3	06/02/2018	StC	48	59	48	64	70	3	18	77	#N/A	21
3	06/02/2018	2BPP	31	38	22	25	47	0	1	11	#N/A	10
3	06/02/2018	2BI	46	64	35	56	47	4	13	57	#N/A	21
4	06/03/2018	TP	17	29	15	94	64	0	3	14	#N/A	10
4	06/03/2018	T2	18	26	6	22	165	0	4	27	#N/A	11
4	06/03/2018	US	18	27	6	22	110	2	6	24	#N/A	12
4	06/03/2018	WwTW1	77	114	278	899	94	90	558	1730	#N/A	112
4	06/03/2018	WwTW2	66	529	295	1728	123	33	809	2396	#N/A	129
4	06/03/2018	WwTW3	92	102	315	344	170	0	996	3224	#N/A	172
4	06/03/2018	DS	9	17	37	92	114	0	10	38	#N/A	13
4	06/03/2018	T1	6	13	6	22	62	3	2	9	#N/A	10
4	06/03/2018	TB	21	35	6	47	104	0	62	195	#N/A	20
4	06/03/2018	StC	20	27	32	22	110	0	24	73	#N/A	14
4	06/03/2018	2BPP	15	20	55	22	111	2	2	9	#N/A	7
4	06/03/2018	2BI	25	31	24	47	91	11	21	64	#N/A	15
5	10/04/2018	TP	17	44	28	64	25	6	1	15	34	13
5	10/04/2018	T2	28	71	28	26	121	9	6	29	46	15
5	10/04/2018	US	50	57	78	93	91	3	18	75	138	21
5	10/04/2018	WwTW1	1171	1279	1704	1965	287	35	722	2537	5775	233
5	10/04/2018	WwTW2	1238	1421	1626	2235	132	38	459	1918	4315	178
5	10/04/2018	WwTW3	1696	1779	2298	2455	226	11	688	2547	5696	231
5	10/04/2018	DS	143	156	172	209	83	3	50	212	434	29
5	10/04/2018	T1	0	11	28	26	168	7	2	10	23	14
5	10/04/2018	TB	148	181	153	177	73	6	45	196	392	29
5	10/04/2018	StC	48	56	97	110	65	3	25	100	165	23
5	10/04/2018	2BPP	20	26	28	26	98	8	2	11	26	10
5	10/04/2018	2BI	53	73	74	104	119	3	15	68	127	21
6	15/05/2018	TP	12	12	44	16	4	0	2	16	34	13
6	15/05/2018	T2	9	15	39	16	36	0	5	26	56	14
6	15/05/2018	US	18	27	108	96	49	4	13	53	34	18
6	15/05/2018	WwTW1	307	258	926	1088	217	7	1282	3830	3688	117
6	15/05/2018	WwTW2	400	530	1005	2568	143	29	1196	3579	3875	105
6	15/05/2018	WwTW3	383	434	1025	1311	85	11	831	2478	3889	75
6	15/05/2018	DS	78	93	160	151	36	0	149	419	1325	25
6	15/05/2018	T1	4	7	19	70	28	0	2	13	10	14
6	15/05/2018	TB	54	59	159	204	46	3	198	537	232	29
6	15/05/2018	StC	37	46	97	154	125	0	93	277	122	23
6	15/05/2018	2BPP	10	15	117	100	132	0	2	13	20	9
6	15/05/2018	2BI	44	44	125	121	208	4	54	155	305	22

											Date accurate to month	
Set	Date	Site	SRP µg P L^{-1}	TRP µg P L^{-1}	TSP µg P L^{-1}	TP µg P L^{-1}	Fe(f) µg Fe L^{-1}	Sus Slds mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Cl^{-} mg L^{-1}	Ca mg L^{-1}
7	19/06/2018	TP	27	42	72	107	29	52	3	13	#N/A	13
7	19/06/2018	T2	27	31	107	44	72	7	10	33	#N/A	17
7	19/06/2018	US	44	53	193	158	143	5	31	89	#N/A	22
7	19/06/2018	WwTW1	511	573	880	1176	132	1	789	1864	#N/A	50
7	19/06/2018	WwTW2	164	505	542	1373	195	67	967	2179	#N/A	54
7	19/06/2018	WwTW3	456	518	770	1071	222	9	810	1964	#N/A	57
7	19/06/2018	DS	174	202	244	297	81	4	289	958	#N/A	58
7	19/06/2018	T1	17	18	174	87	82	30	2	9	#N/A	15
7	19/06/2018	TB	173	188	192	220	64	2	259	866	#N/A	54
7	19/06/2018	StC	49	55	33	44	38	6	139	401	#N/A	24
7	19/06/2018	2BPP	36	38	33	44	61	2	2	9	#N/A	9
7	19/06/2018	2BI	47	50	33	44	57	6	94	219	#N/A	24
8	12/07/2018	TP	40	67	77	134	6	13	2	18	#N/A	16
8	12/07/2018	T2	36	41	92	101	119	1	48	182	#N/A	26
8	12/07/2018	US	42	44	104	107	100	4	10	50	#N/A	25
8	12/07/2018	WwTW1	1624	1748	2152	2575	129	10	854	2609	#N/A	64
8	12/07/2018	WwTW2	1117	1223	1640	2257	184	30	1173	3610	#N/A	66
8	12/07/2018	WwTW3	1296	1327	2098	2452	223	23	1389	4280	#N/A	119
8	12/07/2018	DS	816	938	1259	1590	126	19	429	1305	#N/A	49
8	12/07/2018	T1	23	21	82	50	61	0	2	11	#N/A	18
8	12/07/2018	TB	644	702	1025	1123	88	13	330	1044	#N/A	43
8	12/07/2018	StC	23	18	56	218	19	14	85	271	#N/A	25
8	12/07/2018	2BPP	77	78	151	117	62	9	2	11	#N/A	10
8	12/07/2018	2BI	17	21	41	115	35	13	90	278	#N/A	26
9	16/08/2018	TP	86	120	134	235	239	21	7	18	40	12
9	16/08/2018	T2	58	84	72	122	221	13	6	28	46	15
9	16/08/2018	US	65	107	96	188	193	21	5	20	38	15
9	16/08/2018	WwTW1	500	584	860	1161	748	13	639	2354	4904	39
9	16/08/2018	WwTW2	425	614	812	1729	716	77	778	2888	6241	31
9	16/08/2018	WwTW3	388	463	1160	1481	667	14	1004	3808	8645	48
9	16/08/2018	DS	180	249	342	491	389	24	174	654	965	20
9	16/08/2018	T1	37	51	58	93	228	9	4	9	77	13
9	16/08/2018	TB	132	182	328	430	299	18	176	657	1119	21
9	16/08/2018	StC	122	131	220	345	139	9	87	326	717	22
9	16/08/2018	2BPP	145	147	198	204	93	4	2	12	25	8
9	16/08/2018	2BI	121	129	187	271	87	10	52	204	521	23
10	11/09/2018	TP	350	351	237	239	#N/A	54	4	16	#N/A	14
10	11/09/2018	T2	37	43	46	45	64	2	5	30	#N/A	17
10	11/09/2018	US	69	62	89	76	285	0	5	23	#N/A	20
10	11/09/2018	WwTW1	347	359	1115	1173	588	48	1072	5151	#N/A	69
10	11/09/2018	WwTW2	742	770	1405	1362	772	22	646	3317	#N/A	38
10	11/09/2018	WwTW3	1212	1292	1807	1846	788	27	358	1867	#N/A	22
10	11/09/2018	DS	352	403	493	708	487	10	207	1012	#N/A	27
10	11/09/2018	T1	26	38	66	46	95	4	4	10	#N/A	15
10	11/09/2018	TB	352	341	648	648	379	7	251	1224	#N/A	30
10	11/09/2018	StC	209	225	325	360	68	4	93	435	#N/A	25
10	11/09/2018	2BPP	96	110	162	155	47	6	2	10	#N/A	7
10	11/09/2018	2BI	152	170	258	315	53	8	58	324	#N/A	24
11	18/10/2018	TP	18	20	47	83	33	7	3	16	#N/A	14
11	18/10/2018	T2	16	21	69	56	374	3	4	27	#N/A	14
11	18/10/2018	US	23	31	48	73	95	3	3	20	#N/A	15
11	18/10/2018	WwTW1	331	373	734	963	198	13	616	2305	#N/A	26
11	18/10/2018	WwTW2	450	461	1309	1163	333	17	829	3037	#N/A	32
11	18/10/2018	WwTW3	448	468	1965	2080	699	11	1129	4273	#N/A	54
11	18/10/2018	DS	92	111	303	358	148	4	145	553	#N/A	18
11	18/10/2018	T1	8	13	43	52	74	2	2	11	#N/A	11
11	18/10/2018	TB	54	61	188	230	132	5	92	372	#N/A	16
11	18/10/2018	StC	49	54	116	143	93	4	41	162	#N/A	15
11	18/10/2018	2BPP	13	21	55	63	119	1	2	11	#N/A	7
11	18/10/2018	2BI	49	38	111	135	99	0	31	124	#N/A	17
12	13/11/2018	TP	15	21	21	29	15	0	2	16	#N/A	15
12	13/11/2018	T2	16	26	49	65	122	2	6	30	#N/A	14
12	13/11/2018	US	12	21	44	67	57	0	4	19	#N/A	16
12	13/11/2018	WwTW1	481	510	912	1193	267	8	573	2209	#N/A	65
12	13/11/2018	WwTW2	271	309	654	1088	234	16	574	2219	#N/A	67
12	13/11/2018	WwTW3	461	527	1061	1146	176	14	559	2146	#N/A	63
12	13/11/2018	DS	53	68	179	189	70	8	54	196	#N/A	21
12	13/11/2018	T1	6	10	34	35	42	0	2	9	#N/A	12
12	13/11/2018	TB	48	55	117	134	52	5	36	132	#N/A	17
12	13/11/2018	StC	27	37	18	11	48	4	22	78	#N/A	16
12	13/11/2018	2BPP	8	12	18	11	34	2	2	10	#N/A	10
12	13/11/2018	2BI	19	30	18	11	45	4	12	44	#N/A	17

Set	Date	Site	SRP µg P L^{-1}	TRP µg P L^{-1}	TSP µg P L^{-1}	TP µg P L^{-1}	Fe(f) µg Fe L^{-1}	Sus Slds mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Date accurate to month Cl^{-} mg L^{-1}	Ca mg L^{-1}
13	04/12/2018	TP	33	39	44	39	13	5	2	20	#N/A	16
13	04/12/2018	T2	20	34	15	68	84	6	4	19	#N/A	14
13	04/12/2018	US	15	24	72	66	54	8	3	15	#N/A	16
13	04/12/2018	WwTW1	429	526	1214	1324	4399	19	834	2985	#N/A	90
13	04/12/2018	WwTW2	450	646	821	1289	1306	26	738	2619	#N/A	78
13	04/12/2018	WwTW3	542	624	847	1086	203	14	572	2038	#N/A	67
13	04/12/2018	DS	33	46	112	112	57	7	27	101	#N/A	17
13	04/12/2018	T1	9	14	64	56	51	7	2	9	#N/A	12
13	04/12/2018	TB	27	42	113	124	89	6	42	166	#N/A	20
13	04/12/2018	StC	22	31	89	98	47	0	21	81	#N/A	19
13	04/12/2018	2BPP	10	16	74	75	40	8	2	11	#N/A	11
13	04/12/2018	2BI	18	30	88	162	43	7	10	40	#N/A	17
14	17/01/2019	TP	55	55	10	15	391	9	3	17	#N/A	14
14	17/01/2019	T2	23	54	10	15	203	16	4	20	#N/A	14
14	17/01/2019	US	30	46	38	87	158	13	13	52	#N/A	19
14	17/01/2019	WwTW1	461	439	1699	1961	380	35	741	1988	#N/A	142
14	17/01/2019	WwTW2	885	888	1944	2001	289	7	784	2029	#N/A	153
14	17/01/2019	WwTW3	163	290	768	1202	534	20	844	2904	#N/A	123
14	17/01/2019	DS	49	79	112	156	157	11	79	278	#N/A	26
14	17/01/2019	T1	16	24	10	15	91	7	2	10	#N/A	13
14	17/01/2019	TB	54	71	165	200	187	11	70	260	#N/A	27
14	17/01/2019	StC	37	47	10	15	100	10	37	140	#N/A	22
14	17/01/2019	2BPP	18	33	10	15	81	6	2	11	#N/A	8
14	17/01/2019	2BI	39	64	10	15	76	16	29	108	#N/A	19
15	12/02/2019	TP	15	13	137	188	20	2	0	0	#N/A	0
15	12/02/2019	T2	15	22	180	152	61	6	4	23	#N/A	15
15	12/02/2019	US	11	28	288	46	276	5	10	43	#N/A	18
15	12/02/2019	WwTW1	564	597	777	1141	379	14	576	2077	#N/A	143
15	12/02/2019	WwTW2	19	192	298	1076	114	57	860	3045	#N/A	118
15	12/02/2019	WwTW3	532	624	683	1017	179	16	522	1880	#N/A	130
15	12/02/2019	DS	48	68	77	99	38	6	40	151	#N/A	25
15	12/02/2019	T1	4	4	164	148	25	8	2	10	#N/A	13
15	12/02/2019	TB	32	46	54	68	40	6	35	137	#N/A	24
15	12/02/2019	StC	17	26	164	227	22	5	17	67	#N/A	19
15	12/02/2019	2BPP	7	13	162	191	35	4	2	11	#N/A	10
15	12/02/2019	2BI	18	25	227	242	28	7	13	50	#N/A	19
16	12/03/2019	TP	42	408	277	1266	104	#N/A	3	16	#N/A	8
16	12/03/2019	T2	30	216	271	605	140	147	4	20	#N/A	9
16	12/03/2019	US	35	174	43	266	155	51	3	13	#N/A	9
16	12/03/2019	WwTW1	130	118	627	842	426	15	1090	3967	#N/A	252
16	12/03/2019	WwTW2	47	28	298	326	250	8	775	2851	#N/A	180
16	12/03/2019	WwTW3	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16	12/03/2019	DS	33	158	37	250	144	89	7	27	#N/A	10
16	12/03/2019	T1	54	144	268	448	144	65	2	8	#N/A	7
16	12/03/2019	TB	40	175	45	305	150	116	12	46	#N/A	11
16	12/03/2019	StC	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16	12/03/2019	2BPP	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
16	12/03/2019	2BI	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
17	19/04/2019	TP	11	13	163	77	11	4	1	13	25	15
17	19/04/2019	T2	13	19	5	26	67	3	5	29	52	17
17	19/04/2019	US	12	16	46	25	67	4	17	74	113	22
17	19/04/2019	WwTW1	103	136	240	376	159	10	670	2488	3753	182
17	19/04/2019	WwTW2	55	51	274	386	228	10	753	2759	4196	174
17	19/04/2019	WwTW3	134	156	306	503	198	9	677	2525	3798	183
17	19/04/2019	DS	27	37	21	91	115	5	103	354	663	43
17	19/04/2019	T1	4	4	5	4	34	2	1	10	19	14
17	19/04/2019	TB	23	30	88	136	59	4	89	303	546	40
17	19/04/2019	StC	14	16	5	4	42	3	35	132	234	27
17	19/04/2019	2BPP	16	17	5	4	54	4	1	10	19	9
17	19/04/2019	2BI	11	15	5	4	37	4	27	96	163	24
18	14/05/2019	TP	19	25	57	36	56	5	1	12	#N/A	16
18	14/05/2019	T2	13	17	57	36	23	0	3	23	#N/A	20
18	14/05/2019	US	20	28	57	36	39	4	12	53	#N/A	23
18	14/05/2019	WwTW1	133	154	280	270	190	7	633	2240	#N/A	72
18	14/05/2019	WwTW2	82	106	504	629	662	0	938	3295	#N/A	105
18	14/05/2019	WwTW3	153	216	292	421	198	8	640	2259	#N/A	72
18	14/05/2019	DS	70	93	57	100	70	7	184	658	#N/A	35
18	14/05/2019	T1	6	7	57	36	4	5	1	10	#N/A	17
18	14/05/2019	TB	54	71	57	134	87	5	215	774	#N/A	40
18	14/05/2019	StC	28	32	57	36	26	6	97	357	#N/A	33
18	14/05/2019	2BPP	37	43	57	36	27	4	1	10	#N/A	10
18	14/05/2019	2BI	29	35	57	36	33	7	71	262	#N/A	33

Set	Date	Site	SRP µg P L^{-1}	TRP µg P L^{-1}	TSP µg P L^{-1}	TP µg P L^{-1}	Fe(f) µg Fe L^{-1}	Sus Slds mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Date accurate to month Cl^{-} mg L^{-1}	Ca mg L^{-1}
19	04/06/2019	TP	59	141	84	184	47	55	2	12	#N/A	11
19	04/06/2019	T2	25	35	35	32	59	6	7	39	#N/A	21
19	04/06/2019	US	29	42	38	53	90	7	9	37	#N/A	22
19	04/06/2019	WwTW1	84	157	433	674	309	12	941	3303	#N/A	71
19	04/06/2019	WwTW2	24	39	386	451	318	0	907	3182	#N/A	63
19	04/06/2019	WwTW3	116	204	523	781	345	16	1068	3739	#N/A	80
19	04/06/2019	DS	85	155	243	382	184	12	366	1235	#N/A	42
19	04/06/2019	T1	14	20	47	54	75	7	3	10	#N/A	18
19	04/06/2019	TB	56	84	108	178	106	5	249	843	#N/A	34
19	04/06/2019	StC	29	36	94	126	55	6	124	458	#N/A	31
19	04/06/2019	2BPP	58	68	87	114	66	8	2	11	#N/A	10
19	04/06/2019	2BI	36	47	109	131	54	7	77	287	#N/A	29
20	09/07/2019	TP	36	38	149	134	31	0	0	0	#N/A	0
20	09/07/2019	T2	31	33	122	129	58	0	0	0	#N/A	0
20	09/07/2019	US	23	26	70	63	73	1	8	39	#N/A	24
20	09/07/2019	WwTW1	216	258	512	815	878	3	985	3198	#N/A	151
20	09/07/2019	WwTW2	101	162	389	600	272	4	862	2978	#N/A	146
20	09/07/2019	WwTW3	429	417	933	1029	8794	9	903	3103	#N/A	167
20	09/07/2019	DS	214	209	444	417	#N/A	7	376	1268	#N/A	83
20	09/07/2019	T1	16	15	123	374	59	1	2	14	#N/A	17
20	09/07/2019	TB	75	79	163	317	283	3	236	829	#N/A	57
20	09/07/2019	StC	33	33	399	496	91	4	5	30	#N/A	20
20	09/07/2019	2BPP	62	68	390	404	98	8	2	10	#N/A	17
20	09/07/2019	2BI	41	40	392	452	64	6	145	501	#N/A	45
21	13/08/2019	TP	66	122	66	126	19	39	2	8	10	5
21	13/08/2019	T2	31	101	34	100	98	38	6	29	51	14
21	13/08/2019	US	44	46	44	55	59	7	6	28	49	20
21	13/08/2019	WwTW1	91	101	450	448	466	6	1523	4901	11265	348
21	13/08/2019	WwTW2	80	73	317	376	247	8	1028	3356	7672	218
21	13/08/2019	WwTW3	167	133	470	614	339	16	1313	4147	9331	247
21	13/08/2019	DS	69	82	134	174	103	15	193	630	1411	53
21	13/08/2019	T1	34	40	41	56	119	12	3	10	19	11
21	13/08/2019	TB	58	76	128	159	102	9	183	601	1292	53
21	13/08/2019	StC	43	46	86	114	98	9	93	309	624	30
21	13/08/2019	2BPP	47	56	68	84	187	12	2	11	#N/A	7
21	13/08/2019	2BI	49	54	95	116	69	11	78	270	528	30
22	10/09/2019	TP	56	64	90	52	64	8	2	11	#N/A	10
22	10/09/2019	T2	29	30	90	52	139	9	84	307	#N/A	37
22	10/09/2019	US	36	37	90	52	81	8	7	34	#N/A	20
22	10/09/2019	WwTW1	131	168	192	517	196	11	581	2128	#N/A	109
22	10/09/2019	WwTW2	98	120	434	371	331	21	890	3290	#N/A	152
22	10/09/2019	WwTW3	174	229	383	707	338	10	977	3593	#N/A	170
22	10/09/2019	DS	64	82	90	124	101	11	190	709	#N/A	47
22	10/09/2019	T1	17	15	90	52	86	7	5	14	#N/A	16
22	10/09/2019	TB	57	66	90	325	86	5	156	576	#N/A	41
22	10/09/2019	StC	49	50	90	52	48	9	3	23	#N/A	16
22	10/09/2019	2BPP	62	65	90	52	80	10	2	10	#N/A	15
22	10/09/2019	2BI	49	52	90	159	47	7	83	310	#N/A	32
23	15/10/2019	TP	8	19	9	3	17	4	2	11	#N/A	9
23	15/10/2019	T2	24	27	9	3	120	0	85	322	#N/A	36
23	15/10/2019	US	20	26	9	3	72	3	6	28	#N/A	15
23	15/10/2019	WwTW1	98	131	183	133	102	10	410	1486	#N/A	79
23	15/10/2019	WwTW2	93	120	191	335	189	3	601	2178	#N/A	118
23	15/10/2019	WwTW3	129	172	236	520	191	10	638	2314	#N/A	124
23	15/10/2019	DS	27	37	9	3	70	2	44	167	#N/A	22
23	15/10/2019	T1	7	11	9	3	73	4	2	14	#N/A	13
23	15/10/2019	TB	22	29	9	3	90	0	36	138	#N/A	20
23	15/10/2019	StC	17	22	9	3	52	3	6	29	#N/A	14
23	15/10/2019	2BPP	8	17	9	3	63	6	1	9	#N/A	8
23	15/10/2019	2BI	17	23	9	3	55	3	11	41	#N/A	15
24	12/11/2019	TP	25	26	24	8	10	1	2	14	0	14
24	12/11/2019	T2	20	28	7	18	88	3	4	18	32	15
24	12/11/2019	US	18	24	37	8	59	4	10	41	72	18
24	12/11/2019	WwTW1	54	63	117	236	92	6	420	1430	2361	72
24	12/11/2019	WwTW2	49	58	308	395	220	4	798	2694	4305	123
24	12/11/2019	WwTW3	147	147	207	250	120	2	617	1986	3171	80
24	12/11/2019	DS	21	24	7	32	60	7	20	71	111	20
24	12/11/2019	T1	10	13	7	8	53	2	2	9	17	13
24	12/11/2019	TB	20	28	7	45	69	4	29	107	164	20
24	12/11/2019	StC	15	22	7	31	44	4	14	49	88	17
24	12/11/2019	2BPP	14	17	7	8	49	4	2	10	19	10
24	12/11/2019	2BI	18	26	7	39	46	4	11	40	68	17

Appendix 5

Invertebrate sample log

Date	Season	Site	Sample code
20/11/2017	Autumn	Upstream	1IUS
20/11/2017	Autumn	Downstream	1IDS
20/11/2017	Autumn	Tributary 1	1IT1
20/11/2017	Autumn	Trewinnow Bridge	1I2BPP
20/11/2017	Autumn	TwoBridges Penpoint	1I2BPP
24/05/2018	Spring	Top of catchment	2ITP
24/05/2018	Spring	Upstream	2IUS
24/05/2018	Spring	Downstream	2IDS
24/05/2018	Spring	Tributary 1	2IT1
22/05/2018	Spring	Trewinnow Bridge	2ITB
24/05/2018	Spring	St Clether Bridge	2IStC
22/05/2018	Spring	TwoBridges Penpoint	2I2BPP
22/05/2018	Spring	TwoBridges Inny	2I2BI
30/08/2018	Summer	Top of catchment	No sample collected. Flow too low.
30/08/2018	Summer	Tributary 2	3IT2
31/08/2018	Summer	Upstream	3IUS
31/08/2018	Summer	Downstream	3IDS
31/08/2018	Summer	Tributary 1	3IT1
31/08/2018	Summer	Trewinnow Bridge	3ITB
31/08/2018	Summer	St Clether Bridge	3IStC
30/08/2018	Summer	TwoBridges Penpoint	3I2BPP
30/08/2018	Summer	TwoBridges Inny	3I2BI
21/11/2018	Autumn	Top of catchment	4ITP
21/11/2018	Autumn	Tributary 2	4IT2
21/11/2018	Autumn	Upstream	4IUS
21/11/2018	Autumn	Downstream	4IDS
21/11/2018	Autumn	Tributary 1	4IT1
20/11/2018	Autumn	Trewinnow Bridge	4ITB
20/11/2018	Autumn	St Clether Bridge	4IStC
20/11/2018	Autumn	TwoBridges Penpoint	4I2BPP
20/11/2018	Autumn	TwoBridges Inny	4I2BI
10/05/2019	Spring	Top of catchment	5ITP
10/05/2019	Spring	Tributary 2	5IT2
10/05/2019	Spring	Upstream	5IUS

Date	Season	Site	Sample code
10/05/2019	Spring	Downstream	5IDS
10/05/2019	Spring	Tributary 1	5IT1
10/05/2019	Spring	Trewinnow Bridge	5ITB
10/05/2019	Spring	St Clether Bridge	5IStC
10/05/2019	Spring	TwoBridges Penpoint	5I2BPP
9/05/19	Summer	TwoBridges Inny	5I2BI
29/08/2019	Summer	Top of catchment	No sample collected. Flow too low
29/08/2019	Summer	Tributary 2	6IT2
30/08/2019	Summer	Upstream	6IUS
30/08/2019	Summer	Downstream	6IDS
30/08/2019	Summer	Tributary 1	6IT2
30/08/2019	Summer	Trewinnow Bridge	6ITB
29/08/2019	Summer	St Clether Bridge	6IStC
29/08/2019	Summer	TwoBridges Penpoint	6I2BPP
29/08/2019	Summer	TwoBridges Inny	6I2BI
28/11/2019	Autumn	Top of catchment	7ITP
28/11/2019	Autumn	Tributary 2	7IT2
29/11/2019	Autumn	Upstream	7IUS
29/11/2019	Autumn	Downstream	7IDS
28/11/2019	Autumn	Tributary 1	7IT1
29/11/2019	Autumn	Trewinnow Bridge	7ITB
29/11/2019	No sample collected	St Clether Bridge	7IStC
29/11/2019	No sample collected	TwoBridges Penpoint	7I2BPP
29/11/2019	No sample collected	TwoBridges Inny	7I2BI

Recording sheet used during invertebrate sample processing to record families.

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2		4.1	4.2	4.6	3.7	**0**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7		3.6	2.3	1.4	-0.6	**0**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4		4.2	4.5	4.6	3.9	**0**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5		3.6	5.9	7.2	7.5	**0**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6		5.3	7.4	8.3	8.3	**0**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6		5.8	7.2	7.4	7.4	**0**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1		8.9	9.4	9.5	9.5	**0**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9		5.4	6.9	6.9	7.10	**0**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1		1.2	1.3	-0.9	-0.90	**0**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values			Abundance related WHPT score				0
*BMWP based only on native crayfish	NTaxa = number of scoring taxa			**WHPT NTaxa**				**0**
	ASPT = average score per taxon = score ÷ NTaxa			**Abundance related WHPT ASPT**				**#DIV/0!**

Historic Environment Agency freshwater invertebrate data and site specific physical data

Site	**INNY VALE**	EA Ref	**8889**
Survey	WHPT	NTAXA	ASPT
Spr1991	181.20	29	6.25
Sum1991	181.80	29	6.27
Aut1991	121.50	23	5.28
Spr1992	198.40	31	6.40
Sum1992	161.10	28	5.75
Aut1992	82.80	16	5.18
Sum1994	109.40	22	4.97
Aut1994	105.00	20	5.25
Spr1995	114.80	19	6.04
Aut1995	136.80	23	5.95
Spr2000	208.10	30	6.94
Aut2000	107.60	21	5.12
Spr2003	218.70	31	7.05
Aut2003	195.20	31	6.30
Spr2006	250.10	36	6.95
Aut2006	137.80	22	6.26
Spr2008	217.40	31	7.01
Aut2008	187.60	28	6.70

From HIST_INV_Physical			
AGENCY_AREA	CATCHMENT	WATERBODY_TYPE	WATERBODY_TYPE_DESCRIPTION
SOUTH WEST - CORNWALL	TAMAR	WBRV	RIVER: Natural/semi-natural flowing fresh watercourse
WATER_BODY	SITE_ID	SITE_VERSION	NGR_PREFIX
INNY	8889	1	SX
EASTING	NORTHING	NGR_10_FIG	FULL_EASTING
15400	87010	SX1540087010	215400
FULL_NORTHING	WFD_WATERBODY_ID	ALTITUDE	SLOPE
87010	GB108047007760	230	17.4
DIST_FROM_SOURCE	DISCHARGE	WIDTH	DEPTH
1.65	1	1.9	11.33
BOULDERS_COBBLES	PEBBLES_GRAVEL	SAND	SILT_CLAY
21	45	22	13
ALKALINITY	CONDUCTIVITY	TOTAL_HARDNESS	CALCIUM
48.5			
BASE_DATA_DATE	MIN_SAMPLE_DATE	MAX_SAMPLE_DATE	COUNT_OF_SAMPLES
01/01/1995	17/04/1991	22/10/2008	18

Site	**TREWINNOW BRIDGE**	EA Ref	8890
Survey	WHPT	NTAXA	ASPT
Spr1991	232.4	32	7.26
Sum1991	196.6	28	7.02
Aut1991	188.0	31	6.06
Spr1992	233.2	34	6.86
Sum1992	170.0	26	6.54
Aut1992	162.4	25	6.50
Sum1994	171.3	28	6.12
Aut1994	158.9	27	5.89

From HIST_INV_Physical			
AGENCY_AREA	CATCHMENT	WATERBODY_TYPE	WATERBODY_TYPE_DESCRIPTION
SOUTH WEST - CORNWALL	TAMAR	WBRV	RIVER: Natural/semi-natural flowing fresh watercourse
WATER_BODY	SITE_ID	SITE_VERSION	NGR_PREFIX
INNY	8890	1	SX
EASTING	NORTHING	NGR_10_FIG	FULL_EASTING
17038	86469	SX1703886469	217038
FULL_NORTHING	WFD_WATERBODY_ID	ALTITUDE	SLOPE
86469	GB108047007760	217	7.6
DIST_FROM_SOURCE	DISCHARGE	WIDTH	DEPTH
3.4	2	3.1	28
BOULDERS_COBBLES	PEBBLES_GRAVEL	SAND	SILT_CLAY
35	48	12	5
ALKALINITY	CONDUCTIVITY	TOTAL_HARDNESS	CALCIUM
BASE_DATA_DATE	MIN_SAMPLE_DATE	MAX_SAMPLE_DATE	COUNT_OF_SAMPLES
02/03/2021	17/04/1991	17/09/2019	10

Site	**St Clether Bridge**	EA Ref	8927
Survey	WHPT	NTAXA	ASPT
Spr1990	232.40	34	6.84
Sum1990	207.10	30	6.90
Aut1990	185.70	27	6.88
Spr1992	167.50	23	7.28
Sum1992	219.80	31	7.09
Aut1992	170.30	25	6.81
Spr1994	208.30	29	7.18
Aut1994	201.30	29	6.94
Spr1995	289.90	39	7.43
Aut1995	276.90	40	6.92
Spr2000	273.90	39	7.02
Aut2000	224.90	31	7.25

From HIST_INV_Physical			
AGENCY_AREA	CATCHMENT	WATERBODY_TYPE	WATERBODY_TYPE_DESCRIPTION
SOUTH WEST - CORNWALL	TAMAR	WBRV	RIVER: Natural/semi-natural flowing fresh watercourse
WATER_BODY	SITE_ID	SITE_VERSION	NGR_PREFIX
INNY	8927	1	SX
EASTING	NORTHING	NGR_10_FIG	FULL_EASTING
20520	84182	SX2052084182	220520
FULL_NORTHING	WFD_WATERBODY_ID	ALTITUDE	SLOPE
84182	GB108047007760	177	7.4
DIST_FROM_SOURCE	DISCHARGE	WIDTH	DEPTH
8	3	4.8	30
BOULDERS_COBBLES	PEBBLES_GRAVEL	SAND	SILT_CLAY
46	33	10	11
ALKALINITY	CONDUCTIVITY	TOTAL_HARDNESS	CALCIUM
77.5			
BASE_DATA_DATE	MIN_SAMPLE_DATE	MAX_SAMPLE_DATE	COUNT_OF_SAMPLES
02/03/2021	05/04/1990	17/09/2019	14

Site	**2BI**	EA Ref	8892
Survey	WHPT	NTAXA	ASPT
Spr1991	280.50	41	6.84
Sum1991	274.50	41	6.70
Aut1991	185.60	28	6.63
Spr1992	163.80	23	7.12
Sum1992	150.80	23	6.56
Aut1992	201.90	31	6.51
Spr1994	254.70	33	7.72
Sum1994	190.10	26	7.31
Aut1994	175.90	24	7.33
Spr1995	222.00	30	7.40
Aut1995	245.00	35	7.00
Spr2000	226.00	33	6.85
Aut2000	269.90	37	7.29
Spr2004	233.50	33	7.08
Aut2004	208.60	31	6.73
Spr2008	268.70	36	7.46
Aut2008	217.90	31	7.03
Spr2011	270.70	37	7.32
Aut2011	239.50	34	7.04
Spr2014	230.60	32	7.21
Aut2014	258.10	37	6.98
Spr2017	244.10	34	7.18
Aut2017	233.60	32	7.30

From HIST_INV_Physical			
AGENCY_AREA	CATCHMENT	WATERBODY_TYPE	WATERBODY_TYPE_DESCRIPTION
SOUTH WEST - CORNWALL	TAMAR	WBRV	RIVER: Natural/semi-natural flowing fresh watercourse
WATER_BODY	SITE_ID	SITE_VERSION	NGR_PREFIX
INNY	8892	1	SX
EASTING	NORTHING	NGR_10_FIG	FULL_EASTING
26690	81910	SX2669081910	226690
FULL_NORTHING	WFD_WATERBODY_ID	ALTITUDE	SLOPE
81910	GB108047007760	114	8
DIST_FROM_SOURCE	DISCHARGE	WIDTH	DEPTH
16	3	5.4	30.44
BOULDERS_COBBLES	PEBBLES_GRAVEL	SAND	SILT_CLAY
46	42	6	6
ALKALINITY	CONDUCTIVITY	TOTAL_HARDNESS	CALCIUM
63.3			
BASE_DATA_DATE	MIN_SAMPLE_DATE	MAX_SAMPLE_DATE	COUNT_OF_SAMPLES
01/01/1995	18/04/1991	12/10/2017	23

Invertebrate data collected during the study

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 1US	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**211**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**11**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**1**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 1US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**1**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**1**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8	**1**	5.8 ✓	5.7	5.7	5.7	**5.8**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**1**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5	**2**	5.5 ✓	5.5	5.5	5.5	**5.5**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8	**2**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**7**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**2**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7	**1**	6.7 ✓	6.9	7.1	7.1	**6.7**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 1US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**2**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0	**1**	7.0 ✓	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8	**4**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**3**	1.2 ✓	1.3	-0.9	-0.90	**1.2**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4	**4**	4.4 ✓	4.4	4.4	4.40	**4.4**
Muscidae		3.9	**1**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			118.5
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**22**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**5.3863636**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 1DS	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**12**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**1**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7	**1**	5.8 ✓	5.5	5.5	5.5	**5.8**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**40**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**3**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 1DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**1**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**8**	3.6 ✓	5.9	7.2	7.5	**3.6**
Heptageniidae (incl. Arthropleidae)	10	9.7	**2**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8	**1**	8.8 ✓	9.1	9.2	9.2	**8.8**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**2**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2	**1**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**3**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**5**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**3**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**1**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**1**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**9**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8	**1**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**13**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4	**4**	4.4 ✓	4.4	4.4	4.40	**4.4**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			121.9
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**21**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**5.8047619**

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Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**3**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**8**	3.6 ✓	2.3	1.4	-0.6	**3.6**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**71**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5	**1**	11.3 ✓	12.2	12.2	12.2	**11.3**
Baetidae	4	5.5	**9**	3.6 ✓	5.9	7.2	7.5	**3.6**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8	**1**	8.8 ✓	9.1	9.2	9.2	**8.8**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**6**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**1**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**3**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**1**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**3**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1	**2**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**1**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1		8.9	9.4	9.5	9.5	**0**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 1T1**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**1**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1	**13**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**

Notes	Score = sum of WHPT values	Abundance related WHPT score	96.4
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**15**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.4266667**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 1TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**4**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**146**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2	**1**	5.2 ✓	4.9	4.9	4.9	**5.2**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 1TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**38**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**68**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8	**4**	8.8 ✓	9.1	9.2	9.2	**8.8**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 1TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 1TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2	**1**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**4**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**1**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1	**1**	8.2 ✓	8.1	8.1	8.1	**8.2**
Hydropsychidae	5	6.6	**12**	5.8	7.2 ✓	7.4	7.4	**7.2**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1	**1**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**2**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1		8.9	9.4	9.5	9.5	**0**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 1TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**4**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1	**11**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6	**1**	9.6 ✓	9.6	9.6	9.60	**9.6**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			98.9
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**16**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.18125**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 12BPP**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9	**1**	2.8 ✓	3.1	3.1	3.1	**2.8**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**1**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**104**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 12BPP**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**23**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**71**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**1**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**12**	10.5	11.5 ✓	11.5	11.5	**11.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 12BPP**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2	**1**	5.2 ✓	5.5	5.5	5.5	**5.2**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 12BPP**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**22**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**1**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8	**1**	5.8 ✓	5.7	5.7	5.7	**5.8**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**14**	5.8	7.2 ✓	7.4	7.4	**7.2**
Phryganeidae	10	5.5	**2**	5.5 ✓	5.5	5.5	5.5	**5.5**
Brachycentridae	10	9.5	**1**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1	**1**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8	**1**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1		8.9	9.4	9.5	9.5	**0**
Odontoceridae	10	11.0	**1**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**3**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0	**1**	7.0 ✓	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**1**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**5**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**14**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3	**2**	9.3 ✓	9.5	9.5	9.50	**9.3**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4	**1**	4.4 ✓	4.4	4.4	4.40	**4.4**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			156.9
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**24**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.5375**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 2TP**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**126**	4.7	5.4	5.4 ✓	5.4	**5.4**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**29**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**27**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**220**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**49**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**1**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**10**	10.5	11.5 ✓	11.5	11.5	**11.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5	**3**	4.5 ✓	3.9	3.9	3.9	**4.5**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2	**1**	5.8 ✓	8.8	8.8	8.8	**5.8**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**5**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**2**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7	**2**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1	**10**	8.2	8.1 ✓	8.1	8.1	**8.1**
Hydropsychidae	5	6.6		5.8	7.2	7.4	7.4	**0**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8	**1**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1		8.9	9.4	9.5	9.5	**0**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**10**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4	**1**	4.5 ✓	3.0	3.0	3.00	**4.5**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0	**1**	7.0 ✓	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**1**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**42**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**29**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**

Notes	Score = sum of WHPT values	Abundance related WHPT score	115.8
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**19**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.0947368**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 2US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**21**	4.7	5.4 ✓	5.4	5.4	**5.4**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7	**2**	5.2 ✓	6.7	6.7	6.7	**5.2**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**31**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**73**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2	**1**	5.2 ✓	4.9	4.9	4.9	**5.2**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**105**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5	**13**	11.3	12.2 ✓	12.2	12.2	**12.2**
Baetidae	4	5.5	**181**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**34**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2	**245**	7.9	8.5	9.0 ✓	9.0	**9**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3	**1**	11.0 ✓	11.9	12.1	12.1	**11**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**23**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**24**	10.5	11.5 ✓	11.5	11.5	**11.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**13**	11.4	12.2 ✓	12.2	12.2	**12.2**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**1**	5.9 ✓	6.2	6.2	6.2	**5.9**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5	**3**	4.5 ✓	3.9	3.9	3.9	**4.5**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2	**1**	3.2 ✓	3.2	3.2	3.2	**3.2**
Dytiscidae	5	4.5	**1**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**20**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**12**	8.1	9.2 ✓	8.3	8.3	**9.2**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**6**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1	**2**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**11**	5.9	6.9 ✓	6.9	6.9	**6.9**
Goeridae	10	8.8	**14**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**6**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**3**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**12**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0	**125**	3.0	3.0	3.0 ✓	3.00	**3**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8	**16**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**218**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			212.1
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**30**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**7.07**

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Triclada (flatworms)								
Planariidae	5	4.9	**4**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**21**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**645**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**1**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**2**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**33**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**2**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2	**26**	7.9	8.5 ✓	9.0	9.0	**8.5**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**6**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**8**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**9**	11.4 ✓	12.2	12.2	12.2	**11.4**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**5**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**21**	8.1	9.2 ✓	8.3	8.3	**9.2**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**1**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5	**1**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1	**1**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8	**14**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**1**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**3**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**13**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**86**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**95**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**139**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**1**	4.0 ✓	2.6	2.6	2.60	**4**

Notes	Score = sum of WHPT values	Abundance related WHPT score	162.2
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**24**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.7583333**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 2T1	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9	**32**	4.7	5.4 ✓	5.4	5.4	**5.4**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**4**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**56**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 2T1**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**132**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**56**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**24**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**44**	7.9	8.5 ✓	9.0	9.0	**8.5**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**24**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**1**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**20**	11.4	12.2 ✓	12.2	12.2	**12.2**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 2T1**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5	**8**	4.5 ✓	3.9	3.9	3.9	**4.5**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2	**2**	3.2 ✓	3.2	3.2	3.2	**3.2**
Dytiscidae	5	4.5	**2**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2	**1**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2	**2**	5.8 ✓	8.8	8.8	8.8	**5.8**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**8**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3	**1**	4.2 ✓	4.4	4.4	4.4	**4.2**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2	**1**	11.2 ✓	11.1	11.1	11.1	**11.2**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**16**	5.8	7.2 ✓	7.4	7.4	**7.2**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**8**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**2**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**12**	8.9	9.4 ✓	9.5	9.5	**9.4**
Odontoceridae	10	11.0	**4**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7	**1**	6.7 ✓	6.9	7.1	7.1	**6.7**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**20**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**8**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**5**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1		1.2	1.3	-0.9	-0.90	**0**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			196.4
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**28**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**7.0142857**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 2TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**20**	4.7	5.4 ✓	5.4	5.4	**5.4**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**20**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7	**1**	3.6 ✓	3.8	3.3	3.3	**3.6**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**4**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**4**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**508**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**1**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**1**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**36**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**4**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2	**124**	7.9	8.5	9.0 ✓	9.0	**9**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**8**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**4**	11.4 ✓	12.2	12.2	12.2	**11.4**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5	**1**	4.5 ✓	3.9	3.9	3.9	**4.5**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**8**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**36**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3	**4**	4.2 ✓	4.4	4.4	4.4	**4.2**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**4**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7	**4**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**1**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**8**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**12**	8.9	9.4 ✓	9.5	9.5	**9.4**
Odontoceridae	10	11.0	**12**	11.1	10.3 ✓	10.3	10.3	**10.3**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 2TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**32**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**40**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**4**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**384**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4	**4**	4.4 ✓	4.4	4.4	4.40	**4.4**
Muscidae		3.9	**8**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			176.6
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**30**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**5.8866667**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 2StC	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9	**17**	4.7	5.4 ✓	5.4	5.4	**5.4**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**60**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**73**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**1**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**15**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5	**1**	11.3 ✓	12.2	12.2	12.2	**11.3**
Baetidae	4	5.5	**19**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**4**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**8**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**63**	7.9	8.5 ✓	9.0	9.0	**8.5**
Caenidae	7	6.5	**6**	6.5 ✓	6.5	6.5	6.5	**6.5**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**33**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**3**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**9**	11.4 ✓	12.2	12.2	12.2	**11.4**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**1**	5.9 ✓	6.2	6.2	6.2	**5.9**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**1**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**34**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**6**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**3**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1	**52**	9.9	10.3 ✓	10.2	10.2	**10.3**
Limnephilidae (including Apataniidae)	7	6.2	**14**	5.9	6.9 ✓	6.9	6.9	**6.9**
Goeridae	10	8.8	**7**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**9**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**8**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**9**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**2**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**120**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1	**2**	7.1 ✓	7.3	7.3	7.30	**7.1**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			190.4
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**28**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.8**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 22BPP	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9	**8**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**4**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**120**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**8**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**12**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**16**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**8**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**100**	7.9	8.5	9.0 ✓	9.0	**9**
Caenidae	7	6.5	**16**	6.5	6.5 ✓	6.5	6.5	**6.5**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**44**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**1**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**12**	11.4	12.2 ✓	12.2	12.2	**12.2**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 22BPP**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2	**16**	5.2	5.5 ✓	5.5	5.5	**5.5**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 22BPP**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**32**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**1**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1	**4**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**4**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**1**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**4**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 22BPP	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**1**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8	**12**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**16**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			163.1
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**23**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**7.0913043**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 22BI**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9	**8**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**4**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**120**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 22BI**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**8**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**12**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**16**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**8**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**100**	7.9	8.5	9.0 ✓	9.0	**9**
Caenidae	7	6.5	**16**	6.5	6.5 ✓	6.5	6.5	**6.5**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**44**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**1**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**12**	11.4	12.2 ✓	12.2	12.2	**12.2**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 22BI**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2	**16**	5.2	5.5 ✓	5.5	5.5	**5.5**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 22BI**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2	**4**	3.2 ✓	3.2	3.2	3.2	**3.2**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**32**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**1**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1	**4**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**4**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**5**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**4**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 22BI**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**2**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8	**12**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**16**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**

Notes	Score = sum of WHPT values	Abundance related WHPT score	166.3
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**24**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.9291667**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 3T2**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**1**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**4**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7	**1**	5.8 ✓	5.5	5.5	5.5	**5.8**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**1**	3.6 ✓	2.3	1.4	-0.6	**3.6**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**73**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**7**	3.6 ✓	5.9	7.2	7.5	**3.6**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**1**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**7**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6		5.3	7.4	8.3	8.3	**0**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6		5.8	7.2	7.4	7.4	**0**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**1**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**1**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**4**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**1**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**20**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			66.6
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**13**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**5.1230769**

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Triclada (flatworms)								
Planariidae	5	4.9	**4**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**104**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**20**	3.6	2.5 ✓	1.2	1.2	**2.5**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**20**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**1**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8	**8**	4.0 ✓	2.3	0.8	-1.6	**4**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**140**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5	**1**	11.3 ✓	12.2	12.2	12.2	**11.3**
Baetidae	4	5.5	**44**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**4**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**1**	7.9 ✓	8.5	9.0	9.0	**7.9**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**16**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**20**	4.5	4.8 ✓	4.8	4.8	**4.8**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**10**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**12**	8.1	9.2 ✓	8.3	8.3	**9.2**
Glossosomatidae	7	7.7	**1**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1	**4**	8.2 ✓	8.1	8.1	8.1	**8.2**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**1**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**12**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**16**	8.9	9.4 ✓	9.5	9.5	**9.4**
Odontoceridae	10	11.0	**2**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7	**4**	6.7 ✓	6.9	7.1	7.1	**6.7**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 3US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
Tipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**20**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**24**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**12**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**387**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**12**	4.0	2.6 ✓	2.6	2.60	**2.6**
Notes	Score = sum of WHPT values				Abundance related WHPT score			183.9
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**29**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.3413793**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 3DS**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**4**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**4**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**72**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**4**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 3DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4		4.2	4.5	4.6	3.9	**0**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**4**	3.6 ✓	5.9	7.2	7.5	**3.6**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**8**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**1**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6		5.3	7.4	8.3	8.3	**0**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**1**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**8**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**8**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**20**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1	**88**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			58.7
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**12**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**4.8916667**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 3T1**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**4**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**1**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**4**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**16**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 3T1**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**64**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**28**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8	**1**	8.8 ✓	9.1	9.2	9.2	**8.8**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3	**1**	8.7 ✓	10.7	10.7	10.7	**8.7**
Leuctridae	10	10.0	**12**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**4**	5.9 ✓	6.2	6.2	6.2	**5.9**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8	**1**	9.8 ✓	9.8	9.8	9.8	**9.8**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5	**1**	4.5 ✓	3.9	3.9	3.9	**4.5**
Gerridae	5	5.2	**12**	5.2	5.5 ✓	5.5	5.5	**5.5**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 3T1	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**8**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3	**3**	4.2 ✓	4.4	4.4	4.4	**4.2**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**4**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6		5.8	7.2	7.4	7.4	**0**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**8**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**4**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**4**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 3T1	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**16**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4	**2**	4.5 ✓	3.0	3.0	3.00	**4.5**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**1**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**4**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**92**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**4**	4.0 ✓	2.6	2.6	2.60	**4**

Notes	Score = sum of WHPT values	Abundance related WHPT score	150
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**25**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 3TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**4**	4.1 ✓	4.2	4.6	3.7	**4.1**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**20**	3.6	2.5 ✓	1.2	1.2	**2.5**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**4**	3.6 ✓	2.3	1.4	-0.6	**3.6**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**4**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 3TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4		4.2	4.5	4.6	3.9	**0**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5		3.6	5.9	7.2	7.5	**0**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**1**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**2**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**4**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3	**4**	4.2 ✓	4.4	4.4	4.4	**4.2**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6		5.8	7.2	7.4	7.4	**0**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2		5.9	6.9	6.9	6.9	**0**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**1**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 3TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**1**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**8**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1	**76**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			58.1
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**12**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**4.8416667**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 4US**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**3332**	4.1	4.2	4.6	3.7 ✓	**3.7**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**84**	3.6	2.5 ✓	1.2	1.2	**2.5**
Planorbidae (excl. *Ancylus* group)	3	3.1	**16**	3.2	3.0 ✓	2.4	2.4	**3**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**4**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**88**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**2**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 4US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8	**4**	4.0 ✓	2.3	0.8	-1.6	**4**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**172**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**124**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**8**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8	**4**	8.8 ✓	9.1	9.2	9.2	**8.8**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5	**1**	6.5 ✓	6.5	6.5	6.5	**6.5**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3	**1**	8.7 ✓	10.7	10.7	10.7	**8.7**
Leuctridae	10	10.0	**4**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**1**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**12**	11.4	12.2 ✓	12.2	12.2	**12.2**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 4US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**1**	5.9 ✓	6.2	6.2	6.2	**5.9**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**6**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2	**1**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**88**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**12**	8.1	9.2 ✓	8.3	8.3	**9.2**
Glossosomatidae	7	7.7	**1**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2	**8**	6.1 ✓	6.5	6.8	6.8	**6.1**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**8**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**24**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**4**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**4**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7	**16**	6.7	6.9 ✓	7.1	7.1	**6.9**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**68**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8	**4**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**4**	1.2 ✓	1.3	-0.9	-0.90	**1.2**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**4**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			213.8
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**33**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.4787879**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 4DS	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9	**2**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**440**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**36**	3.6	2.5 ✓	1.2	1.2	**2.5**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**4**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**12**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**32**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**132**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**16**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**2**	11.4 ✓	12.2	12.2	12.2	**11.4**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2	**4**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**16**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**4**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**12**	5.9	6.9 ✓	6.9	6.9	**6.9**
Goeridae	10	8.8		8.8	8.8	9.4	9.4	**0**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**4**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7	**4**	6.7 ✓	6.9	7.1	7.1	**6.7**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**29**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5		5.4	5.5	5.5	5.50	**0**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1	**16**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**
Notes	Score = sum of WHPT values				Abundance related WHPT score			112
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**18**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.2222222**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 4TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**20**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4	**4**	2.7 ✓	2.0	0.4	0.4	**2.7**
Lymnaeidae	3	3.3	**56**	3.6	2.5 ✓	1.2	1.2	**2.5**
Planorbidae (excl. *Ancylus* group)	3	3.1	**2**	3.2 ✓	3.0	2.4	2.4	**3.2**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**1**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**40**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**4**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**2**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 4TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**4**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**80**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**4**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8	**1**	8.8 ✓	9.1	9.2	9.2	**8.8**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3	**1**	8.7 ✓	10.7	10.7	10.7	**8.7**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6	**4**	9.7 ✓	9.4	9.4	9.4	**9.7**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**2**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**2**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3	**2**	4.2 ✓	4.4	4.4	4.4	**4.2**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1	**4**	8.2 ✓	8.1	8.1	8.1	**8.2**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5	**3**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**1**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**1**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**1**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**4**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4	**1**	4.5 ✓	3.0	3.0	3.00	**4.5**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**16**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**2**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**132**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**4**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			165.6
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**30**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**5.52**

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Triclada (flatworms)								
Planariidae	5	4.9	**4**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**264**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7	**4**	3.6 ✓	3.8	3.3	3.3	**3.6**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**3**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1	**4**	3.2 ✓	3.0	2.4	2.4	**3.2**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**92**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**4**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**3**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**184**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**304**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**172**	8.5	10.3	11.1 ✓	11.1	**11.1**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**588**	7.9	8.5	9.0 ✓	9.0	**9**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**12**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**60**	10.5	11.5 ✓	11.5	11.5	**11.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**44**	11.4	12.2 ✓	12.2	12.2	**12.2**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**4**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**76**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**16**	8.1	9.2 ✓	8.3	8.3	**9.2**
Glossosomatidae	7	7.7	**8**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2	**4**	6.1 ✓	6.5	6.8	6.8	**6.1**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**24**	5.8	7.2 ✓	7.4	7.4	**7.2**
Phryganeidae	10	5.5	**1**	5.5 ✓	5.5	5.5	5.5	**5.5**
Brachycentridae	10	9.5	**4**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1	**4**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**28**	5.9	6.9 ✓	6.9	6.9	**6.9**
Goeridae	10	8.8	**72**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**20**	8.9	9.4 ✓	9.5	9.5	**9.4**
Odontoceridae	10	11.0	**5**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 5US	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**52**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4	**1**	4.5 ✓	3.0	3.0	3.00	**4.5**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**8**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**12**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**436**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**

Notes	Score = sum of WHPT values	Abundance related WHPT score	228.9
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**34**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.7323529**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**12**	4.7	5.4 ✓	5.4	5.4	**5.4**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**248**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7	**2**	3.6 ✓	3.8	3.3	3.3	**3.6**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**8**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**4**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**7460**	3.6	2.3	1.4	-0.6 ✓	**-0.6**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**1**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**4**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**332**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**12**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2	**188**	7.9	8.5	9.0 ✓	9.0	**9**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**12**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**36**	10.5	11.5 ✓	11.5	11.5	**11.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**48**	11.4	12.2 ✓	12.2	12.2	**12.2**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5DS**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**1**	5.9 ✓	6.2	6.2	6.2	**5.9**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6	**4**	3.6 ✓	3.4	3.4	3.4	**3.6**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2	**4**	3.2 ✓	3.2	3.2	3.2	**3.2**
Dytiscidae	5	4.5	**16**	4.5	4.8 ✓	4.8	4.8	**4.8**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2	**12**	5.8	8.8 ✓	8.8	8.8	**8.8**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**64**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**24**	8.1	9.2 ✓	8.3	8.3	**9.2**
Glossosomatidae	7	7.7	**4**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2	**8**	6.1 ✓	6.5	6.8	6.8	**6.1**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**8**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5	**8**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**8**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**32**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**32**	8.9	9.4 ✓	9.5	9.5	**9.4**
Odontoceridae	10	11.0	**1**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**92**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**52**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**12**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**1072**	1.2	1.3	-0.9	-0.90 ✓	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6	**1**	9.6 ✓	9.6	9.6	9.60	**9.6**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1	**4**	7.0 ✓	7.6	7.6	7.60	**7**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4	**4**	4.4 ✓	4.4	4.4	4.40	**4.4**
Muscidae		3.9	**5**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			239.6
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**37**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.4756757**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**8**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**276**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**24**	3.6	2.5 ✓	1.2	1.2	**2.5**
Planorbidae (excl. *Ancylus* group)	3	3.1	**12**	3.2	3.0 ✓	2.4	2.4	**3**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**4**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**124**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**4**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**1**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**128**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**8**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**92**	7.9	8.5 ✓	9.0	9.0	**8.5**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3	**48**	8.7	10.7 ✓	10.7	10.7	**10.7**
Leuctridae	10	10.0	**16**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6	**1**	9.7 ✓	9.4	9.4	9.4	**9.7**
Perlodidae	10	10.8	**16**	10.5	11.5 ✓	11.5	11.5	**11.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**44**	11.4	12.2 ✓	12.2	12.2	**12.2**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5TB**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**1**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2	**2**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**32**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**8**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7	**1**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2	**1**	6.1 ✓	6.5	6.8	6.8	**6.1**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6		5.8	7.2	7.4	7.4	**0**
Phryganeidae	10	5.5	**20**	5.5	5.5 ✓	5.5	5.5	**5.5**
Brachycentridae	10	9.5	**4**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1	**4**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**3**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**12**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**4**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**1**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7	**4**	6.7 ✓	6.9	7.1	7.1	**6.7**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 5TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**109**	5.4	6.9	6.9 ✓	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**96**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**16**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**1348**	1.2	1.3	-0.9	-0.90 ✓	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**5**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			245.6
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**36**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.8222222**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 6US**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9	**2**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**188**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**12**	3.6	2.5 ✓	1.2	1.2	**2.5**
Planorbidae (excl. *Ancylus* group)	3	3.1	**4**	3.2 ✓	3.0	2.4	2.4	**3.2**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**8**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**76**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**4**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**4**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 6US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**120**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**100**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**8**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2	**12**	7.9	8.5 ✓	9.0	9.0	**8.5**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**16**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**1**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**16**	5.9	6.2 ✓	6.2	6.2	**6.2**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**4**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**52**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**4**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7	**2**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2	**4**	6.1 ✓	6.5	6.8	6.8	**6.1**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6		5.8	7.2	7.4	7.4	**0**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5	**4**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**2**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**8**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**3**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 6US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**16**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**12**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**40**	5.5	6.1 ✓	5.8	3.90	**6.1**
Chironomidae	2	1.1	**56**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1	**4**	7.0 ✓	7.6	7.6	7.60	**7**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**

Notes	Score = sum of WHPT values	Abundance related WHPT score	187
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**30**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.2333333**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 6DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**1**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**188**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7	**12**	3.6	3.8 ✓	3.3	3.3	**3.8**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**160**	3.6	2.5	1.2 ✓	1.2	**1.2**
Planorbidae (excl. *Ancylus* group)	3	3.1	**16**	3.2	3.0 ✓	2.4	2.4	**3**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**1220**	3.6	2.3	1.4	-0.6 ✓	**-0.6**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**1**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**1**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**208**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7	**4**	8.5 ✓	10.3	11.1	11.1	**8.5**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2	**4**	7.9 ✓	8.5	9.0	9.0	**7.9**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**8**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**4**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6	**4**	11.4 ✓	12.2	12.2	12.2	**11.4**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**4**	5.9 ✓	6.2	6.2	6.2	**5.9**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2	**16**	8.1	9.0 ✓	9.0	9.0	**9**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2	**4**	5.8 ✓	8.8	8.8	8.8	**5.8**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**188**	5.3	7.4	8.3 ✓	8.3	**8.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**16**	8.1	9.2 ✓	8.3	8.3	**9.2**
Glossosomatidae	7	7.7	**2**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2	**74**	6.1	6.5 ✓	6.8	6.8	**6.5**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1	**12**	8.2	8.1 ✓	8.1	8.1	**8.1**
Hydropsychidae	5	6.6	**12**	5.8	7.2 ✓	7.4	7.4	**7.2**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5	**5**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1	**1**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**4**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**36**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**2**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**176**	5.4	6.9	6.9 ✓	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**52**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**156**	5.5	6.1	5.8 ✓	3.90	**5.8**
Chironomidae	2	1.1	**1104**	1.2	1.3	-0.9	-0.90 ✓	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1	**1**	7.1 ✓	7.3	7.3	7.30	**7.1**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**44**	4.0	2.6 ✓	2.6	2.60	**2.6**

Notes	Score = sum of WHPT values	Abundance related WHPT score	217.2
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**34**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.3882353**

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Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**192**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4	**2**	2.7 ✓	2.0	0.4	0.4	**2.7**
Lymnaeidae	3	3.3	**296**	3.6	2.5	1.2 ✓	1.2	**1.2**
Planorbidae (excl. *Ancylus* group)	3	3.1	**12**	3.2	3.0 ✓	2.4	2.4	**3**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6	**4**	3.6 ✓	3.8	3.8	3.8	**3.6**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9	**4**	4.4 ✓	3.5	3.4	2.3	**4.4**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**44**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4		4.2	4.5	4.6	3.9	**0**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**108**	3.6	5.9	7.2 ✓	7.5	**7.2**
Heptageniidae (incl. Arthropleidae)	10	9.7		8.5	10.3	11.1	11.1	**0**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**28**	9.3	10.6 ✓	10.6	10.6	**10.6**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8		10.5	11.5	11.5	11.5	**0**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**16**	4.5	4.8 ✓	4.8	4.8	**4.8**
Gyrinidae	5	8.2	**3**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**108**	5.3	7.4	8.3 ✓	8.3	**8.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**4**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2	**82**	6.1	6.5 ✓	6.8	6.8	**6.5**
Philopotamidae	8	11.2	**1**	11.2 ✓	11.1	11.1	11.1	**11.2**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1	**8**	8.2 ✓	8.1	8.1	8.1	**8.2**
Hydropsychidae	5	6.6	**20**	5.8	7.2 ✓	7.4	7.4	**7.2**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5	**4**	9.6 ✓	9.5	8.9	8.9	**9.6**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**2**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**4**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**4**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0		11.1	10.3	10.3	10.3	**0**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 6TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**48**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**28**	5.4	5.5 ✓	5.5	5.50	**5.5**
Simuliidae	5	5.8	**224**	5.5	6.1	5.8 ✓	3.90	**5.8**
Chironomidae	2	1.1	**400**	1.2	1.3	-0.9 ✓	-0.90	**-0.9**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1	**4**	7.0 ✓	7.6	7.6	7.60	**7**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**20**	4.0	2.6 ✓	2.6	2.60	**2.6**
Notes	Score = sum of WHPT values				Abundance related WHPT score			162.1
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**27**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.003704**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 7US	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9	**2**	4.7 ✓	5.4	5.4	5.4	**4.7**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**184**	4.1	4.2	4.6 ✓	3.7	**4.6**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**4**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**56**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**1**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**4**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7US**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8	**1**	4.0 ✓	2.3	0.8	-1.6	**4**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**108**	4.2	4.5	4.6 ✓	3.9	**4.6**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**24**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**44**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2	**1**	7.9 ✓	8.5	9.0	9.0	**7.9**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3	**4**	8.7 ✓	10.7	10.7	10.7	**8.7**
Leuctridae	10	10.0	**1**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**4**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**8**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2	**4**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**112**	5.3	7.4	8.3 ✓	8.3	**8.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**4**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**4**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**44**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**4**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**1**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 7US	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**24**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**1**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1	**3**	1.2 ✓	1.3	-0.9	-0.90	**1.2**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**1**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			170.4
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**27**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.3111111**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7DS**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9	**1**	2.8 ✓	3.1	3.1	3.1	**2.8**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**52**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**4**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**120**	3.6	2.3	1.4 ✓	-0.6	**1.4**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1	**4**	3.6 ✓	2.0	-0.8	-0.8	**3.6**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**72**	4.2	4.5 ✓	4.6	3.9	**4.5**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**68**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**40**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4	**1**	8.3 ✓	8.8	9.4	9.4	**8.3**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**4**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7DS**	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0	**4**	5.9 ✓	6.2	6.2	6.2	**5.9**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**1**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**24**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**2**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**1**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**4**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**36**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**8**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**1**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7DS**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**41**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**4**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**8**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**16**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1	**1**	7.1 ✓	7.3	7.3	7.30	**7.1**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1	**4**	7.0 ✓	7.6	7.6	7.60	**7**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4	**1**	4.4 ✓	4.4	4.4	4.40	**4.4**
Muscidae		3.9	**4**	4.0 ✓	2.6	2.6	2.60	**4**

Notes	Score = sum of WHPT values	Abundance related WHPT score	163.1
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**27**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.0407407**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7T1**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9	**13**	4.7	5.4 ✓	5.4	5.4	**5.4**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**32**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3		3.6	2.5	1.2	1.2	**0**
Planorbidae (excl. *Ancylus* group)	3	3.1	**28**	3.2	3.0 ✓	2.4	2.4	**3**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**48**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2		3.4	2.5	0.8	0.8	**0**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

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Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8	**1**	4.0 ✓	2.3	0.8	-1.6	**4**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4		4.2	4.5	4.6	3.9	**0**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**3**	3.6 ✓	5.9	7.2	7.5	**3.6**
Heptageniidae (incl. Arthropleidae)	10	9.7	**13**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0	**2**	9.3 ✓	10.6	10.6	10.6	**9.3**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**3**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

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Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

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Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5		4.5	4.8	4.8	4.8	**0**
Gyrinidae	5	8.2	**1**	8.1 ✓	9.0	9.0	9.0	**8.1**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**8**	5.3 ✓	7.4	8.3	8.3	**5.3**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4	**4**	8.1 ✓	9.2	8.3	8.3	**8.1**
Glossosomatidae	7	7.7		7.8	7.6	7.2	7.2	**0**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**2**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1		9.9	10.3	10.2	10.2	**0**
Limnephilidae (including Apataniidae)	7	6.2	**4**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**13**	8.8	8.8 ✓	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**6**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**14**	11.1	10.3 ✓	10.3	10.3	**10.3**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

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Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**5**	5.4 ✓	6.9	6.9	7.10	**5.4**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**1**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8	**3**	5.5 ✓	6.1	5.8	3.90	**5.5**
Chironomidae	2	1.1	**2**	1.2 ✓	1.3	-0.9	-0.90	**1.2**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9		4.0	2.6	2.6	2.60	**0**

Notes	Score = sum of WHPT values	Abundance related WHPT score	131.3
*BMWP based only on native crayfish	NTaxa = number of scoring taxa	**WHPT NTaxa**	**21**
	ASPT = average score per taxon = score ÷ NTaxa	**Abundance related WHPT ASPT**	**6.252381**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Triclada (flatworms)								
Planariidae	5	4.9		4.7	5.4	5.4	5.4	**0**
Dugesiidae	5	2.9		2.8	3.1	3.1	3.1	**0**
Dendrocoelidae	5	3.0		3.0	2.6	2.6	2.6	**0**
Mollusca (snails, limpets and mussels)								
Neritidae	6	6.4		6.4	6.5	6.9	6.9	**0**
Viviparidae	6	5.7		5.2	6.7	6.7	6.7	**0**
Valvatidae	3	3.2		3.3	3.1	2.7	2.7	**0**
Hydrobiidae	3	4.2	**24**	4.1	4.2 ✓	4.6	3.7	**4.2**
Bithyniidae	3	3.7		3.6	3.8	3.3	3.3	**0**
Physidae	3	2.4		2.7	2.0	0.4	0.4	**0**
Lymnaeidae	3	3.3	**8**	3.6 ✓	2.5	1.2	1.2	**3.6**
Planorbidae (excl. *Ancylus* group)	3	3.1		3.2	3.0	2.4	2.4	**0**
Ancylus group (= Ancylidae)	6	5.7		5.8	5.5	5.5	5.5	**0**
Acroloxidae	6	3.6		3.6	3.8	3.8	3.8	**0**
Unionidae	6	5.3		5.2	6.9	6.9	6.9	**0**
Sphaeriidae (Pea mussels)	3	3.9		4.4	3.5	3.4	2.3	**0**
Dreissenidae		3.7		3.7	3.7	3.7	3.7	**0**
Oligochaeta (worms)								
Oligochaeta	1	2.7	**88**	3.6	2.3 ✓	1.4	-0.6	**2.3**
Hirudinea (leeches)								
Piscicolidae	4	5.2		5.2	4.9	4.9	4.9	**0**
Glossiphoniidae	3	3.2	**2**	3.4 ✓	2.5	0.8	0.8	**3.4**
Hirudinidae	3	-0.8		-0.8	-0.8	-0.8	-0.8	**0**
Erpobdellidae	3	3.1		3.6	2.0	-0.8	-0.8	**0**

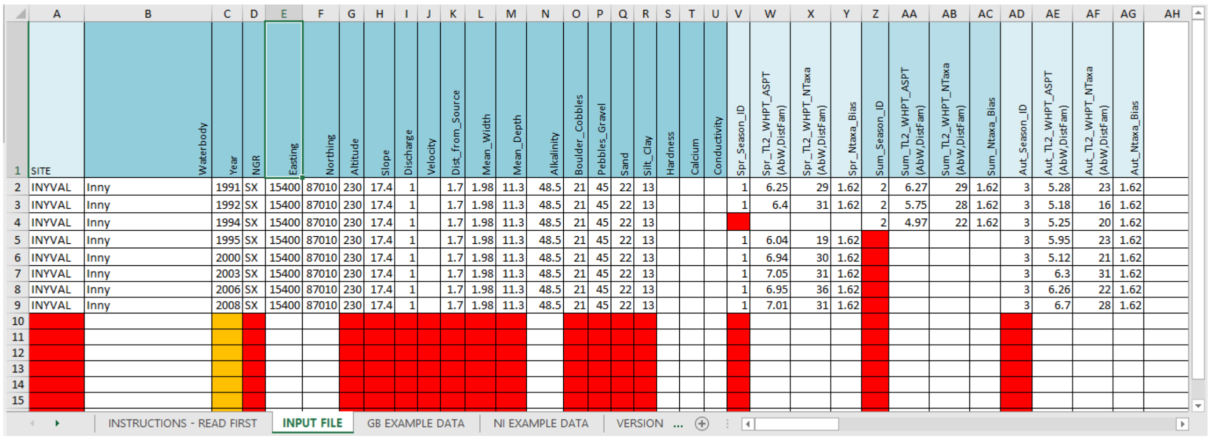
Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Crustacea (crayfish, slaters and shrimps)								
Astacidae (incl. non-native species)	8*	7.9		7.9	7.9	7.9	7.9	**0**
Asellidae	3	2.8		4.0	2.3	0.8	-1.6	**0**
Corophiidae	6	5.8		5.7	5.8	5.8	5.8	**0**
Crangonyctidae	6	3.9		3.8	4.0	3.6	3.6	**0**
Gammaridae	6	4.4	**3**	4.2 ✓	4.5	4.6	3.9	**4.2**
Niphargidae	6	6.3		6.3	6.3	6.3	6.3	**0**
Ephemeroptera (mayflies)								
Siphlonuridae (incl. Ameletidae)	10	11.5		11.3	12.2	12.2	12.2	**0**
Baetidae	4	5.5	**52**	3.6	5.9 ✓	7.2	7.5	**5.9**
Heptageniidae (incl. Arthropleidae)	10	9.7	**20**	8.5	10.3 ✓	11.1	11.1	**10.3**
Leptophlebiidae	10	8.8		8.8	9.1	9.2	9.2	**0**
Potamanthidae	10	10.0		9.8	10.4	10.4	10.4	**0**
Ephemeridae	10	8.4		8.3	8.8	9.4	9.4	**0**
Ephemerellidae	10	8.2		7.9	8.5	9.0	9.0	**0**
Caenidae	7	6.5		6.5	6.5	6.5	6.5	**0**
Plecoptera (stoneflies)								
Taeniopterygidae	10	11.3		11.0	11.9	12.1	12.1	**0**
Nemouridae	7	9.3		8.7	10.7	10.7	10.7	**0**
Leuctridae	10	10.0		9.3	10.6	10.6	10.6	**0**
Capniidae	10	9.6		9.7	9.4	9.4	9.4	**0**
Perlodidae	10	10.8	**8**	10.5 ✓	11.5	11.5	11.5	**10.5**
Perlidae	10	12.7		12.6	13.0	13.0	13.0	**0**
Chloroperlidae	10	11.6		11.4	12.2	12.2	12.2	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Odonata Zygoptera (damselflies)								
Platycnemididae	6	6.0		6.0	6.0	6.0	6.0	**0**
Coenagrionidae (= Coenagriidae)	6	3.5		3.4	3.8	3.8	3.8	**0**
Lestidae	8							
Calopterygidae (= Agriidae)	8	6.0		5.9	6.2	6.2	6.2	**0**
Odonata Anisoptera (dragonflies)								
Cordulegasteridae	8	9.8		9.8	9.8	9.8	9.8	**0**
Aeshnidae	8	4.7		4.7	4.7	4.7	4.7	**0**
Corduliidae	8							
Gomphidae	8							
Libellulidae	8	4.1		4.1	4.1	4.1	4.1	**0**
Hemiptera (bugs)								
Mesoveliidae	5	4.7		4.7	4.7	4.7	4.7	**0**
Hydrometridae	5	4.3		4.3	4.3	4.3	4.3	**0**
Veliidae		4.5		4.5	3.9	3.9	3.9	**0**
Gerridae	5	5.2		5.2	5.5	5.5	5.5	**0**
Nepidae	5	2.9		2.9	2.9	2.9	2.9	**0**
Naucoridae	5	3.7		3.7	3.7	3.7	3.7	**0**
Aphelocheiridae	10	8.5		8.6	8.5	8.0	8.0	**0**
Notonectidae	5	3.4		3.4	3.9	3.9	3.9	**0**
Pleidae	5	3.3		3.3	3.3	3.3	3.3	**0**
Corixidae	5	3.8		3.7	3.9	3.7	3.7	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT **Taxon** **Sample: 7TB**	**BMWP**	**Presence only (PO) WHPT**	***Enter numerical abundance here***	**WHPT for abundance category 1 (1-9)**	**WHPT for abundance category 2 (10-99)**	**WHPT for abundance category 3 (100-999)**	**WHPT for abundance category 4+ (1000 +)**	**Abundance related WHPT for this sample**
Coleoptera (beetles)								
Haliplidae	5	3.6		3.6	3.4	3.4	3.4	**0**
Paelobiidae (= Hygrobiidae)	5	3.8		3.8	3.8	3.8	3.8	**0**
Noteridae	5	3.2		3.2	3.2	3.2	3.2	**0**
Dytiscidae	5	4.5	**4**	4.5 ✓	4.8	4.8	4.8	**4.5**
Gyrinidae	5	8.2		8.1	9.0	9.0	9.0	**0**
ydrophilidae (incl. Georissidae, Helophoridae & Hydrochidae)	5	6.2		5.8	8.8	8.8	8.8	**0**
Hydraenidae	5	8.9		8.5	10.5	10.5	10.5	**0**
Scirtidae (= Helododae)	5	6.9		6.9	6.8	6.8	6.8	**0**
Dryopidae	5	6.0		6.0	6.0	6.0	6.0	**0**
Elmidae	5	6.6	**60**	5.3	7.4 ✓	8.3	8.3	**7.4**
Megaloptera (alderflies)								
Sialidae	4	4.3		4.2	4.4	4.4	4.4	**0**
Neuroptera Planipennia (lacewings)								
Sisyridae		5.7		5.7	5.7	5.7	5.7	**0**
Trichoptera (caddisflies)								
Rhyacophilidae	7	8.4		8.1	9.2	8.3	8.3	**0**
Glossosomatidae	7	7.7	**1**	7.8 ✓	7.6	7.2	7.2	**7.8**
Hydroptilidae	6	6.2		6.1	6.5	6.8	6.8	**0**
Philopotamidae	8	11.2		11.2	11.1	11.1	11.1	**0**
Psychomyiidae	8	5.8		5.8	5.7	5.7	5.7	**0**
Polycentropodidae	7	8.1		8.2	8.1	8.1	8.1	**0**
Hydropsychidae	5	6.6	**4**	5.8 ✓	7.2	7.4	7.4	**5.8**
Phryganeidae	10	5.5		5.5	5.5	5.5	5.5	**0**
Brachycentridae	10	9.5		9.6	9.5	8.9	8.9	**0**
Lepidostomatidae	10	10.1	**4**	9.9 ✓	10.3	10.2	10.2	**9.9**
Limnephilidae (including Apataniidae)	7	6.2	**4**	5.9 ✓	6.9	6.9	6.9	**5.9**
Goeridae	10	8.8	**8**	8.8 ✓	8.8	9.4	9.4	**8.8**
Beraeidae	10	8.7		8.8	7.3	7.3	7.3	**0**
Sericostomatidae	10	9.1	**8**	8.9 ✓	9.4	9.5	9.5	**8.9**
Odontoceridae	10	11.0	**1**	11.1 ✓	10.3	10.3	10.3	**11.1**
Molannidae	10	6.6		6.5	7.6	7.6	7.6	**0**
Leptoceridae	10	6.7		6.7	6.9	7.1	7.1	**0**

Use this sheet to become familiar with the abundance-weighted WHPT ASPT and how it differs from BMWP indices and the presence/absence version of WHPT Taxon Sample: 7TB	BMWP	Presence only (PO) WHPT	*Enter numerical abundance here*	WHPT for abundance category 1 (1-9)	WHPT for abundance category 2 (10-99)	WHPT for abundance category 3 (100-999)	WHPT for abundance category 4+ (1000 +)	Abundance related WHPT for this sample
Diptera (true flies)								
ipulidae (including Cylindrotomidae, Limoniidae & Pedicidae)	5	5.9	**34**	5.4	6.9 ✓	6.9	7.10	**6.9**
Psychodidae		4.4		4.5	3.0	3.0	3.00	**0**
Ptychopteridae		6.4		6.4	6.4	6.4	6.40	**0**
Dixidae		7.0		7.0	7.0	7.0	7.00	**0**
Chaoboridae		3.0		3.0	3.0	3.0	3.00	**0**
Culicidae		2.0		2.0	1.9	1.9	1.90	**0**
Ceratopogonidae		5.5	**1**	5.4 ✓	5.5	5.5	5.50	**5.4**
Simuliidae	5	5.8		5.5	6.1	5.8	3.90	**0**
Chironomidae	2	1.1	**12**	1.2	1.3 ✓	-0.9	-0.90	**1.3**
Stratiomyidae		3.6		3.6	3.6	3.6	3.60	**0**
Rhagionidae		9.6		9.6	9.6	9.6	9.60	**0**
Tabanidae		7.1		7.1	7.3	7.3	7.30	**0**
Athericidae		9.3		9.3	9.5	9.5	9.50	**0**
Empididae		7.1		7.0	7.6	7.6	7.60	**0**
Dolichopodidae		4.9		4.9	4.9	4.9	4.90	**0**
Syrphidae		1.9		1.9	1.9	1.9	1.90	**0**
Sciomyzidae		3.4		3.4	3.4	3.4	3.40	**0**
Ephydridae		4.4		4.4	4.4	4.4	4.40	**0**
Muscidae		3.9	**4**	4.0 ✓	2.6	2.6	2.60	**4**
Notes	Score = sum of WHPT values				Abundance related WHPT score			132.1
*BMWP based only on native crayfish	NTaxa = number of scoring taxa				**WHPT NTaxa**			**21**
	ASPT = average score per taxon = score ÷ NTaxa				**Abundance related WHPT ASPT**			**6.2904762**

RICT Validation spreadsheet

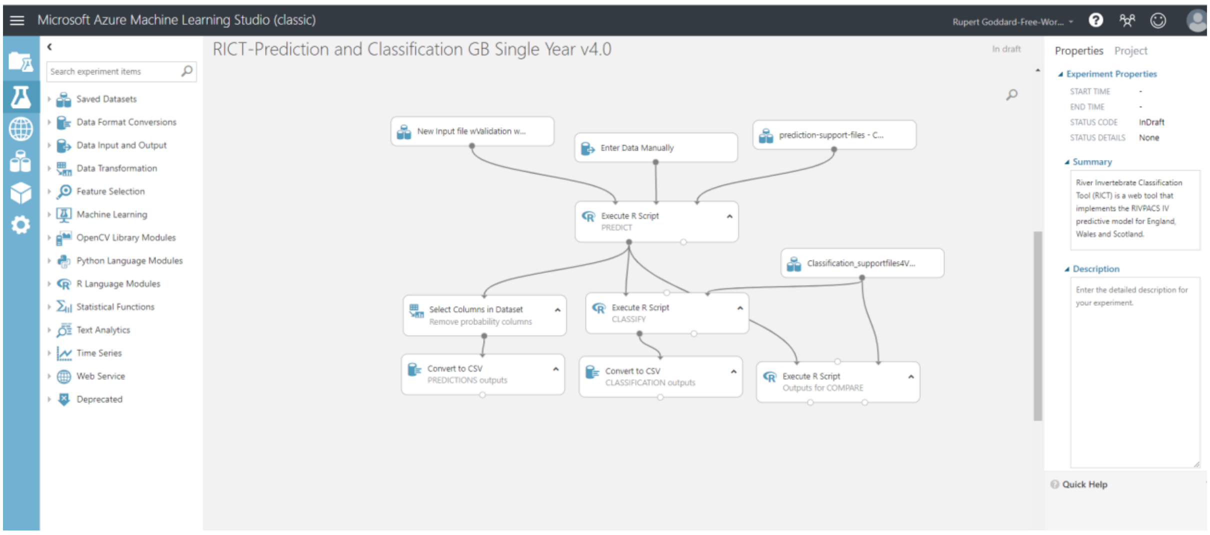


SITE	Waterbody	Year	NGR	Easting	Northing	Altitude	Slope	Discharge	Velocity	Dist_from_Source	Mean_Width	Mean_Depth	Alkalinity	Boulder_Cobbles	Pebbles_Gravel	Sand	Silt_Clay	Hardness	Calcium	Conductivity
INYVAL	Inny	1991	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			
INYVAL	Inny	1992	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			
INYVAL	Inny	1994	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			
INYVAL	Inny	1995	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			
INYVAL	Inny	2000	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			
INYVAL	Inny	2003	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			
INYVAL	Inny	2006	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			
INYVAL	Inny	2008	SX	15400	87010	230	17.4	1		1.7	1.98	11.3	48.5	21	45	22	13			

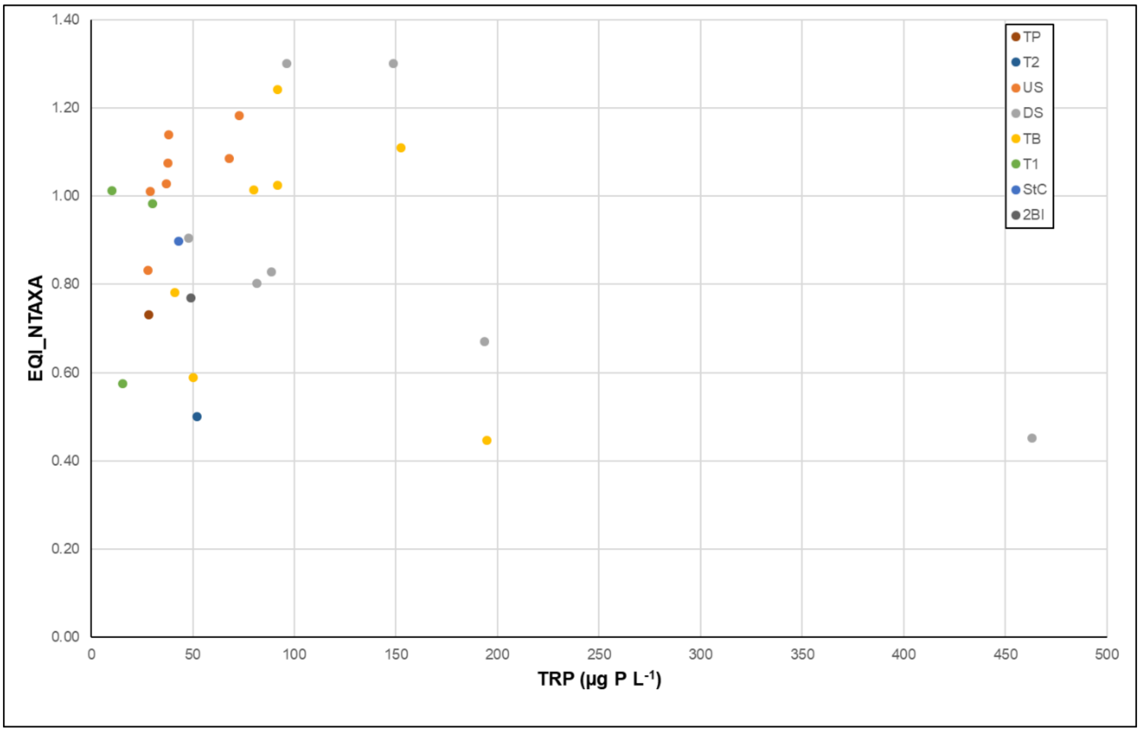
SITE	Year	Spr_Season_ID	Spr_TL2_WHPT_ASPT (AbW,DistFam)	Spr_TL2_WHPT_NTaxa (AbW,DistFam)	Spr_Ntaxa_Bias	Sum_Season_ID	Sum_TL2_WHPT_ASPT (AbW,DistFam)	Sum_TL2_WHPT_NTaxa (AbW,DistFam)	Sum_Ntaxa_Bias	Aut_Season_ID	Aut_TL2_WHPT_ASPT (AbW,DistFam)	Aut_TL2_WHPT_NTaxa (AbW,DistFam)	Aut_Ntaxa_Bias
INYVAL	1991	1	6.25	29	1.62	2	6.27	29	1.62	3	5.28	23	1.62
INYVAL	1992	1	6.4	31	1.62	2	5.75	28	1.62	3	5.18	16	1.62
INYVAL	1994					2	4.97	22	1.62	3	5.25	20	1.62
INYVAL	1995	1	6.04	19	1.62					3	5.95	23	1.62
INYVAL	2000	1	6.94	30	1.62					3	5.12	21	1.62
INYVAL	2003	1	7.05	31	1.62					3	6.3	31	1.62
INYVAL	2006	1	6.95	36	1.62					3	6.26	22	1.62
INYVAL	2008	1	7.01	31	1.62					3	6.7	28	1.62

INSTRUCTIONS - READ FIRST | INPUT FILE | GB EXAMPLE DATA | NI EXAMPLE DATA | VERSION

RICT model start page



Relationship between TRP concentration and EQI NTAXA was not significant (F(1,26)=2.568; *p=0.121*)



Processed Historic Diatom data

SampleID			
Site name		INYVLEA8889	INYVLEA8889
Sample Date		23-Apr-09	16-Sep-09
Alkalinity		48.50	48.50
Watercourse		Inny	Inny
REACH		M	M
	TAXA		
CY9999	Cyclotella		
ME9999	Melosira		
ME015A	Melosira varians		
ST9999	Stephanodiscus		
TH038A	Thalassiosira		
AC028A	Karayevia oblongella	37	39
ZZZ835	Achnanthidium minutissimum type		
AM012A	Achnanthidium minutissimum	54	25
AM012A	Amphora pediculus		
CA002A	Caloneis bacillum		
CO001A	Cocconeis pediculus		
CO001A	Cocconeis placentula		
CO001B	Cocconeis euglypta		
CO001C	Cocconeis lineata		3
ZZZ986	Cocconeis pseudolineata		
YH001A	Ctenophora pulchella		
DE001A	Denticula tenuis	1	
DA9999	Diadesmis		
DT004A	Diatoma tenue		
DT003A	Diatoma vulgare		
EY011A	Encyonema minutum		
EY016A	Encyonema silesiacum		
EU9999	Eunotia		8
EU070A	Eunotia bilunaris		
EU009A	Eunotia exigua		
EU047A	Eunotia incisa		
EU105A	Eunotia subarcuatoides		

Processed Historic Diatom data

SampleID			
Site name		INYVLEA8889	INYVLEA8889
Sample Date		23-Apr-09	16-Sep-09
Alkalinity		48.50	48.50
Watercourse		Inny	Inny
REACH		Ivl	Ivl
	TAXA		
FR026A	Fragilaria bidens		
FR009A	Fragilaria capucina		
FR007A	Fragilaria vaucheriae		
FRFO-01	Fragilariforma	2	
FU002A	Frustulia rhomboides		
FU002B	Frustulia rhomboides var. saxonica	2	
GO9999	Gomphonema		
GO029A	Gomphonema clavatum	2	
GO004A	Gomphonema gracile		
GO050A	Gomphonema minutum		
GM002A	Gomphonema olivaceoides		
GM001A	Gomphonema olivaceum		
GO013A	Gomphonema parvulum	4	9
GOMP-09	Gomphonema exilissimum		
HA001A	Hantzschia amphioxys		
MR001A	Meridion circulare	38	2
NA9999	Navicula	1	
GEIS-05	Geissleria acceptata		
NA084A	Navicula atomus	27	89
NA084B	Navicula atomus var. permitis		
NA021A	Navicula cincta		
NA007A	Navicula cryptocephala		
NA751A	Navicula cryptotenella		
NA060A	Navicula digitoradiata		
NA023A	Navicula gregaria	17	25
NA009B	Navicula lanceolata	20	14
NA042A	Navicula minima	39	63

Processed Historic Diatom data

SampleID			
Site name		INYVLEA8889	INYVLEA8889
Sample Date		23-Apr-09	16-Sep-09
Alkalinity		48.50	48.50
Watercourse		Inny	Inny
REACH		M	M
	TAXA		
EOLI-01	Eolimna minima		
ADLA-03	Adlafia minuscula		
NA112A	Navicula minuscula		
NA112D	Navicula minuscula var. muralis		
NA003A	Navicula radiosa		
NA008A	Navicula rhynchocephala	1	
NA617A	Navicula saprophila		
FIST-01	Fistulifera saprophila		
CRAT-07	Craticula subminuscula		
SL9999	Sellaphora subrotundata		
NA095A	Navicula tripunctata		
NI9999	Nitzschia		
NI065A	Nitzschia archibaldii		
NI028A	Nitzschia capitellata		6
NI015A	Nitzschia dissipata		
NI002A	Nitzschia fonticola		
NI017A	Nitzschia gracilis		
NI052A	Nitzschia heufleriana		
NI043A	Nitzschia inconspicua	1	
NI031A	Nitzschia linearis	3	1
NI009A	Nitzschia palea		
NI033A	Nitzschia paleacea	8	
NI193A	Nitzschia perminuta		
NITZ-02	Nitzschia pseudofonticola		
NI152A	Nitzschia pusilla		1
NI166A	Nitzschia sociabilis		
PI9999	Pinnularia		

Processed Historic Diatom data

SampleID			
Site name		INYVLEA8889	INYVLEA8889
Sample Date		23-Apr-09	16-Sep-09
Alkalinity		48.50	48.50
Watercourse		Inny	Inny
REACH		lvl	lvl
	TAXA		
PI014A	Pinnularia appendiculata	1	
ZZZ922	Planothidium		
ZZZ896	Planothidium frequentissimum	1	8
ZZZ897	Planothidium lanceolatum	51	11
ZZZ852	Psammothidium helveticum		
RE001A	Reimeria sinuata	1	7
RC002A	Rhoicosphenia abbreviata		
SL001A	Sellaphora pupula		
SL002A	Sellaphora seminulum		
SA012A	Stauroneis kriegeri		1
SU073A	Surirella brebissonii		
SU076A	Surirella roba		
SY001A	Ulnaria ulna		1
TA001A	Tabellaria flocculosa		1
MAYA-03	Mayamaea atomus var. permitis		
ZZZ987	Navicula [small species]		
ADLA-02	Adlafia minuscula var. muralis		
ADLA-04	Adlafia suchlandtii		
FR045E	Synedrella subconstricta		
DT021A	Diatoma mesodon	6	
FR007C	Fragilaria vaucheriae var. capitellata	1	
EU110A	Eunotia minor	3	2
FR009L	Fragilaria capucina var. amphicephala		
GO080A	Gomphonema pumilum		
FR009H	Fragilaria gracilis		

Processed Historic Diatom data

SampleID							
Site name		INYVLEA8889	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		17-Jun-16	23-Apr-09	16-Sep-09	06-Apr-10	09-Sep-10	12-Apr-11
Alkalinity		48.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
CY9999	Cyclotella						
ME9999	Melosira						
ME015A	Melosira varians				2		
ST9999	Stephanodiscus						
TH038A	Thalassiosira						
AC028A	Karayevia oblongella	18		6			
ZZZ835	Achnanthidium minutissimum type	38					
AM012A	Achnanthidium minutissimum		46	45	79	9	102
AM012A	Amphora pediculus		12	103	46	56	4
CA002A	Caloneis bacillum						
CO001A	Cocconeis pediculus		3	2		8	
CO001A	Cocconeis placentula					66	1
CO001B	Cocconeis euglypta		1	35	2	52	
CO001C	Cocconeis lineata		2	3			
ZZZ986	Cocconeis pseudolineata						
YH001A	Ctenophora pulchella						
DE001A	Denticula tenuis						
DA9999	Diadesmis						
DT004A	Diatoma tenue						
DT003A	Diatoma vulgare		40		10	1	129
EY011A	Encyonema minutum						
EY016A	Encyonema silesiacum				2		
EU9999	Eunotia						
EU070A	Eunotia bilunaris						
EU009A	Eunotia exigua						
EU047A	Eunotia incisa						
EU105A	Eunotia subarcuatoides						

Processed Historic Diatom data

SampleID							
Site name		INYVLEA8889	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		17-Jun-16	23-Apr-09	16-Sep-09	06-Apr-10	09-Sep-10	12-Apr-11
Alkalinity		48.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
FR026A	Fragilaria bidens		3				
FR009A	Fragilaria capucina	6	1	4	12	3	2
FR007A	Fragilaria vaucheriae	1	1	1	15	1	1
FRFO-01	Fragilariforma						
FU002A	Frustulia rhomboides						
FU002B	Frustulia rhomboides var. saxonica						
GO9999	Gomphonema			4		4	20
GO029A	Gomphonema clavatum						
GO004A	Gomphonema gracile	1				1	
GO050A	Gomphonema minutum			9		9	
GM002A	Gomphonema olivaceoides						
GM001A	Gomphonema olivaceum		1				
GO013A	Gomphonema parvulum	2			3	5	
GOMP-09	Gomphonema exilissimum						
HA001A	Hantzschia amphioxys	1					
MR001A	Meridion circulare		10	1	8	1	
NA9999	Navicula			1			
GEIS-05	Geissleria acceptata						
NA084A	Navicula atomus	73					
NA084B	Navicula atomus var. permitis	28			2	7	
NA021A	Navicula cincta				1		
NA007A	Navicula cryptocephala		1				
NA751A	Navicula cryptotenella	1					
NA060A	Navicula digitoradiata						
NA023A	Navicula gregaria	27	105	3	75	20	40
NA009B	Navicula lanceolata	3	33	8	38	4	5
NA042A	Navicula minima	50	6	22	4		

Processed Historic Diatom data

SampleID							
Site name		INYVLEA8889	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		17-Jun-16	23-Apr-09	16-Sep-09	06-Apr-10	09-Sep-10	12-Apr-11
Alkalinity		48.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
EOLI-01	Eolimna minima						
ADLA-03	Adlafia minuscula						
NA112A	Navicula minuscula						
NA112D	Navicula minuscula var. muralis						4
NA003A	Navicula radiosa						
NA008A	Navicula rhynchocephala						
NA617A	Navicula saprophila	4					5
FIST-01	Fistulifera saprophila						
CRAT-07	Craticula subminuscula						
SL9999	Sellaphora subrotundata						
NA095A	Navicula tripunctata		13	5	12	20	1
NI9999	Nitzschia	1					2
NI065A	Nitzschia archibaldii	1					
NI028A	Nitzschia capitellata						
NI015A	Nitzschia dissipata		2	1	3	1	
NI002A	Nitzschia fonticola				3		
NI017A	Nitzschia gracilis					2	
NI052A	Nitzschia heufleriana						
NI043A	Nitzschia inconspicua			7		1	
NI031A	Nitzschia linearis		7	1	1		
NI009A	Nitzschia palea						
NI033A	Nitzschia paleacea		7		6		
NI193A	Nitzschia perminuta						
NITZ-02	Nitzschia pseudofonticola						
NI152A	Nitzschia pusilla			1		6	
NI166A	Nitzschia sociabilis						
PI9999	Pinnularia	2					

Processed Historic Diatom data

SampleID							
Site name		INYVLEA8889	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		17-Jun-16	23-Apr-09	16-Sep-09	06-Apr-10	09-Sep-10	12-Apr-11
Alkalinity		48.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
PI014A	Pinnularia appendiculata						
ZZZ922	Planothidium			9		1	
ZZZ896	Planothidium frequentissimum			6			1
ZZZ897	Planothidium lanceolatum	14	6	14	5		1
ZZZ852	Psammothidium helveticum						
RE001A	Reimeria sinuata		1	28	11	3	3
RC002A	Rhoicosphenia abbreviata		4	2	18	25	2
SL001A	Sellaphora pupula	1					
SL002A	Sellaphora seminulum	30				9	
SA012A	Stauroneis kriegeri						
SU073A	Surirella brebissonii	1	1		1		1
SU076A	Surirella roba		1				
SY001A	Ulnaria ulna		2		1		5
TA001A	Tabellaria flocculosa						
MAYA-03	Mayamaea atomus var. permitis						
ZZZ987	Navicula [small species]						
ADLA-02	Adlafia minuscula var. muralis						
ADLA-04	Adlafia suchlandtii						
FR045E	Synedrella subconstricta						
DT021A	Diatoma mesodon						
FR007C	Fragilaria vaucheriae var. capitellata		10				
EU110A	Eunotia minor						
FR009L	Fragilaria capucina var. amphicephala	2					
GO080A	Gomphonema pumilum		15		15		13
FR009H	Fragilaria gracilis						

Processed Historic Diatom data

SampleID							
Site name		STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		06-Oct-11	21-Jun-12	22-Oct-12	09-Apr-14	09-Sep-14	17-Jun-16
Alkalinity		77.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
CY9999	Cyclotella					4	8
ME9999	Melosira						
ME015A	Melosira varians		8			1	35
ST9999	Stephanodiscus						
TH038A	Thalassiosira						1
AC028A	Karayevia oblongella	2	4	7		2	2
ZZZ835	Achnanthidium minutissimum type				26	35	69
AM012A	Achnanthidium minutissimum	38	63	30			
AM012A	Amphora pediculus	49	19	31	2	19	3
CA002A	Caloneis bacillum						
CO001A	Cocconeis pediculus	18	1	3		20	10
CO001A	Cocconeis placentula	41	14	22	2		
CO001B	Cocconeis euglypta	47	13	25		32	8
CO001C	Cocconeis lineata		20	57		18	2
ZZZ986	Cocconeis pseudolineata		1	9		46	
YH001A	Ctenophora pulchella						
DE001A	Denticula tenuis						
DA9999	Diadesmis		1				
DT004A	Diatoma tenue						
DT003A	Diatoma vulgare	2				2	3
EY011A	Encyonema minutum						
EY016A	Encyonema silesiacum						
EU9999	Eunotia						
EU070A	Eunotia bilunaris			1			
EU009A	Eunotia exigua						
EU047A	Eunotia incisa						
EU105A	Eunotia subarcuatoides						

Processed Historic Diatom data

SampleID							
Site name		STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		06-Oct-11	21-Jun-12	22-Oct-12	09-Apr-14	09-Sep-14	17-Jun-16
Alkalinity		77.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
FR026A	Fragilaria bidens						
FR009A	Fragilaria capucina		1			3	3
FR007A	Fragilaria vaucheriae	2					1
FRFO-01	Fragilariforma						
FU002A	Frustulia rhomboides			1			
FU002B	Frustulia rhomboides var. saxonica						
GO9999	Gomphonema		3	3			
GO029A	Gomphonema clavatum						
GO004A	Gomphonema gracile						
GO050A	Gomphonema minutum		6			14	4
GM002A	Gomphonema olivaceoides				4		
GM001A	Gomphonema olivaceum						
GO013A	Gomphonema parvulum		6		3		6
GOMP-09	Gomphonema exilissimum						1
HA001A	Hantzschia amphioxys						
MR001A	Meridion circulare	2	1	1	2	1	
NA9999	Navicula				1		
GEIS-05	Geissleria acceptata				3		
NA084A	Navicula atomus		18			3	3
NA084B	Navicula atomus var. permitis		22	28		6	49
NA021A	Navicula cincta						
NA007A	Navicula cryptocephala			2			
NA751A	Navicula cryptotenella	16				9	
NA060A	Navicula digitoradiata						
NA023A	Navicula gregaria	6	23	7	38	11	25
NA009B	Navicula lanceolata	1	14	17	61	5	
NA042A	Navicula minima	10	16	17	8	32	14

Processed Historic Diatom data

SampleID							
Site name		STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		06-Oct-11	21-Jun-12	22-Oct-12	09-Apr-14	09-Sep-14	17-Jun-16
Alkalinity		77.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
EOLI-01	Eolimna minima						
ADLA-03	Adlafia minuscula				2		
NA112A	Navicula minuscula						
NA112D	Navicula minuscula var. muralis						
NA003A	Navicula radiosa						
NA008A	Navicula rhynchocephala						
NA617A	Navicula saprophila	5					13
FIST-01	Fistulifera saprophila				45		
CRAT-07	Craticula subminuscula	1		1			
SL9999	Sellaphora subrotundata			1			
NA095A	Navicula tripunctata	50	1	2		17	3
NI9999	Nitzschia		2	4			
NI065A	Nitzschia archibaldii				21		
NI028A	Nitzschia capitellata		2				
NI015A	Nitzschia dissipata						
NI002A	Nitzschia fonticola						
NI017A	Nitzschia gracilis						
NI052A	Nitzschia heufleriana						
NI043A	Nitzschia inconspicua		3	1	1	3	2
NI031A	Nitzschia linearis						3
NI009A	Nitzschia palea	5					2
NI033A	Nitzschia paleacea						
NI193A	Nitzschia perminuta		1				
NITZ-02	Nitzschia pseudofonticola						
NI152A	Nitzschia pusilla			2			
NI166A	Nitzschia sociabilis						
PI9999	Pinnularia						

Processed Historic Diatom data

SampleID							
Site name		STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927	STCEA8927
Sample Date		06-Oct-11	21-Jun-12	22-Oct-12	09-Apr-14	09-Sep-14	17-Jun-16
Alkalinity		77.50	77.50	77.50	77.50	77.50	77.50
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
REACH		StC	StC	StC	StC	StC	StC
	TAXA						
PI014A	Pinnularia appendiculata						
ZZZ922	Planothidium				1		
ZZZ896	Planothidium frequentissimum	2	3	2	2		
ZZZ897	Planothidium lanceolatum	4	3	1	3	2	2
ZZZ852	Psammothidium helveticum						
RE001A	Reimeria sinuata	5	18	19	32	9	21
RC002A	Rhoicosphenia abbreviata	7	15	11		7	2
SL001A	Sellaphora pupula						
SL002A	Sellaphora seminulum		7				
SA012A	Stauroneis kriegeri						
SU073A	Surirella brebissonii						
SU076A	Surirella roba						
SY001A	Ulnaria ulna				11	2	1
TA001A	Tabellaria flocculosa						
MAYA-03	Mayamaea atomus var. permitis				43		
ZZZ987	Navicula [small species]						
ADLA-02	Adlafia minuscula var. muralis				1		
ADLA-04	Adlafia suchlandtii						
FR045E	Synedrella subconstricta						
DT021A	Diatoma mesodon						
FR007C	Fragilaria vaucheriae var. capitellata						
EU110A	Eunotia minor						
FR009L	Fragilaria capucina var. amphicephala						
GO080A	Gomphonema pumilum	2		13	1		
FR009H	Fragilaria gracilis				1	1	20

Processed Historic Diatom data

SampleID								
Site name		2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892
Sample Date		15-Apr-10	09-Sep-10	11-May-11	06-Oct-11	14-Apr-14	22-Sep-14	17-Jun-16
Alkalinity		63.30	63.30	63.30	63.30	63.30	63.30	63.30
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny	Inny
REACH		2BI	2BI	2BI	2BI	2BI	2BI	2BI
	TAXA							
CY9999	Cyclotella							
ME9999	Melosira							
ME015A	Melosira varians	9					2	7
ST9999	Stephanodiscus							
TH038A	Thalassiosira							
AC028A	Karayevia oblongella							
ZZZ835	Achnanthidium minutissimum type					69	28	59
AM012A	Achnanthidium minutissimum	76	18	47	30			
AM012A	Amphora pediculus	3	26	80	54	23	9	15
CA002A	Caloneis bacillum						1	
CO001A	Cocconeis pediculus	1		2	8		24	4
CO001A	Cocconeis placentula		73	8	63	1		12
CO001B	Cocconeis euglypta	1	16	2	27	4	19	2
CO001C	Cocconeis lineata			1			2	
ZZZ986	Cocconeis pseudolineata	1		7	2		4	3
YH001A	Ctenophora pulchella		1					
DE001A	Denticula tenuis							
DA9999	Diadesmis							
DT004A	Diatoma tenue	3						
DT003A	Diatoma vulgare	11	4	3	3		49	
EY011A	Encyonema minutum							
EY016A	Encyonema silesiacum		1					
EU9999	Eunotia							
EU070A	Eunotia bilunaris							
EU009A	Eunotia exigua				1			
EU047A	Eunotia incisa							
EU105A	Eunotia subarcuatoides							

Processed Historic Diatom data

SampleID								
Site name		2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892
Sample Date		15-Apr-10	09-Sep-10	11-May-11	06-Oct-11	14-Apr-14	22-Sep-14	17-Jun-16
Alkalinity		63.30	63.30	63.30	63.30	63.30	63.30	63.30
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny	Inny
REACH		2BI	2BI	2BI	2BI	2BI	2BI	2BI
	TAXA							
FR026A	Fragilaria bidens	1						
FR009A	Fragilaria capucina		2	2	1	1		15
FR007A	Fragilaria vaucheriae	9	5	1	2			1
FRFO-01	Fragilariforma							
FU002A	Frustulia rhomboides							
FU002B	Frustulia rhomboides var. saxonica							
GO9999	Gomphonema		7	12		4		
GO029A	Gomphonema clavatum							1
GO004A	Gomphonema gracile							
GO050A	Gomphonema minutum		5			2		3
GM002A	Gomphonema olivaceoides				3	1		
GM001A	Gomphonema olivaceum							
GO013A	Gomphonema parvulum	10	3		1	1	1	2
GOMP-09	Gomphonema exilissimum							
HA001A	Hantzschia amphioxys							
MR001A	Meridion circulare	1	1					
NA9999	Navicula					1		
GEIS-05	Geissleria acceptata							
NA084A	Navicula atomus							5
NA084B	Navicula atomus var. permitis	16					21	47
NA021A	Navicula cincta		5					
NA007A	Navicula cryptocephala						6	1
NA751A	Navicula cryptotenella			1	16		3	6
NA060A	Navicula digitoradiata						1	
NA023A	Navicula gregaria	114	48	42	6	47	87	26
NA009B	Navicula lanceolata	75	5	6	3	26	12	4
NA042A	Navicula minima	5		6	38	6	10	83

Processed Historic Diatom data

SampleID								
Site name		2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892
Sample Date		15-Apr-10	09-Sep-10	11-May-11	06-Oct-11	14-Apr-14	22-Sep-14	17-Jun-16
Alkalinity		63.30	63.30	63.30	63.30	63.30	63.30	63.30
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny	Inny
REACH		2BI	2BI	2BI	2BI	2BI	2BI	2BI
	TAXA							
EOLI-01	Eolimna minima							
ADLA-03	Adlafia minuscula							
NA112A	Navicula minuscula							
NA112D	Navicula minuscula var. muralis			1				
NA003A	Navicula radiosa							
NA008A	Navicula rhynchocephala		1					
NA617A	Navicula saprophila			6	3			8
FIST-01	Fistulifera saprophila					15		
CRAT-07	Craticula subminuscula				1			1
SL9999	Sellaphora subrotundata							
NA095A	Navicula tripunctata		64	9	17		5	2
NI9999	Nitzschia	3		2		1		
NI065A	Nitzschia archibaldii					5		
NI028A	Nitzschia capitellata			1				1
NI015A	Nitzschia dissipata	3	4	5	5	5	1	
NI002A	Nitzschia fonticola	24						
NI017A	Nitzschia gracilis		2					
NI052A	Nitzschia heufleriana						2	
NI043A	Nitzschia inconspicua	2	2	2	6	17	6	6
NI031A	Nitzschia linearis	1		2				2
NI009A	Nitzschia palea	5	1	5		2	7	2
NI033A	Nitzschia paleacea					1	3	
NI193A	Nitzschia perminuta							
NITZ-02	Nitzschia pseudofonticola						2	
NI152A	Nitzschia pusilla			1				
NI166A	Nitzschia sociabilis			2				
PI9999	Pinnularia							1

Processed Historic Diatom data

SampleID								
Site name		2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892	2BIEA8892
Sample Date		15-Apr-10	09-Sep-10	11-May-11	06-Oct-11	14-Apr-14	22-Sep-14	17-Jun-16
Alkalinity		63.30	63.30	63.30	63.30	63.30	63.30	63.30
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny	Inny
REACH		2BI	2BI	2BI	2BI	2BI	2BI	2BI
	TAXA							
PI014A	Pinnularia appendiculata							
ZZZ922	Planothidium							
ZZZ896	Planothidium frequentissimum							3
ZZZ897	Planothidium lanceolatum			6		1		
ZZZ852	Psammothidium helveticum							
RE001A	Reimeria sinuata	5	2	5		42		8
RC002A	Rhoicosphenia abbreviata	35	13	33	22		12	11
SL001A	Sellaphora pupula							
SL002A	Sellaphora seminulum		6					
SA012A	Stauroneis kriegeri							
SU073A	Surirella brebissonii	3		1			3	1
SU076A	Surirella roba							
SY001A	Ulnaria ulna							
TA001A	Tabellaria flocculosa							
MAYA-03	Mayamaea atomus var. permitis					12		
ZZZ987	Navicula [small species]							
ADLA-02	Adlafia minuscula var. muralis							
ADLA-04	Adlafia suchlandtii							
FR045E	Synedrella subconstricta			1				
DT021A	Diatoma mesodon		1					
FR007C	Fragilaria vaucheriae var. capitellata					4		
EU110A	Eunotia minor							
FR009L	Fragilaria capucina var. amphicephala							
GO080A	Gomphonema pumilum	3	2	17	4	15	2	
FR009H	Fragilaria gracilis						2	11

Processed Historic Diatom data

SampleID						
Site name		2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924
Sample Date		24-Apr-13	15-Oct-13	27-Apr-16	21-Jun-16	01-Nov-16
Alkalinity						
Watercourse		Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water
REACH		2BPP	2BPP	2BPP	2BPP	2BPP
	TAXA					
CY9999	Cyclotella					
ME9999	Melosira					4
ME015A	Melosira varians					
ST9999	Stephanodiscus				1	
TH038A	Thalassiosira					
AC028A	Karayevia oblongella				2	2
ZZZ835	Achnanthidium minutissimum type			33	193	104
AM012A	Achnanthidium minutissimum	13	177			
AM012A	Amphora pediculus				2	5
CA002A	Caloneis bacillum					
CO001A	Cocconeis pediculus					
CO001A	Cocconeis placentula			2		24
CO001B	Cocconeis euglypta					1
CO001C	Cocconeis lineata		56		28	50
ZZZ986	Cocconeis pseudolineata				4	39
YH001A	Ctenophora pulchella					
DE001A	Denticula tenuis					
DA9999	Diadesmis					
DT004A	Diatoma tenue					
DT003A	Diatoma vulgare					
EY011A	Encyonema minutum		1			
EY016A	Encyonema silesiacum					
EU9999	Eunotia		1			
EU070A	Eunotia bilunaris					
EU009A	Eunotia exigua					
EU047A	Eunotia incisa				4	
EU105A	Eunotia subarcuatoides				1	1

Processed Historic Diatom data

SampleID						
Site name		2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924
Sample Date		24-Apr-13	15-Oct-13	27-Apr-16	21-Jun-16	01-Nov-16
Alkalinity						
Watercourse		Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water
REACH		2BPP	2BPP	2BPP	2BPP	2BPP
	TAXA					
FR026A	Fragilaria bidens					
FR009A	Fragilaria capucina	9		12	2	
FR007A	Fragilaria vaucheriae			1	3	
FRFO-01	Fragilariforma					
FU002A	Frustulia rhomboides					
FU002B	Frustulia rhomboides var. saxonica					
GO9999	Gomphonema			44		7
GO029A	Gomphonema clavatum					
GO004A	Gomphonema gracile					
GO050A	Gomphonema minutum			1		
GM002A	Gomphonema olivaceoides	25		18	1	1
GM001A	Gomphonema olivaceum					
GO013A	Gomphonema parvulum	11		5	4	4
GOMP-09	Gomphonema exilissimum					
HA001A	Hantzschia amphioxys					
MR001A	Meridion circulare	10		41		
NA9999	Navicula					3
GEIS-05	Geissleria acceptata					
NA084A	Navicula atomus				4	
NA084B	Navicula atomus var. permitis	31				
NA021A	Navicula cincta					
NA007A	Navicula cryptocephala				1	
NA751A	Navicula cryptotenella					
NA060A	Navicula digitoradiata					
NA023A	Navicula gregaria	131	30	61	20	4
NA009B	Navicula lanceolata	70	12	10		25
NA042A	Navicula minima	1	24		8	

Processed Historic Diatom data

SampleID						
Site name		2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924
Sample Date		24-Apr-13	15-Oct-13	27-Apr-16	21-Jun-16	01-Nov-16
Alkalinity						
Watercourse		Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water
REACH		2BPP	2BPP	2BPP	2BPP	2BPP
	TAXA					
EOLI-01	Eolimna minima			6		8
ADLA-03	Adlafia minuscula			1		
NA112A	Navicula minuscula	1				
NA112D	Navicula minuscula var. muralis					
NA003A	Navicula radiosa				1	
NA008A	Navicula rhynchocephala					
NA617A	Navicula saprophila					
FIST-01	Fistulifera saprophila			6		
CRAT-07	Craticula subminuscula					
SL9999	Sellaphora subrotundata					
NA095A	Navicula tripunctata					
NI9999	Nitzschia					2
NI065A	Nitzschia archibaldii	10		7		
NI028A	Nitzschia capitellata	2				
NI015A	Nitzschia dissipata	2		1		
NI002A	Nitzschia fonticola					
NI017A	Nitzschia gracilis					
NI052A	Nitzschia heufleriana					
NI043A	Nitzschia inconspicua				1	
NI031A	Nitzschia linearis					
NI009A	Nitzschia palea	2				
NI033A	Nitzschia paleacea			2		
NI193A	Nitzschia perminuta		1			
NITZ-02	Nitzschia pseudofonticola					
NI152A	Nitzschia pusilla	1				
NI166A	Nitzschia sociabilis					
PI9999	Pinnularia					

Processed Historic Diatom data

SampleID						
Site name		2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924	2BPPEA8924
Sample Date		24-Apr-13	15-Oct-13	27-Apr-16	21-Jun-16	01-Nov-16
Alkalinity						
Watercourse		Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water	Penpoint Water
REACH		2BPP	2BPP	2BPP	2BPP	2BPP
	TAXA					
PI014A	Pinnularia appendiculata					
ZZZ922	Planothidium					1
ZZZ896	Planothidium frequentissimum		3		4	3
ZZZ897	Planothidium lanceolatum	2		2	1	2
ZZZ852	Psammothidium helveticum				1	
RE001A	Reimeria sinuata	4	4	39	8	28
RC002A	Rhoicosphenia abbreviata					2
SL001A	Sellaphora pupula					
SL002A	Sellaphora seminulum		2			
SA012A	Stauroneis kriegeri					
SU073A	Surirella brebissonii	1				
SU076A	Surirella roba					
SY001A	Ulnaria ulna	14		10	1	
TA001A	Tabellaria flocculosa				1	
MAYA-03	Mayamaea atomus var. permitis			5		
ZZZ987	Navicula [small species]		1			
ADLA-02	Adlafia minuscula var. muralis					
ADLA-04	Adlafia suchlandtii					1
FR045E	Synedrella subconstricta					
DT021A	Diatoma mesodon	1				
FR007C	Fragilaria vaucheriae var. capitellata					
EU110A	Eunotia minor					
FR009L	Fragilaria capucina var. amphicephala					
GO080A	Gomphonema pumilum					
FR009H	Fragilaria gracilis	2	1	1	11	8

Processed Diatom data

Sample ID		AUT1	AUT1	AUT1	SPR2	SPR2	SPR2
Site name		1_US 6261	1_DS 6386	1_TB 6282	2_US 6119	2_DS 6353	2_TB 6269
Sample date		20/11/2017	30/11/2017	20/11/2017	24/05/2018	24/05/2018	22/05/2018
Alkalinity		47.52	71.41	67.66	47.52	71.41	67.66
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		US	DS	TB	US	DS	TB
NA009B	Navicula lanceolata	10	15	18	9	1	
NA023A	Navicula gregaria	18	19	29	20	2	7
NA042A	Sellophora nigri	40	45	15	7	37	10
NA054A	Navicula veneta		5	10	2	4	6
NA066A	Navicula capitata						
NA084A	Navicula atomus	2	8	1		28	26
NA134A	Navicula subminuscula						
NA617A	Navicula saprophila		5		1	25	20
NA675A	Navicula tenelloides	2					
NA768A	Navicula reichardtiana						
NA9999	Navicula sp.	2	2				
NI002A	Nitzschia fonticola						
NI008A	Nitzschia frustulum						
NI014A	Nitzschia amphibia						
NI017A	Nitzschia gracilis						
NI028A	Nitzschia capitellata						2
NI030A	Nitzschia acidoclinata						
NI031A	Nitzschia linearis						
NI033A	Nitzschia paleacea			2	5		
NI043A	Nitzschia inconspicua			2	1	6	7
NI044A	Nitzschia intermedia						
NI152A	Nitzschia pusilla						
NI166A	Nitzschia sociabilis						
NI193A	Nitzschia perminuta						
NI203A	Nitzschia liebetruthii						
NI212A	Nitzschia fossilis						

Processed Diatom data

Sample ID		AUT1	AUT1	AUT1	SPR2	SPR2	SPR2
Site name		1_US 6261	1_DS 6386	1_TB 6282	2_US 6119	2_DS 6353	2_TB 6269
Sample date		20/11/2017	30/11/2017	20/11/2017	24/05/2018	24/05/2018	22/05/2018
Alkalinity		47.52	71.41	67.66	47.52	71.41	67.66
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		US	DS	TB	US	DS	TB
NI9999	Nitzschia sp.		3		1	4	
PI9999	Pinnularia sp.	1	1				
RC002A	Rhoicosphenia abbreviata					4	
RE001A	Reimeria sinuata	32	94	57	89	22	10
SA9999	Stauroneis sp.		1				
SR002A	Staurosira elliptica						
SU001A	Surirella angusta						
SU022A	Surirella brightwellii						
SU073A	Surirella brebissonii					5	
SY001A	Synedra ulna						
TA001A	Tabellaria flocculosa						
TU003A	Tabularia fasciculata						
UN9994	Pennate undif.						
UN9995	Centric undif.						
YH001A	Ctenophora pulchella						
ZZZ834	Gomphonema "intricatum" type	1					
ZZZ835	Achnanthidium minutissimum type	8	11	14	114	138	134
ZZZ848	Placoneis sp.						
ZZZ872	Placoneis clementis						
ZZZ896	Planothidium frequentissimum	6	19	19	5		5
ZZZ897	Planothidium lanceolatum	17	11	26	32	27	33
ZZZ986	Cocconeis placentula var. pseudolineata						
ZZZ987	Naviculoid (small undiff)	2	1	1			

Processed Diatom data

Sample ID		SPR2	SUM3	SUM3	SUM3	SUM3	AUT4
Site name		2_StC 5122	3_US 6066	3_DS 6126	3_TB 6011	3_StC 6060	4_US 6299
Sample date		24/05/2018	31/08/2018	31/08/2018	31/08/2018	31/05/2018	21/11/2018
Alkalinity		53.29	47.52	71.41	67.66	53.29	47.52
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		StC	US	DS	TB	StC	US
AC143A	Achnanthes oblongella	2	8	8	7		11
AC9999	Achnanthes sp.						
AM012A	Amphora pediculus	5				10	2
CO001A	Cocconeis placentula	1	15				
CO001B	Cocconeis placentula var. euglypta		17			6	5
DT021A	Diatoma mesodon		2				
EU070A	Eunotia bilunaris						
EU110A	Eunotia minor		2				2
EU9999	Eunotia sp.						
EY011A	Encyonema minutum		2				
EY016A	Encyonema silesiacum						
SS002A	Staurosirella pinnata						
FR007A	Fragilaria vaucheriae	9	3			4	
FR009A	Fragilaria capucina		2		2	1	
FR026A	Fragilaria bidens	1					
FR9999	Fragilaria sp.						
FRFO-01	Fragilariforma sp.						
FU002A	Frustulia rhomboides						
GO003A	Gomphonema angustatum	1	2	4	10	48	3
GO006A	Gomphonema acuminatum		3				
GO013A	Gomphonema parvulum					1	
GO023A	Gomphonema truncatum						
ME015A	Melosira varians		46	8	2		4
MR001A	Meridion circulare	17	1				2
NA007A	Navicula cryptocephala		1				1
NA008A	Navicula rhynchocephala		3		1		2

Processed Diatom data

Sample ID		SPR2	SUM3	SUM3	SUM3	SUM3	AUT4
Site name		2_StC 5122	3_US 6066	3_DS 6126	3_TB 6011	3_StC 6060	4_US 6299
Sample date		24/05/2018	31/08/2018	31/08/2018	31/08/2018	31/05/2018	21/11/2018
Alkalinity		53.29	47.52	71.41	67.66	53.29	47.52
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		StC	US	DS	TB	StC	US
NA009B	Navicula lanceolata	1	4				4
NA023A	Navicula gregaria	13	37	1		25	28
NA042A	Sellophora nigri	9	1	5	15	7	33
NA054A	Navicula veneta	5	10	54	25		
NA066A	Navicula capitata		2				
NA084A	Navicula atomus	2	2	139	12	1	6
NA134A	Navicula subminuscula						1
NA617A	Navicula saprophila	2		6	1		
NA675A	Navicula tenelloides						
NA768A	Navicula reichardtiana						2
NA9999	Navicula sp.		2			1	
NI002A	Nitzschia fonticola					5	
NI008A	Nitzschia frustulum					1	
NI014A	Nitzschia amphibia					5	
NI017A	Nitzschia gracilis					2	
NI028A	Nitzschia capitellata		3	2	8	13	2
NI030A	Nitzschia acidoclinata			4	15	2	
NI031A	Nitzschia linearis						
NI033A	Nitzschia paleacea	1	4	2	4		
NI043A	Nitzschia inconspicua	33	2	36	49	16	2
NI044A	Nitzschia intermedia			2	13	14	
NI152A	Nitzschia pusilla						
NI166A	Nitzschia sociabilis				1		2
NI193A	Nitzschia perminuta	2			2		
NI203A	Nitzschia liebetruthii						
NI212A	Nitzschia fossilis						

Processed Diatom data

Sample ID		SPR2	SUM3	SUM3	SUM3	SUM3	AUT4
Site name		2_StC 5122	3_US 6066	3_DS 6126	3_TB 6011	3_StC 6060	4_US 6299
Sample date		24/05/2018	31/08/2018	31/08/2018	31/08/2018	31/05/2018	21/11/2018
Alkalinity		53.29	47.52	71.41	67.66	53.29	47.52
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		StC	US	DS	TB	StC	US
NI9999	Nitzschia sp.				1		
PI9999	Pinnularia sp.						
RC002A	Rhoicosphenia abbreviata	5	4			19	
RE001A	Reimeria sinuata	91	69	2	2	10	96
SA9999	Stauroneis sp.						
SR002A	Staurosira elliptica			16	67		6
SU001A	Surirella angusta		2				
SU022A	Surirella brightwellii						
SU073A	Surirella brebissonii	1	6		1		2
SY001A	Synedra ulna				1	3	
TA001A	Tabellaria flocculosa						
TU003A	Tabularia fasciculata						
UN9994	Pennate undif.						
UN9995	Centric undif.		9	1	2	29	
YH001A	Ctenophora pulchella			1	4	1	
ZZZ834	Gomphonema "intricatum" type	8	4				
ZZZ835	Achnanthidium minutissimum type	81	38	2	24	52	32
ZZZ848	Placoneis sp.		1			3	
ZZZ872	Placoneis clementis				8		
ZZZ896	Planothidium frequentissimum	2	5	11	18	5	16
ZZZ897	Planothidium lanceolatum	26	12	15	34	46	46
ZZZ986	Cocconeis placentula var. pseudolineata						
ZZZ987	Naviculoid (small undiff)					1	2

Processed Diatom data

Sample ID		AUT4	AUT4	AUT4	SPR5	SPR5	SPR5
Site name		4_DS 5176	4_TB 6213	4_StC 6210	5_US 5177	5_DS 6271	5_TB 5079
Sample date		21/11/2018	20/11/2018	20/11/2018	10/05/2019	10/05/2019	10/05/2019
Alkalinity		71.41	67.66	53.29	47.52	71.41	67.66
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		DS	TB	StC	US	DS	TB
AC143A	Achnanthes oblongella	30	26	2	13	6	23
AC9999	Achnanthes sp.	1					
AM012A	Amphora pediculus		2	18			2
CO001A	Cocconeis placentula	1					
CO001B	Cocconeis placentula var. euglypta	3	7				1
DT021A	Diatoma mesodon					4	1
EU070A	Eunotia bilunaris						
EU110A	Eunotia minor						
EU9999	Eunotia sp.						
EY011A	Encyonema minutum	1					
EY016A	Encyonema silesiacum			2			
SS002A	Staurosirella pinnata						
FR007A	Fragilaria vaucheriae	2		9	41	84	8
FR009A	Fragilaria capucina			4	4	6	4
FR026A	Fragilaria bidens						
FR9999	Fragilaria sp.					16	
FRFO-01	Fragilariforma sp.						
FU002A	Frustulia rhomboides						1
GO003A	Gomphonema angustatum	7	12	10	13	5	8
GO006A	Gomphonema acuminatum						
GO013A	Gomphonema parvulum					4	13
GO023A	Gomphonema truncatum						1
ME015A	Melosira varians		1	44	5		
MR001A	Meridion circulare	2	1		1	12	16
NA007A	Navicula cryptocephala						
NA008A	Navicula rhynchocephala				2		

Processed Diatom data

Sample ID		AUT4	AUT4	AUT4	SPR5	SPR5	SPR5
Site name		4_DS 5176	4_TB 6213	4_StC 6210	5_US 5177	5_DS 6271	5_TB 5079
Sample date		21/11/2018	20/11/2018	20/11/2018	10/05/2019	10/05/2019	10/05/2019
Alkalinity		71.41	67.66	53.29	47.52	71.41	67.66
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		DS	TB	StC	US	DS	TB
NA009B	Navicula lanceolata	3	1		10	11	4
NA023A	Navicula gregaria	8	1	22	29	12	12
NA042A	Sellophora nigri	31	32	11	6	11	4
NA054A	Navicula veneta	17					
NA066A	Navicula capitata						
NA084A	Navicula atomus	4	19	2	8		1
NA134A	Navicula subminuscula						
NA617A	Navicula saprophila	4	1		5		
NA675A	Navicula tenelloides						
NA768A	Navicula reichardtiana		20	9	6	13	7
NA9999	Navicula sp.					1	
NI002A	Nitzschia fonticola						
NI008A	Nitzschia frustulum						
NI014A	Nitzschia amphibia			25			
NI017A	Nitzschia gracilis						
NI028A	Nitzschia capitellata		1	3		4	
NI030A	Nitzschia acidoclinata					2	
NI031A	Nitzschia linearis						6
NI033A	Nitzschia paleacea				2		
NI043A	Nitzschia inconspicua	8	26	85		2	4
NI044A	Nitzschia intermedia						
NI152A	Nitzschia pusilla						
NI166A	Nitzschia sociabilis			3	2		
NI193A	Nitzschia perminuta						
NI203A	Nitzschia liebetruthii						
NI212A	Nitzschia fossilis						

Processed Diatom data

Sample ID		AUT4	AUT4	AUT4	SPR5	SPR5	SPR5
Site name		4_DS 5176	4_TB 6213	4_StC 6210	5_US 5177	5_DS 6271	5_TB 5079
Sample date		21/11/2018	20/11/2018	20/11/2018	10/05/2019	10/05/2019	10/05/2019
Alkalinity		71.41	67.66	53.29	47.52	71.41	67.66
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		DS	TB	StC	US	DS	TB
NI9999	Nitzschia sp.					1	
PI9999	Pinnularia sp.						
RC002A	Rhoicosphenia abbreviata			8		1	
RE001A	Reimeria sinuata	59	17	3	14	6	5
SA9999	Stauroneis sp.						
SR002A	Staurosira elliptica		23	2			
SU001A	Surirella angusta						
SU022A	Surirella brightwellii						
SU073A	Surirella brebissonii		3		4	1	5
SY001A	Synedra ulna						
TA001A	Tabellaria flocculosa						
TU003A	Tabularia fasciculata						4
UN9994	Pennate undif.						
UN9995	Centric undif.			8			
YH001A	Ctenophora pulchella		2			2	11
ZZZ834	Gomphonema "intricatum" type		1			1	
ZZZ835	Achnanthidium minutissimum type	21	41	25	127	96	140
ZZZ848	Placoneis sp.			2			
ZZZ872	Placoneis clementis						
ZZZ896	Planothidium frequentissimum	91	41	2	5	8	18
ZZZ897	Planothidium lanceolatum	17	34	19	23	24	45
ZZZ986	Cocconeis placentula var. pseudolineata	2					
ZZZ987	Naviculoid (small undiff)			1			

Processed Diatom data

Sample ID		SPR5	SUM6	SUM6	SUM6	SUM6	AUT7
Site name		5_StC 5170	6_US 6102	6_DS 2253	6_TB 5151	6_StC 6194	7_US 5163
Sample date		09/05/2019	30/08/2019	30/08/2019	30/08/2019	29/08/2019	29/11/2019
Alkalinity		53.29	47.52	71.41	67.66	53.29	47.52
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		StC	US	DS	TB	StC	US
AC143A	Achnanthes oblongella	2	42	5	4		38
AC9999	Achnanthes sp.						1
AM012A	Amphora pediculus	46	3			13	6
CO001A	Cocconeis placentula	6	3				3
CO001B	Cocconeis placentula var. euglypta		18	1		7	
DT021A	Diatoma mesodon						
EU070A	Eunotia bilunaris						
EU110A	Eunotia minor						
EU9999	Eunotia sp.						
EY011A	Encyonema minutum						
EY016A	Encyonema silesiacum						
SS002A	Staurosirella pinnata						
FR007A	Fragilaria vaucheriae	18	1		1	20	
FR009A	Fragilaria capucina	9				6	1
FR026A	Fragilaria bidens						
FR9999	Fragilaria sp.						
FRFO-01	Fragilariforma sp.						
FU002A	Frustulia rhomboides						
GO003A	Gomphonema angustatum	2	1	1	13	5	6
GO006A	Gomphonema acuminatum						
GO013A	Gomphonema parvulum		7	4	3	8	
GO023A	Gomphonema truncatum						
ME015A	Melosira varians		5			8	
MR001A	Meridion circulare			2			2
NA007A	Navicula cryptocephala						
NA008A	Navicula rhynchocephala						

Processed Diatom data

Sample ID		SPR5	SUM6	SUM6	SUM6	SUM6	AUT7
Site name		5_StC 5170	6_US 6102	6_DS 2253	6_TB 5151	6_StC 6194	7_US 5163
Sample date		09/05/2019	30/08/2019	30/08/2019	30/08/2019	29/08/2019	29/11/2019
Alkalinity		53.29	47.52	71.41	67.66	53.29	47.52
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		StC	US	DS	TB	StC	US
NA009B	Navicula lanceolata						8
NA023A	Navicula gregaria	5	8	2	3	7	12
NA042A	Sellophora nigri	1	5	10	8	7	20
NA054A	Navicula veneta						3
NA066A	Navicula capitata					1	
NA084A	Navicula atomus	1	23	22	4	2	
NA134A	Navicula subminuscula						
NA617A	Navicula saprophila		3		2		
NA675A	Navicula tenelloides						
NA768A	Navicula reichardtiana		23	52	39		
NA9999	Navicula sp.					2	
NI002A	Nitzschia fonticola						
NI008A	Nitzschia frustulum						
NI014A	Nitzschia amphibia	3			3	28	
NI017A	Nitzschia gracilis						
NI028A	Nitzschia capitellata						
NI030A	Nitzschia acidoclinata			15			
NI031A	Nitzschia linearis						
NI033A	Nitzschia paleacea	2				2	
NI043A	Nitzschia inconspicua	29	38	85	148	65	
NI044A	Nitzschia intermedia						
NI152A	Nitzschia pusilla						
NI166A	Nitzschia sociabilis						
NI193A	Nitzschia perminuta						
NI203A	Nitzschia liebetruthii					2	
NI212A	Nitzschia fossilis					23	

Processed Diatom data

Sample ID		SPR5	SUM6	SUM6	SUM6	SUM6	AUT7
Site name		5_StC 5170	6_US 6102	6_DS 2253	6_TB 5151	6_StC 6194	7_US 5163
Sample date		09/05/2019	30/08/2019	30/08/2019	30/08/2019	29/08/2019	29/11/2019
Alkalinity		53.29	47.52	71.41	67.66	53.29	47.52
Watercourse		Inny	Inny	Inny	Inny	Inny	Inny
Reach		StC	US	DS	TB	StC	US
NI9999	Nitzschia sp.				2	3	3
PI9999	Pinnularia sp.						
RC002A	Rhoicosphenia abbreviata	6			2	41	
RE001A	Reimeria sinuata	32	50	2		2	122
SA9999	Stauroneis sp.						
SR002A	Staurosira elliptica			14	12	10	
SU001A	Surirella angusta						
SU022A	Surirella brightwellii					1	
SU073A	Surirella brebissonii	23				2	
SY001A	Synedra ulna						
TA001A	Tabellaria flocculosa					2	
TU003A	Tabularia fasciculata						
UN9994	Pennate undif.						1
UN9995	Centric undif.	1				1	1
YH001A	Ctenophora pulchella		2				
ZZZ834	Gomphonema "intricatum" type		2				
ZZZ835	Achnanthidium minutissimum type	75	56	46	54	24	43
ZZZ848	Placoneis sp.						
ZZZ872	Placoneis clementis						
ZZZ896	Planothidium frequentissimum	12	13	13	2	8	9
ZZZ897	Planothidium lanceolatum	37	30	42	19	20	34
ZZZ986	Cocconeis placentula var. pseudolineata						
ZZZ987	Naviculoid (small undiff)					1	

Processed Diatom data

Sample ID		AUT7	AUT7				
Site name		7_DS 6101	7_TB 6114				
Sample date		29/11/2019	29/11/2019				
Alkalinity		71.41	67.66				
Watercourse		Inny	Inny				
Reach		DS	TB				
AC143A	Achnanthes oblongella	6	33				
AC9999	Achnanthes sp.						
AM012A	Amphora pediculus	2					
CO001A	Cocconeis placentula						
CO001B	Cocconeis placentula var. euglypta						
DT021A	Diatoma mesodon						
EU070A	Eunotia bilunaris						
EU110A	Eunotia minor						
EU9999	Eunotia sp.		4				
EY011A	Encyonema minutum						
EY016A	Encyonema silesiacum						
SS002A	Staurosirella pinnata						
FR007A	Fragilaria vaucheriae	1					
FR009A	Fragilaria capucina						
FR026A	Fragilaria bidens						
FR9999	Fragilaria sp.						
FRFO-01	Fragilariforma sp.						
FU002A	Frustulia rhomboides						
GO003A	Gomphonema angustatum	6	2				
GO006A	Gomphonema acuminatum						
GO013A	Gomphonema parvulum		10				
GO023A	Gomphonema truncatum						
ME015A	Melosira varians						
MR001A	Meridion circulare	5					
NA007A	Navicula cryptocephala	1					
NA008A	Navicula rhynchocephala						

Processed Diatom data

Sample ID		AUT7	AUT7				
Site name		7_DS 6101	7_TB 6114				
Sample date		29/11/2019	29/11/2019				
Alkalinity		71.41	67.66				
Watercourse		Inny	Inny				
Reach		DS	TB				
NA009B	Navicula lanceolata	7	9				
NA023A	Navicula gregaria	36	20				
NA042A	Sellophora nigri	30	41				
NA054A	Navicula veneta						
NA066A	Navicula capitata						
NA084A	Navicula atomus	31					
NA134A	Navicula subminuscula						
NA617A	Navicula saprophila	15					
NA675A	Navicula tenelloides						
NA768A	Navicula reichardtiana	2	1				
NA9999	Navicula sp.						
NI002A	Nitzschia fonticola						
NI008A	Nitzschia frustulum						
NI014A	Nitzschia amphibia						
NI017A	Nitzschia gracilis						
NI028A	Nitzschia capitellata						
NI030A	Nitzschia acidoclinata						
NI031A	Nitzschia linearis						
NI033A	Nitzschia paleacea		2				
NI043A	Nitzschia inconspicua	3	2				
NI044A	Nitzschia intermedia						
NI152A	Nitzschia pusilla		4				
NI166A	Nitzschia sociabilis						
NI193A	Nitzschia perminuta						
NI203A	Nitzschia liebetruthii						
NI212A	Nitzschia fossilis						

Processed Diatom data

Sample ID		AUT7	AUT7				
Site name		7_DS 6101	7_TB 6114				
Sample date		29/11/2019	29/11/2019				
Alkalinity		71.41	67.66				
Watercourse		Inny	Inny				
Reach		DS	TB				
NI9999	Nitzschia sp.						
PI9999	Pinnularia sp.						
RC002A	Rhoicosphenia abbreviata	2					
RE001A	Reimeria sinuata	48	64				
SA9999	Stauroneis sp.						
SR002A	Staurosira elliptica						
SU001A	Surirella angusta						
SU022A	Surirella brightwellii						
SU073A	Surirella brebissonii						
SY001A	Synedra ulna						
TA001A	Tabellaria flocculosa						
TU003A	Tabularia fasciculata						
UN9994	Pennate undif.						
UN9995	Centric undif.						
YH001A	Ctenophora pulchella						
ZZZ834	Gomphonema "intricatum" type		2				
ZZZ835	Achnanthidium minutissimum type	97	50				
ZZZ848	Placoneis sp.						
ZZZ872	Placoneis clementis						
ZZZ896	Planothidium frequentissimum	6	14				
ZZZ897	Planothidium lanceolatum	22	64				
ZZZ986	Cocconeis placentula var. pseudolineata						
ZZZ987	Naviculoid (small undiff)						

DARLEQ3 output for historic Environment Agency diatom monitoring data 2009 - 2016. INYVLEA = Inny Vale, STCEA = St Clether Bridge, 2BIEA = River Inny at Two Bridges. 2BPPEA = Penpont Water at Two Bridges. TDI5LM is the Trophic Diatom Index iteration 5, generated using light microscope identification. Sample date is plotted against EQRTDI5LM in Figure 5.11.

Site Name	Sample Date	Total count	% Scoring taxa	TDI5LM	eTDI5LM	EQR TDI5LM	WFD Class TDI5LM	% Motile valves	% Organic Tolerant valves	% Planktic valves	% Saline Tolerant valves
INYVALE	23/04/2009	284	100.00	64.15	38.91	0.47	Moderate	42.25	41.90	0.00	0.70
INYVALE	16/09/2009	276	100.00	65.16	38.91	0.46	Moderate	72.46	75.00	0.00	0.00
StCEA	17/06/2016	259	100.00	58.52	38.91	0.54	Moderate	73.75	73.36	0.00	0.00
StCEA	23/04/2009	332	100.00	74.38	45.89	0.38	Poor	53.01	47.59	0.00	0.00
StCEA	16/09/2009	315	100.00	77.52	45.89	0.33	Poor	15.56	13.02	0.00	2.22
StCEA	06/04/2010	372	100.00	75.66	45.89	0.36	Poor	38.71	34.95	0.00	0.27
StCEA	09/09/2010	308	100.00	69.50	45.89	0.45	Moderate	20.45	13.31	0.00	0.32
StCEA	12/04/2011	337	100.00	79.60	45.89	0.30	Poor	15.73	16.02	0.00	0.00
StCEA	06/10/2011	312	100.00	76.13	45.89	0.35	Poor	28.21	8.65	0.00	0.00
StCEA	21/06/2012	282	100.00	72.99	45.89	0.40	Poor	30.85	31.91	0.00	1.42
StCEA	22/10/2012	282	100.00	65.34	45.89	0.51	Moderate	19.15	14.89	0.00	0.35
StCEA	09/04/2014	208	100.00	56.75	45.89	0.64	Good	62.50	63.46	0.00	0.48
StCEA	09/09/2014	293	98.63	57.34	45.89	0.63	Good	27.30	18.43	1.37	1.02
StCEA	17/06/2016	242	96.69	52.88	45.89	0.70	Good	21.49	28.10	3.31	0.83
2BIEA	15/04/2010	404	100.00	75.88	42.73	0.34	Poor	58.17	58.42	0.00	0.50
2BIEA	09/09/2010	318	100.00	73.18	42.73	0.37	Poor	43.40	21.07	0.00	2.52
2BIEA	11/05/2011	318	100.00	79.94	42.73	0.28	Poor	27.04	22.96	0.00	0.63
2BIEA	06/10/2011	315	100.00	70.82	42.73	0.41	Moderate	28.89	18.10	0.00	1.90
2BIEA	14/04/2014	279	100.00	55.71	42.73	0.62	Good	39.78	37.63	0.00	6.09
2BIEA	22/09/2014	301	100.00	65.52	42.73	0.48	Moderate	49.50	42.52	0.00	1.99
2BIEA	17/06/2016	294	100.00	52.04	42.73	0.67	Good	47.62	47.28	0.00	2.04
2BPPEA	24/04/2013	296	100.00	64.43	50.19	0.57	Moderate	74.32	77.03	0.00	0.00
2BPPEA	15/10/2013	312	100.00	82.26	50.19	0.28	Poor	22.44	22.12	0.00	0.32
2BPPEA	27/04/2016	279	100.00	45.66	50.19	0.87	High	29.03	30.47	0.00	0.00
2BPPEA	21/06/2016	293	99.66	34.69	50.19	1.00	High	11.95	12.63	0.34	0.34
2BPPEA	01/11/2016	306	100.00	46.06	50.19	0.87	High	11.11	10.78	0.00	0.00

Total Count = Number of diatom valves counted within the sample.

% Scoring taxa =

TDI5 LM =Trophic Diatom index score generated through Iteration 5 for the Light Microscope. Higher values indicating progressively higher levels of nutrients

eTDI5LM = Expected TDI5 LM score (modelled) in a pristine river system of similar geochemistry.

EQR TDI5LM = Ecological Quality ratio for TDI5 LM, score 0 to 1, where 1 indicates no nutrient impact and 0 indicates diatom assemblage indicative of major anthropogenic activities.

WFD Class TDI5LM = Water Framework Directive Class to represent nutrient status of river based on diatom assemblage, where blue= high class of diatom assemblage, green = good, orange = moderate, yellow= poor and red = bad.

% Motile valves = an indication of silt and biofilm maturity.

% Organic Tolerant Valves = calculated as the sum of valves belonging to taxa that are tolerant to organic pollution. Acts as an indicator of the reliability of the TDI as an estimator of eutrophication. <20% of total count indicates organic pollution is absent or showing minimal effects.

% Planktic valves = Planktonic valves i.e. normally found in water column will skew results so are excluded from the TDI metric.

% Saline Tolerant Valves = Indicates the number of valves tolerant of higher salinity

DARLEQ3 output for diatom monitoring undertaken during this study, 2017 – 2019. Diatoms prepared and identified by external consultant. EQR = Ecological Quality ratio. TDI5LM = Trophic diatom index iteration5, identified using light microscope. Sample date is plotted against EQRTDI5LM in Figure 5.12.

SAMPLE _DATE	Season	Reach	Total count	% scoring taxa	TDI5LM	expected TDI5LM	EQR TDI5LM	Class TDI5LM	% Motile valves	% Organic Tolerant valves	% Planktic valves	% Saline tolerant valves
2017	Aut	US	316	100.00	31.19	38.63	0.90	High	24.68	22.47	0.00	0.00
2017	Aut	DS	313	100.00	45.54	44.59	0.79	Good	33.23	29.39	0.00	0.00
2017	Aut	TB	321	100.00	40.76	43.75	0.84	High	24.30	20.87	0.00	0.62
2018	Spr	US	315	100.00	44.10	38.63	0.73	Good	14.29	13.65	0.00	0.32
2018	Sum	US	324	97.22	54.08	38.63	0.60	Moderate	24.69	16.36	2.78	1.23
2018	Aut	US	312	100.00	54.16	38.63	0.60	Moderate	27.88	25.00	0.00	0.64
2018	Spr	DS	321	100.00	44.70	44.59	0.80	Good	27.10	30.84	0.00	1.87
2018	Sum	DS	319	98.43	70.60	44.59	0.42	Moderate	76.80	61.76	0.31	11.60
2018	Aut	DS	312	100.00	48.03	44.59	0.75	Good	22.76	18.59	0.00	2.56
2018	Spr	TB	318	100.00	41.76	43.75	0.83	High	18.24	22.64	0.00	2.20
2018	Sum	TB	329	94.83	68.59	43.75	0.45	Moderate	47.11	36.47	0.61	16.72
2018	Aut	TB	312	100.00	53.99	43.75	0.65	Good	33.01	25.96	0.00	8.97
2018	Spr	StC	318	100.00	48.88	40.22	0.68	Good	21.07	19.81	0.00	11.01
2018	Sum	StC	331	90.63	60.56	40.22	0.53	Moderate	29.00	26.28	8.76	5.44
2018	Aut	StC	319	97.49	69.23	40.22	0.41	Moderate	51.10	39.50	2.51	26.65
2019	Spr	US	320	100.00	40.82	38.63	0.77	Good	21.56	19.38	0.00	0.00
2019	Sum	US	333	100.00	49.44	38.63	0.66	Good	29.13	25.23	0.00	12.01
2019	Aut	US	313	99.36	45.70	38.63	0.71	Good	14.70	12.78	0.32	0.00
2019	Spr	DS	333	99.40	36.95	44.59	0.91	High	17.42	13.81	0.00	1.20
2019	Sum	DS	316	95.25	63.85	44.59	0.52	Moderate	58.86	43.67	0.00	26.90
2019	Aut	DS	320	100.00	50.19	44.59	0.72	Good	34.38	38.12	0.00	0.94
2019	Spr	TB	344	100.00	39.38	43.75	0.86	High	12.79	12.79	0.00	5.52
2019	Sum	TB	319	100.00	64.09	43.75	0.51	Moderate	64.89	52.66	0.00	46.39
2019	Aut	TB	322	100.00	48.26	43.75	0.74	Good	24.53	26.09	0.00	0.62
2019	Spr	StC	310	99.68	55.12	40.22	0.60	Good	20.65	12.26	0.32	9.35
2019	Sum	StC	321	99.69	68.10	40.22	0.43	Moderate	45.48	28.97	0.31	21.50

2018 Macrophyte survey data

Physical properties						
pH	6.74					
Temp	16.8	°C				
Cond	527	µs				
Turbidity	3.33	FAU				
Sus. Slds	0.75	mg/l		+/- 4m		
NGR @ top of reach			SX16908 86719		Alt	224m
NGR @ bottom of reach			SX16898 86676		Alt	228m

Reach	Section	Stretch	Position	Code	% Coverage	Species
1	1	1	L	111L	10	*Glyceria fluitans*
1	1	1	M	111M		NIL
1	1	1	R	111R	75	*Glyceria fluitans*
1	1	1	R	111R	<1	*Myosoton aquatium*
1	1	1	R	111R		Pot # Check IDs of pots……
1	1	3	L	113L	25	*Glyceria fluitans*
1	1	3	L	113L	<1	*Veronica beccabunga*
1	1	3	L	113L	<1	*Persicaria hydropiper*
1	1	3	M	113M	5	*Glyceria fluitans*
1	1	3	M	113M	60	*Oenanthe crocata*
1	1	3	R	113R	2	*Myriophyllum alterniflorum*
1	1	2	L	112L	20	*Glyceria fluitans*
1	1	2	L	112L	5	*Veronica beccabunga*
1	1	2	M	112M	2	*Myriophyllum alterniflorum*
1	1	2	R	112R		NIL
1	2	9	L	129L	30	*Oenanthe crocata*
1	2	9	L	129L	3	*Glyceria fluitans*
1	2	9	M	129M	40	*Oenanthe crocata*
1	2	9	R	129R		NIL
1	2	5	L	125L	15	*Glyceria fluitans*
1	2	5	L	125L	<1	*Rumex obtusifolius*
1	2	5	L	125L	<1	*Lemna minor*
1	2	5	L	125L	<1	*Galium palustre*
1	2	5	M	125M	50	*Oenanthe crocata*
1	2	5	R	125R	1	*Glyceria fluitans*
1	2	5	R	125R	2	*Myriophyllum alterniflorum*
1	2	5	R	125R	1	*Common water starwort or*
1	2	5	R	125R	2	*Hygrohypnum luridum*
1	2	10	R	1210R	10	*Oenanthe crocata*
1	2	10	R	1210R	<1	*Persicaria hydropiper*
1	2	10	R	1210R	<1	*Ranunculus repens*
1	2	10	R	1210R	<1	*Veronica beccabunga*
1	2	10	R	1210R	<1	*Glyceria fluitans*
1	2	10	M	1210M		NIL
1	2	10	L	1210L	60	*Myriophyllum alterniflorum*
1	2	10	L	1210L	1	*Myosoton aquatium*
1	3	14	R	1314R	25	*Filipendula ulmaria*
1	3	14	R	1314R	3	*Myosoton aquatium*
1	3	14	R	1314R	3	*Glyceria fluitans*
1	3	14	M	1314M		NIL
1	3	14	L	1314L	20	*Myriophyllum alterniflorum*
1	3	13	L	1313L	80	*Myriophyllum alterniflorum*
1	3	13	M	1313M		NIL
1	3	13	R	1313R		NIL
1	3	12	L	1312L	15	Moss pot 4074
1	3	12	M	1312M		NIL
1	3	12	R	1312R		NIL

Reach	Section	Stretch	Position	Code	% Coverage	Species
1	4	15	L	1415L	1	*Glyceria fluitans*
1	4	15	L	1415L	30	Bryophyte
1	4	15	M	1415M	2	*Myosoton aquatium*
1	4	15	R	1415R	15	*Scrophularia nodosa*
1	4	15	R	1415R	3	*Valeriana officinalis*
1	4	16	R	1416R	1	*Myosoton aquatium*
1	4	16	R	1416R	5	Blanket weed Pot 4247
1	4	16	M	1416M	<1	*Glyceria fluitans*
1	4	16	L	1416L	30	*Hygroamblystegium fluviatile/tenax*
1	4	16	L	1416L	1	*Glyceria fluitans*
1	4	16	L	1416L	1	*Spargarium sp. Reed*
1	4	20	L	1420L	4	*Glyceria fluitans*
1	4	20	L	1420L	3	*Myosoton aquatium*
1	4	20	L	1420L	1	*Callitriche stagnalis*
1	4	20	M	1420M	<1	*Callitriche stagnalis*
1	4	20	M	1420M	5	*Hygroamblystegium fluviatile/tenax*
1	4	20	R	1420R		NIL
1	5	22	L	1522L	10	*Hygroamblystegium fluviatile/tenax*
1	5	22	L	1522L	30	*Oenanthe crocata*
1	5	22	L	1522L	1	*Veronica beccabunga*
1	5	22	M	1522M	40	*Oenanthe crocata*
1	5	22	R	1522R	90	*Oenanthe crocata*
1	5	23	L	1523L	30	*Oenanthe crocata*
1	5	23	M	1523M	90	*Oenanthe crocata*
1	5	23	R	1523R	80	*Oenanthe crocata*
1	5	24	L	1524L	<1	*Cardamine flexuosa*
1	5	24	L	1524L	<1	*Cirsium palustre*
1	5	24	L	1524L	<1	*Ranunculus repens*
1	5	24	L	1524L	<1	*Glyceria fluitans*
1	5	24	L	1524L	<1	*Holcus lanatus*
1	5	24	L	1524L	<1	*Stellaria palustris*
1	5	24	L	1524L	10	*Oenanthe crocata*
1	5	24	M	1524M	50	*Oenanthe crocata*
1	5	24	M	1524M	1	*Hygroamblystegium fluviatile/tenax*
1	5	24	M	1524M	10	*Fontinalis antipytretica*
1	5	24	L	1524L	30	*Oenanthe crocata*
1	5	24	L	1524L	1	*Myriophyllum alterniflorum*
1	6	25	L	1625L	40	*Oenanthe crocata*
1	6	25	L	1625L	<1	*Persicaria hydropiper*
1	6	25	L	1625L	<1	*Glyceria maxima*
1	6	25	M	1625M	60	*Oenanthe crocata*
1	6	25	R	1625R		NIL
1	6	27	L	1627L	3	*Agrosits stolonifera*
1	6	27	L	1627L	3	*Glyceria fluitans*
1	6	27	L	1627L	<1	*Persicaria hydropiper*
1	6	27	L	1627L	<1	*Callitriche stagnalis*
1	6	27	L	1627L	<1	*Myosoton aquatium*
1	6	27	L	1627L	<1	*Ranunculus repens*
1	6	27	M	1627M	2	*Fontinalis antipytretica*
1	6	27	R	1627R	20	*Callitriche stagnalis*
1	6	27	R	1627R	1	*Persicaria hydropiper*
1	6	27	R	1627R	3	Green algae
1	6	29	L	1629L	25	*Oenanthe crocata*
1	6	29	M	1629M	50	*Oenanthe crocata*
1	6	29	R	1629R	40	*Oenanthe crocata*
1	7	31	L	1731L	<1	*Fontinalis antipytretica*
1	7	31	M	1731M	50	*Oenanthe crocata*
1	7	31	R	1731R		NIL
1	7	32	R	1732R	<1	*Myriophyllum alterniflorum*
1	7	32	R	1732R	1	*Fontinalis antipytretica*
1	7	32	M	1732M		NIL
1	7	32	L	1732L	<1	*Callitriche stagnalis*
1	7	34	L	1734L		NIL
1	7	34	M	1734M	<1	*Hygroamblystegium fluviatile/tenax*
1	7	34	M	1734M	10	*Myriophyllum alterniflorum*
1	7	34	R	1734R	<1	*Stellaria palustris*
1	7	34	R	1734R	<1	*Oenanthe crocata*

Reach	Section	Stretch	Position	Code	% Coverage	Species
1	8	35	L	1835L		NIL
1	8	35	M	1835M	1	*Myriophyllum alterniflorum*
1	8	35	M	1835M	6	*Oenanthe crocata*
1	8	35	R	1835R		NIL
1	8	37	L	1837L		NIL
1	8	37	M	1837M	12	*Myriophyllum alterniflorum*
1	8	37	M	1837M	3	*Hygroamblystegium fluviatile/tenax*
1	8	37	R	1837R	10	*Callitriche stagnalis*
1	8	37	R	1837R	25	*Hygroamblystegium fluviatile/tenax*
1	8	39	L	1839L		NIL
1	8	39	L	1839L	25	*Myriophyllum alterniflorum*
1	8	39	L	1839L	25	*Hygroamblystegium fluviatile/tenax*
1	8	39	R	1839R		NIL
1	9	40	L	1940L		NIL
1	9	40	M	1940M	30	*Hygroamblystegium fluviatile/tenax*
1	9	40	M	1940M	30	*Myriophyllum alterniflorum*
1	9	40	M	1940M	<1	Brown - like seaweed
						Cushion moss Blanket weed green
1	9	40	R	1940R	12	*Cardamine flexuosa*
1	9	40	R	1940R	<1	Filamentous green algae
1	9	43	L	1943L		NIL
1	9	43	M	1943M	1	*Myriophyllum alterniflorum*
1	9	43	M	1943M	<1	*Hygroamblystegium fluviatile/tenax*
1	9	43	R	1943R	<1	*Lemna minor*
1	9	43	R	1943R	25	*Hygroamblystegium fluviatile/tenax*
1	9	44	L	1944L		NIL
1	9	44	M	1944M	45	*Oenanthe crocata*
1	9	44	M	1944M	<1	*Myriophyllum alterniflorum*
1	9	44	M	1944M	<1	Filamentous green algae
1	9	44	M	1944M	<1	*Hygroamblystegium fluviatile/tenax*
1	9	44	R	1944R	15	*Oenanthe crocata*
1	9	44	R	1944R	<1	*Urtica dioica*
1	9	44	R	1944R	<1	*Glyceria fluitans*
1	9	44	R	1944R	<1	*Juncus tenageia*
1	10	46	L	11046L	<1	*Holcus lanatus*
1	10	46	M	11046M	90	*Oenanthe crocata*
1	10	46	R	11046R	6	*Holcus lanatus*
1	10	46	R	11046R	15	Bryphyte
1	10	46	R	11046R	40	Moss pot 4245
1	10	47	L	11047L	<1	*Glyceria fluitans*
1	10	47	L	11047L	3	*Hygroamblystegium fluviatile/tenax*
1	10	47	M	11047M	<1	Filamentous green algae
1	10	47	R	11047R	25	Liverwort Pellia sp.
1	10	47	R	11047R	50	Moss
1	10	50	L	11050L	20	*Myriophyllum alterniflorum*
1	10	50	M	11050M	<1	*Myriophyllum alterniflorum*
1	10	50	M	11050M	<1	*Hygroamblystegium fluviatile/tenax*
1	10	50	R	11050R	12	*Myriophyllum alterniflorum*
1	10	50	R	11050R	<1	*Hygroamblystegium fluviatile/tenax*

Macrophyte data 2019

Physical Properties					
pH	7.85		Turb	7	ATU
Temp	19.9	^{o}C	Sus Slds	9.4	mg L^{-1}
Cond	6640	µs cm-1	DO	91.5	%
Depth at top	0.127	m	DO	8.41	mg L^{-1}

Distance	Reach	Section	Stretch	Position	Code	Bed score	% Coverage	Species	Corrected Slope (m/5m)
0-5m	2	1	4	L	214L	6	15	*Glyceria fluitans*	0.0008
	2	1	4	L	214L	6	30	*Oenanthe crocata*	0.0008
	2	1	4	L	214L	6	1	*Fontinalis antipyretica*	0.0008
	2	1	4	L	214L	6	3	*Callitriche stagnalis*	0.0008
	2	1	4	M	214M	6	5	*Hygroamblystegium fluviatile/tenax*	0.0008
	2	1	4	M	214M	6	5	Tufted filamentous algae	0.0008
	2	1	4	R	214R	6	66	Blanket filamentous algae	0.0008
	2	1	0	L	210L	6	23	*Glyceria fluitans*	0.0008
	2	1	0	M	210M	6	1	*Glyceria fluitans*	0.0008
	2	1	0	M	210M	6	2	*Apium nodiflorum*	0.0008
	2	1	0	R	210R	6	0	NIL	0.0008
	2	1	2	L	212L	6	7	*Callitriche stagnalis*	0.0008
	2	1	2	M	212M	6	7	Blanket filamentous algae	0.0008
	2	1	2	R	212R	6	14	Blanket filamentous algae	0.0008
5-10m	2	2	7	L	227L	8	3	*Glyceria fluitans*	0.0042
	2	2	7	M	227M	8	3	Tufted filamentous algae	0.0042
	2	2	7	R	227R	8	7	*Fontinalis antipyretica*	0.0042
	2	2	7	R	227R	8	4	*Hygroamblystegium fluviatile/tenax*	0.0042
	2	2	9	L	229L	8	1	*Apium nodiflorum*	0.0042
	2	2	9	M	229M	8	8	Tufted filamentous algae	0.0042
	2	2	9	M	229M	8	2	*Hygroamblystegium fluviatile/tenax*	0.0042
	2	2	9	R	229R	8	0	NIL	0.0042
	2	2	5	L	225L	8	55	*Glyceria fluitans*	0.0042
	2	2	5	L	225L	8	3	*Callitriche stagnalis*	0.0042
	2	2	5	L	225L	8	2	Tufted filamentous algae	0.0042
	2	2	5	M	225M	8	0	NIL	0.0042
	2	2	5	L	225L	8	8	*Hygroamblystegium fluviatile/tenax*	0.0042
	2	2	5	R	225R	8	40	Blanket filamentous algae	0.0042
10-15m	2	3	14	L	2314L	7	32	*Glyceria fluitans*	-0.01
	2	3	14	L	2314L	7	7	*Oenanthe crocata*	-0.01
	2	3	14	L	2314L	7	30	*Veronica beccabunga*	-0.01
	2	3	14	M	2314M	7	1	*Apium nodiflorum*	-0.01
	2	3	14	R	2314R	7	2	Tufted filamentous algae	-0.01
	2	3	14	R	2314R	7	8	*Oenanthe crocata*	-0.01
	2	3	10	L	2310L	7	36	*Callitriche stagnalis*	-0.01
	2	3	10	M	2310M	7	0	NIL	-0.01
	2	3	10	R	2310R	7	5	*Myriophyllum verticillatum*	-0.01
	2	3	10	R	2310R	7	1	*Apium nodiflorum*	-0.01
	2	3	10	R	2310R	7	16	*Hygroamblystegium fluviatile/tenax*	-0.01
	2	3	12	L	2312L	7	6	*Glyceria fluitans*	-0.01
	2	3	12	L	2312L	7	1	*Hygroamblystegium fluviatile/tenax*	-0.01
	2	3	12	M	2312M	7	7	*Hygroamblystegium fluviatile/tenax*	-0.01
	2	3	12	R	2312R	7	0	NIL	-0.01

Distance	Reach	Section	Stretch	Position	Code	Bed score	% Coverage	Species	Corrected Slope (m/5m)
15-20m	2	4	15	L	2415L	7	0	NIL	-0.006
	2	4	15	M	2415M	7	5	*Apium nodiflorum*	-0.006
	2	4	15	M	2415M	7	4	*Hygroamblystegium fluviatile/tenax*	-0.006
	2	4	15	R	2415R	7	13	*Fontinalis antipyretica*	-0.006
	2	4	17	L	2417L	7	2	Tufted filamentous algae	-0.006
	2	4	17	M	2417M	7	1	Tufted filamentous algae	-0.006
	2	4	17	M	2417M	7	1	Blanket filamentous algae	-0.006
	2	4	17	R	2417R	7	10	*Callitriche stagnalis*	-0.006
	2	4	19	L	2419L	7	1	Tufted filamentous algae	-0.006
	2	4	19	L	2419L	7	1	*Hygroamblystegium fluviatile/tenax*	-0.006
	2	4	19	M	2419M	7	20	Tufted filamentous algae	-0.006
	2	4	19	M	2419M	7	2	Blanket filamentous algae	-0.006
	2	4	19	M	2419M	7	1	*Apium nodiflorum*	-0.006
	2	4	19	R	2419R	7	0	NIL	-0.006
20-25m	2	5	21	L	2521L	5	12	*Hygroamblystegium fluviatile/tenax*	-0.005
	2	5	21	M	2521M	5	8	*Glyceria fluitans*	-0.005
	2	5	21	M	2521M	5	7	*Hygroamblystegium fluviatile/tenax*	-0.005
	2	5	21	R	2521M	5	4	*Holcus mollis*	-0.005
	2	5	22	L	2522L	5	0	NIL	-0.005
	2	5	22	M	2522M	5	5	*Glyceria fluitans*	-0.005
	2	5	22	M	2522M	5	2	Blanket filamentous algae	-0.005
	2	5	22	M	2522R	5	6	Blanket filamentous algae	-0.005
	2	5	22	M	2522R	5	<1	*Callitriche stagnalis*	-0.005
	2	5	24	L	2524L	5	29	Tufted filamentous algae	-0.005
	2	5	24	M	2524M	5	1	*Glyceria fluitans*	-0.005
	2	5	24	M	2524M	5	4	*Hygroamblystegium fluviatile/tenax*	-0.005
	2	5	24	M	2524M	5	1	Blanket filamentous algae	-0.005
	2	5	24	R	2524R	5	3	Blanket filamentous algae	-0.005
25-30m	2	6	27	L	2627L	9	1	*Callitriche stagnalis*	-0.026
	2	6	27	M	2627M	9	1	*Glyceria fluitans*	-0.026
	2	6	27	M	2627M	9	12	Tufted filamentous algae	-0.026
	2	6	27	R	2627R	9	1	*Scrophularia auriculata*	-0.026
	2	6	27	R	2627R	9	1	*Callitriche stagnalis*	-0.026
	2	6	27	R	2627R	9	7	*Glyceria fluitans*	-0.026
	2	6	29	L	2629L	9	3	*Hygroamblystegium fluviatile/tenax*	-0.026
	2	6	29	M	2629M	9	16	*Glyceria fluitans*	-0.026
	2	6	29	M	2629M	9	7	*Callitriche stagnalis*	-0.026
	2	6	29	R	2629R	9	1	*Hygroamblystegium fluviatile/tenax*	-0.026
	2	6	29	R	2629R	9	6	*Glyceria fluitans*	-0.026
	2	6	29	R	2629R	9	6	Tufted filamentous algae	-0.026
	2	6	25	L	2625L	9	1	*Apium nodiflorum*	-0.026
	2	6	25	L	2625L	9	6	Tufted filamentous algae	-0.026
	2	6	25	M	2625M	9	8	*Glyceria fluitans*	-0.026
	2	6	25	M	2625M	9	8	*Fontinalis antipyretica*	-0.026
	2	6	25	M	2625M	9	5	*Hygroamblystegium fluviatile/tenax*	-0.026
	2	6	25	R	2625R	9	10	*Glyceria fluitans*	-0.026
	2	6	25	R	2625R	9	1	Blanket filamentous algae	-0.026
	2	6	25	R	2625R	9	5	*Hygroamblystegium fluviatile/tenax*	-0.026

Distance	Reach	Section	Stretch	Position	Code	Bed score	% Coverage	Species	Corrected Slope (m/5m)
30-35m	2	7	32	L	2732L	9	16	*Glyceria fluitans*	-0.03
	2	7	32	L	2732L	9	6	*Hygroamblystegium fluviatile/tenax*	-0.03
	2	7	32	M	2732M	9	7	*Callitriche stagnalis*	-0.03
	2	7	32	M	2732M	9	5	Tufted filamentous algae	-0.03
	2	7	32	R	2732R	9	4	*Apium nodiflorum*	-0.03
	2	7	32	R	2732R	9	5	*Hygroamblystegium fluviatile/tenax*	-0.03
	2	7	32	R	2732R	9	7	*Fontinalis antipyretica*	-0.03
	2	7	30	L	2730L	9	7	*Glyceria fluitans*	-0.03
	2	7	30	L	2730L	9	4	*Hygroamblystegium fluviatile/tenax*	-0.03
	2	7	30	L	2730L	9	3	*Fontinalis antipyretica*	-0.03
	2	7	30	M	2730M	9	6	*Glyceria fluitans*	-0.03
	2	7	30	R	2730R	9	1	*Glyceria fluitans*	-0.03
	2	7	34	L	2734L	9	0	NIL	-0.03
	2	7	34	M	2734M	9	5	*Myriophyllum verticillatum*	-0.03
	2	7	34	M	2734M	9	5	Tufted filamentous algae	-0.03
	2	7	34	M	2734M	9	2	*Glyceria fluitans*	-0.03
	2	7	34	R	2734R	9	14	*Hygroamblystegium fluviatile/tenax*	-0.03
	2	7	34	R	2734R	9	6	Tufted filamentous algae	-0.03
35-40m	2	8	37	L	2837L	7	<1	*Apium nodiflorum*	-0.009
	2	8	37	M	2837M	7	15	*Glyceria fluitans*	-0.009
	2	8	37	M	2837M	7	4	Tufted filamentous algae	-0.009
	2	8	37	M	2837M	7	4	*Hygroamblystegium fluviatile/tenax*	-0.009
	2	8	37	R	2837R	7	4	*Glyceria fluitans*	-0.009
	2	8	37	R	2837R	7	23	*Hygroamblystegium fluviatile/tenax*	-0.009
	2	8	37	R	2837R	7	10	Tufted filamentous algae	-0.009
	2	8	39	L	2839L	7	2	*Apium nodiflorum*	-0.009
	2	8	39	L	2839L	7	7	*Hygroamblystegium fluviatile/tenax*	-0.009
	2	8	39	L	2839L	7	1	Tufted filamentous algae	-0.009
	2	8	39	M	2839M	7	3	*Apium nodiflorum*	-0.009
	2	8	39	M	2839M	7	21	*Glyceria fluitans*	-0.009
	2	8	39	M	2839M	7	3	Tufted filamentous algae	-0.009
	2	8	39	M	2839M	7	2	*Hygroamblystegium fluviatile/tenax*	-0.009
	2	8	39	R	2839R	7	10	Tufted filamentous algae	-0.009
	2	8	39	R	2839R	7	2	Blanket filamentous algae	-0.009
	2	8	39	R	2839R	7	25	*Hygroamblystegium fluviatile/tenax*	-0.009
	2	8	35	L	2825L	7	2	*Glyceria fluitans*	-0.009
	2	8	35	M	2825M	7	2	*Glyceria fluitans*	-0.009
	2	8	35	M	2825M	7	6	*Hygroamblystegium fluviatile/tenax*	-0.009
	2	8	35	R	2825R	7	2	*Glyceria fluitans*	-0.009
	2	8	35	R	2825R	7	9	Tufted filamentous algae	-0.009
40-45m	2	9	40	L	2940L	4	50	*Glyceria fluitans*	0
	2	9	40	M	2940M	4	2	*Callitriche stagnalis*	0
	2	9	40	M	2940M	4	8	*Hygroamblystegium fluviatile/tenax*	0
	2	9	40	M	2940M	4	3	Tufted filamentous algae	0
	2	9	40	R	2940R	4	0	NIL	0
	2	9	43	L	2943L	4	4	*Glyceria fluitans*	0
	2	9	43	M	2943M	4	4	*Callitriche stagnalis*	0
	2	9	43	R	2943R	4	16	*Hygroamblystegium fluviatile/tenax*	0
	2	9	43	R	2943R	4	5	Tufted filamentous algae	0
	2	9	42	L	2942L	4	2	*Callitriche stagnalis*	0
	2	9	42	L	2942L	4	18	*Glyceria fluitans*	0
	2	9	42	L	2942L	4	100	Fine brown filamentous algae	0
	2	9	42	M	2942M	4	0	NIL	0
	2	9	42	R	2942R	4	1	*Hygroamblystegium fluviatile/tenax*	0
45-50m	2	10	47	L	21047L	4	1	*Apium nodiflorum*	0.099
	2	10	47	M	21047M	4	<1	Tufted filamentous algae	0.099
	2	10	47	M	21047M	4	22	*Callitriche stagnalis*	0.099
	2	10	47	M	21047M	4	5	*Apium nodiflorum*	0.099
	2	10	47	M	21047M	4	<1	*Fontinalis antipyretica*	0.099
	2	10	47	R	21047R	4	6	*Apium nodiflorum*	0.099
	2	10	47	R	21047R	4	1	*Glyceria fluitans*	0.099
	2	10	47	R	21047R	4	10	*Hygroamblystegium fluviatile/tenax*	0.099
	2	10	47	R	21047R	4	1	Tufted filamentous algae	0.099
	2	10	46	L	21046L	4	13	*Callitriche stagnalis*	0.099
	2	10	46	L	21046L	4	1	Tufted filamentous algae	0.099
	2	10	46	M	21046L	4	1	*Apium nodiflorum*	0.099
	2	10	47	M	21046L	4	10	Tufted filamentous algae	0.099
	2	10	47	R	21046R	4	10	*Apium nodiflorum*	0.099
	2	10	47	R	21046R	4	14	*Hygroamblystegium fluviatile/tenax*	0.099
	2	10	48	L	21048L	4	1	*Callitriche stagnalis*	0.099
	2	10	48	M	21048M	4	18	*Callitriche stagnalis*	0.099
	2	10	48	R	21048R	4	5	*Glyceria fluitans*	0.099

Distance	Reach	Section	Stretch	Position	Code	Bed score	% Coverage	Species	Corrected Slope (m/5m)
0-5m	1	1	4	L	114L	2	25	*Glyceria fluitans*	0.09
	1	1	4	L	114L	2	19	*Apium nodiflorum*	0.09
	1	1	4	L	114L	2	5	*Persicaria hydropiper*	0.09
	1	1	4	L	114L	2	40	*Myriophyllum alterniflorum*	0.09
	1	1	4	M	114M	2	12	*Glyceria fluitans*	0.09
	1	1	4	M	114M	2	26	*Callitriche stagnalis*	0.09
	1	1	4	M	114M	2	90	*Myriophyllum alterniflorum*	0.09
	1	1	4	R	114R	2	20	*Glyceria fluitans*	0.09
	1	1	4	R	114R	2	75	*Callitriche stagnalis*	0.09
	1	1	4	R	114R	2	10	*Myriophyllum alterniflorum*	0.09
	1	1	1	L	111L	2	15	*Apium nodiflorum*	0.09
	1	1	1	L	111L	2	18	*Oenanthe crocata*	0.09
	1	1	1	M	111M	2	10	*Oenanthe crocata*	0.09
	1	1	1	R	111R	2	16	*Glyceria fluitans*	0.09
	1	1	1	L	111R	2	10	*Callitriche stagnalis*	0.09
	1	1	1	M	111R	2	10	*Oenanthe crocata*	0.09
	1	1	2	L	112L	2	8	*Callitriche stagnalis*	0.09
	1	1	2	M	112M	2	0	NIL	0.09
	1	1	2	R	112R	2	30	*Callitriche stagnalis*	0.014
5-10m	1	2	9	L	129L	2	30	*Myriophyllum alterniflorum*	0.014
	1	2	9	L	129L	2	30	Tufted filamentous algae	0.014
	1	2	9	M	129M	2	8	*Callitriche stagnalis*	0.014
	1	2	9	M	129M	2	5	*Apium nodiflorum*	0.014
	1	2	9	R	129R	2	70	*Glyceria fluitans*	0.014
	1	2	9	R	129R	2	8	*Apium nodiflorum*	0.014
	1	2	9	R	129R	2	80	*Callitriche stagnalis*	0.014
	1	2	9	R	129R	2	10	*Myriophyllum alterniflorum*	0.014
	1	2	10	L	1210L	2	50	*Glyceria fluitans*	0.014
	1	2	10	L	1210L	2	8	*Callitriche stagnalis*	0.014
	1	2	10	L	1210L	2	100	Tufted filamentous algae	0.014
	1	2	10	M	1210M	2	2	*Oenanthe crocata*	0.014
	1	2	10	R	1210R	2	40	*Glyceria maxima*	0.014
	1	2	10	R	1210R	2	10	*Callitriche stagnalis*	0.014
	1	2	10	R	1210R	2	50	*Myriophyllum alterniflorum*	0.014
	1	2	7	L	127L	2	60	*Apium nodiflorum*	0.014
	1	2	7	L	127L	2	5	*Solanum dulcamara*	0.014
	1	2	7	L	127L	2	10	*Veronica beccabunga*	0.014
	1	2	7	L	127L	2	80	*Glyceria maxima*	0.014
	1	2	7	L	127L	2	20	*Glyceria fluitans*	0.014
	1	2	7	L	127L	2	10	*Callitriche stagnalis*	0.014
	1	2	7	M	127M	2	1	*Oenanthe crocata*	0.014
	1	2	7	R	127R	2	5	*Callitriche stagnalis*	0.014
	1	2	7	R	127R	2	30	*Glyceria fluitans*	0.014
	1	2	7	R	127R	2	90	*Myriophyllum alterniflorum*	0.014
10-15m	1	3	15	L	1315L	5	40	*Oenanthe crocata*	-0.009
	1	3	15	L	1315L	5	5	*Callitriche stagnalis*	-0.009
	1	3	15	M	1315M	5	0	NIL	-0.009
	1	3	15	R	1315R	5	15	*Oenanthe crocata*	-0.009
	1	3	14	R	1314R	5	50	*Oenanthe crocata*	-0.009
	1	3	14	M	1314M	5	0	NIL	-0.009
	1	3	14	R	1314R	5	18	*Oenanthe crocata*	-0.009
	1	3	14	R	1314R	5	3	*Callitriche stagnalis*	-0.009
	1	3	13	L	1313L	5	10	*Callitriche stagnalis*	-0.009
	1	3	13	M	1313M	5	12	*Callitriche stagnalis*	-0.009
	1	3	13	M	1313M	5	8	Tufted filamentous algae	-0.009
	1	3	13	M	1313M	5	1	*Persicaria hydropiper*	-0.009
	1	3	13	R	1313R	5	15	*Callitriche stagnalis*	-0.009
	1	3	13	R	1313R	5	12	*Myriophyllum alterniflorum*	-0.009
	1	3	13	R	1313R	5	4	Tufted filamentous algae	-0.009

Distance	Reach	Section	Stretch	Position	Code	Bed score	% Coverage	Species	Corrected Slope (m/5m)
15-20m	1	4	19	L	1419L	6	100	*Glyceria maxima*	-0.0104
	1	4	19	L	1419L	6	2	*Stellaria aquatica*	-0.0104
	1	4	19	L	1419L	6	11	*Callitriche stagnalis*	-0.0104
	1	4	19	M	1419M	6	100	*Dactylis glomerata*	-0.0104
	1	4	19	M	1419M	6	15	*Oenanthe crocata*	-0.0104
	1	4	19	R	1419R	6	100	*Oenanthe crocata*	-0.0104
	1	4	17	L	1417L	6	12	*Myosotis scorpioides*	-0.0104
	1	4	17	L	1417L	6	1	*Veronica beccabunga*	-0.0104
	1	4	17	L	1417L	6	90	*Oenanthe crocata*	-0.0104
	1	4	17	L	1417L	6	10	*Callitriche stagnalis*	-0.0104
	1	4	17	L	1417L	6	6	*Glyceria fluitans*	-0.0104
	1	4	17	M	1417M	6	100	*Oenanthe crocata*	-0.0104
	1	4	17	M	1417M	6	16	*Glyceria maxima*	-0.0104
	1	4	18	L	1418L	6	100	*Glyceria fluitans*	-0.0104
	1	4	18	L	1418L	6	8	*Callitriche stagnalis*	-0.0104
	1	4	18	M	1418M	6	6	*Oenanthe crocata*	-0.0104
	1	4	18	R	1418R	6	18	*Oenanthe crocata*	-0.0104
	1	4	18	R	1418M	6	6	*Glyceria fluitans*	-0.0104
20-25m	1	5	21	L	1521L	6	90	*Oenanthe crocata*	-0.026
	1	5	21	L	1521L	6	5	*Glyceria fluitans*	-0.026
	1	5	21	M	1521M	6	80	*Oenanthe crocata*	-0.026
	1	5	21	M	1521M	6	14	*Callitriche stagnalis*	-0.026
	1	5	21	R	1521R	6	32	*Oenanthe crocata*	-0.026
	1	5	21	R	1521R	6	15	*Glyceria maxima*	-0.026
	1	5	22	L	1522L	6	100	*Oenanthe crocata*	-0.026
	1	5	22	M	1522M	6	100	*Oenanthe crocata*	-0.026
	1	5	22	R	1522R	6	100	*Oenanthe crocata*	-0.026
	1	5	25	L	1525L	6	60	*Oenanthe crocata*	-0.026
	1	5	25	L	1525L	6	50	*Glyceria fluitans*	-0.026
	1	5	25	M	1525M	6	37	*Oenanthe crocata*	-0.026
	1	5	25	M	1525M	6	14	*Glyceria fluitans*	-0.026
	1	5	25	R	1525R	6	4	*Oenanthe crocata*	-0.026
	1	5	25	R	1525R	6	2	*Callitriche stagnalis*	-0.026
	1	6	27	L	1627L	8	0	NIL	-0.007
25-30m	1	6	27	M	1627M	8	4	*Oenanthe crocata*	-0.007
	1	6	27	R	1627R	8	60	*Callitriche stagnalis*	-0.007
	1	6	28	L	1628L	8	0	NIL	-0.007
	1	6	28	M	1628M	8	0	NIL	-0.007
	1	6	28	R	1628R	8	19	*Callitriche stagnalis*	-0.007
	1	6	28	R	1628R	8	5	*Glyceria fluitans*	-0.007
	1	6	29	L	1629L	8	3	*Lotus pedunculatus*	-0.007
	1	6	29	L	1629L	8	55	*Callitriche stagnalis*	-0.007
	1	6	29	L	1629L	8	100	*Glyceria fluitans*	-0.007
	1	6	29	M	1629M	8	60	Tufted filamentous algae	-0.007
	1	6	29	M	1629M	8	23	*Hygroamblystegium fluviatile/tenax*	-0.007
	1	6	29	M	1629M	8	8	*Oenanthe crocata*	-0.007
	1	6	29	R	1629R	8	12	*Callitriche stagnalis*	-0.007
	1	6	29	R	2837R	8	11	*Myriophyllum alterniflorum*	-0.007
	1	7	30	L	1730L	7	0	NIL	0.006
30-35m	1	7	30	M	1730M	7	12	*Hygroamblystegium fluviatile/tenax*	0.006
	1	7	30	M	1730M	7	7	Tufted filamentous algae	0.006
	1	7	30	R	1730R	7	10	*Callitriche stagnalis*	0.006
	1	7	30	R	1730R	7	28	*Glyceria fluitans*	0.006
	1	7	30	R	1730R	7	90	*Hygroamblystegium fluviatile/tenax*	0.006
	1	7	31	L	1731L	7	9	*Glyceria fluitans*	0.006
	1	7	31	M	1731M	7	3	*Hygroamblystegium fluviatile/tenax*	0.006
	1	7	31	R	1731R	7	6	*Oenanthe crocata*	0.006
	1	7	31	R	1731R	7	26	*Hygroamblystegium fluviatile/tenax*	0.006
	1	7	32	L	1732L	7	27	*Myriophyllum verticillatum*	0.006
	1	7	32	M	1732M	7	100	*Myriophyllum verticillatum*	0.006
	1	7	32	R	1732M	7	14	*Callitriche stagnalis*	0.006
	1	7	32	R	1732M	7	7	*Glyceria fluitans*	0.006
	1	8	35	L	1835L	6	12	*Glyceria fluitans*	-0.018
35-40m	1	8	35	M	1835M	6	16	*Hygroamblystegium fluviatile/tenax*	-0.018
	1	8	35	R	1835R	6	28	*Hygroamblystegium fluviatile/tenax*	-0.018
	1	8	40	L	1840L	6	11	*Oenanthe crocata*	-0.018
	1	8	40	L	1840L	6	21	*Glyceria fluitans*	-0.018
	1	8	40	M	1840M	6	100	*Oenanthe crocata*	-0.018
	1	8	40	R	1840R	6	48	*Oenanthe crocata*	-0.018
	1	8	40	R	1840R	6	18	*Hygroamblystegium fluviatile/tenax*	-0.018
	1	8	39	L	1839L	6	14	*Glyceria fluitans*	-0.018
	1	8	39	L	1839L	6	3	*Oenanthe crocata*	-0.018
	1	8	39	M	1839M	6	100	*Oenanthe crocata*	-0.018
	1	8	39	R	1839R	6	55	*Oenanthe crocata*	-0.018
	1	8	39	R	1839R	6	40	*Hygroamblystegium fluviatile/tenax*	-0.018

Distance	Reach	Section	Stretch	Position	Code	Bed score	% Coverage	Species	Corrected Slope (m/5m)
40-45m	1	9	42	L	1942L	8	90	*Callitriche stagnalis*	-0.0146
	1	9	42	L	1942L	8	22	*Glyceria fluitans*	-0.0146
	1	9	42	M	1942M	8	7	Tufted filamentous algae	-0.0146
	1	9	42	R	1942R	8	27	*Veronica beccabunga*	-0.0146
	1	9	42	R	1942R	8	30	*Callitriche stagnalis*	-0.0146
	1	9	42	R	1942R	8	13	*Glyceria fluitans*	-0.0146
	1	9	42	R	1942R	8	6	*Oenanthe crocata*	-0.0146
	1	9	45	L	1945L	8	11	*Glyceria fluitans*	-0.0146
	1	9	45	L	1945L	8	6	*Hygroamblystegium fluviatile/tenax*	-0.0146
	1	9	45	L	1945L	8	11	*Apium nodiflorum*	-0.0146
	1	9	45	M	1945M	8	13	*Callitriche stagnalis*	-0.0146
	1	9	45	R	1945R	8	100	*Glyceria fluitans*	-0.0146
	1	9	44	L	1944L	8	83	*Glyceria fluitans*	-0.0146
	1	9	44	L	1944L	8	23	*Callitriche stagnalis*	-0.0146
	1	9	44	M	1944M	8	1	*Hygroamblystegium fluviatile/tenax*	-0.0146
	1	9	44	R	1944R	8	100	*Glyceria fluitans*	-0.0146
	1	9	44	R	1944R	8	13	*Myriophyllum verticillatum*	-0.0146
	1	9	44	R	1944R	8	12	*Callitriche stagnalis*	-0.0146
	1	9	44	R	1944R	8	5	*Myriophyllum alterniflorum*	-0.0146
45-50m	1	10	49	L	11049L	7	28	*Callitriche stagnalis*	0.0146
	1	10	49	M	11049M	7	0	NIL	0.0146
	1	10	49	R	11049R	7	1	*Glyceria fluitans*	0.0146
	1	10	49	R	11049R	7	19	Blanket filamentous algae	0.0146
	1	10	46	L	11046L	7	35	*Glyceria fluitans*	0.0146
	1	10	46	L	11046L	7	14	*Callitriche stagnalis*	0.0146
	1	10	46	L	11046L	7	2	Blanket filamentous algae	0.0146
	1	10	46	M	11046M	7	6	*Glyceria fluitans*	0.0146
	1	10	46	M	11046M	7	8	*Callitriche stagnalis*	0.0146
	1	10	46	M	11046M	7	24	*Myriophyllum verticillatum*	0.0146
	1	10	46	M	11046M	7	8	*Hygroamblystegium fluviatile/tenax*	0.0146
	1	10	46	R	11046R	7	100	*Glyceria fluitans*	0.0146
	1	10	46	R	11046R	7	95	*Callitriche stagnalis*	0.0146
	1	10	47	L	11047L	7	63	*Glyceria fluitans*	0.0146
	1	10	47	L	11047L	7	32	*Callitriche stagnalis*	0.0146
	1	10	47	L	11047L	7	6	Blanket filamentous algae	0.0146
	1	10	47	M	11047M	7	15	*Apium nodiflorum*	0.0146
	1	10	47	M	11047M	7	3	*Glyceria fluitans*	0.0146
	1	10	47	M	11047M	7	3	*Oenanthe crocata*	0.0146
	1	10	47	M	11047M	7	10	*Hygroamblystegium fluviatile/tenax*	0.0146
	1	10	47	M	11047M	7	10	Tufted filamentous algae	0.0146
	1	10	47	R	11047R	7	95	*Glyceria fluitans*	0.0146
	1	10	47	R	11047R	7	46	*Callitriche stagnalis*	0.0146
	1	10	47	R	11047R	7	4	Tufted filamentous algae	0.0146

LEAFPACS2 predicted (Exp) values for RMNI, NTAXA NFG and ALG, together with final EQR and WFD class for Historic EA sample data taken from St Clether Bridge and Current data taken from Upstream2018, Upstream2019, Upstream/Downstream29019 and Downstream2019.
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Site	Survey date	Exp RMNI score	Exp NTAXA	Exp NFG	raw RMNI EQR	raw NTAXA EQR	raw NFG EQR	raw ALG EQR	adj RMNI EQR	min diversity EQR	adj diversity EQR	adj ALG EQR	interim EQR	weight alg	final EQR	CLASS
StC2011	03/08/2011	5.26	6.8	4.4	1.0	2.1	1.3	1.0	0.9	1.3	1.4	0.9	0.9	0.6	0.9	***High***
StC2013	02/08/2013	5.26	6.8	4.4	1.0	2.1	1.6	1.0	1.0	1.6	1.7	1.0	1.0	0.6	1.0	***High***
StC2014	01/07/2014	5.26	6.8	4.4	0.9	2.1	1.6	1.0	0.9	1.6	1.7	0.9	0.9	0.6	0.9	***High***
US2018	05/07/2018	4.22	4.9	3.4	0.7	1.8	2.1	1.0	0.6	1.8	2.0	1.0	0.6	0.0	0.6	**Good**
US2019	22/07/2019	4.22	4.9	3.4	0.6	1.4	1.5	1.0	0.5	1.4	1.5	0.7	0.5	0.0	0.5	**Moderate**
DS2019	21/06/2019	4.49	5.0	3.4	0.6	1.4	1.5	1.0	0.5	1.4	1.5	0.9	0.5	0.1	0.5	**Moderate**
100m USDS 2019	21/06/2019	4.37	5.0	3.4	0.6	1.6	1.5	1.0	0.5	1.5	1.6	0.9	0.5	0.0	0.5	**Moderate**

LEAFPACS2 confidence in modelled calculation for WFD status class for the site. Contains UKTAG information © UKTAG and database right Data from data.gov.uk, Open Government Licence.

Site Details							Confidence of Class				
Water Body	**SITE ID**	**mean EQR**	**n surveys**	**final EQR capped**	**Modelled Standard Error**	**Class**	**Bad**	**Poor**	**Moderate**	**Good**	**High**
River Inny	St Clether Bridge	0.943	3	0.943	*0.017*	***High***	0.0	0.0	0.0	0.0	100.0
River Inny	US	0.533	2	0.533	*0.056*	***Moderate***	0.0	0.9	87.7	11.4	0.0
River Inny	DS	0.486	1	0.486	*0.083*	***Moderate***	14.7	77.0	8.3	N/A	N/A
River Inny	Combined	0.483	1	0.483	*0.083*	***Moderate***	0.0	15.6	76.6	7.8	0.0

Appendix 6

Ecotoxicology NaCl range test experiment data

Exposure (mg NaCl L^{-1})	Exposure time (h)	Temp (^oC)	Conductivity (µS cm^{-1})	Salinity (PSU)	DO (mg L^{-1})	DO (% ASV)	pH	**Cumulative response (immobilisation)**	Percent cumulative response
0	0	15.0	127	0	8.06	80.5	6.18		
	24	14.7	130	0	7.13	69.5	6.31		
(n=0 reps)	48	14.7	132	0	7.05	68.9	6.61		
	72								
1000	0	15.1	2120	0.9	8.01	79.0	6.7		
	24	14.7	2120	0.9	6.62	65.3	6.69		
(n=0 reps)	48	14.7	2130	0.9	7.14	70.7	6.74		
	72								
2500	0	15.1	4880	2.5	8.01	80.2	6.84		
	24	14.7	4920	2.6	6.87	67.4	6.96		
(n=0 reps)	48	14.7	4940	2.6	7.14	70.5	6.43		
	72								
3500	0	15.1	6700	3.6	7.93	78.4	6.89		
	24	14.7	6730	3.6	6.54	64.6	6.96		
(n=0 reps)	48	14.7	6770	3.6	6.82	67.4	6.98		
	72							1	20
5000	0	15.1	9330	5.2	8.00	80.6	6.89		
	24	14.7	9380	5.2	7.01	68.7	7.03		
(n=0 reps)	48	14.7	9430	5.2	70.4	70.4	6.97	4	80
	72								
10000	0	15.2	17740	10.4	8.04	79.8	6.88		
	24	14.7	17800	10.4	7.02	69.0	7.08	5	100
(n=0 reps)	48	14.7	17940	10.5	7.14	70.5	6.90	5	100
	72							5	100

Dilution water = synthetic river water based on ASTM (1980) and Rowett et al (2016).

Ecotoxicology NaCl experiment data

Parameter	Time	Temp	COND	Salinity	DO	DO	Ph	Mortality (individuals)		Mortality
								Total	**Cumulative**	as % of
Conc.	hrs	°C	µs cm^{-1}		ppm	%		**mortality**	**mortality**	dwc
0	0	15.1	135.0	0	7.00	6.03	6.03	**0**	**0**	0
	24	14.8	138.6	0	6.34	6.61	6.61	**2**	**2**	10
	48	15.1	138.6	0	7.16	5.88	5.88	**0**	**2**	10
	96	14.7	134.6	0	8.01	79.40	6.01	**2**	**4**	20
10	0	15.2	153.1	0	6.25	62.90	6.04	**0**	**0**	0
	24	14.9	153.5	0	6.35	62.50	6.63	**0**	**0**	0
	48	15	153.8	0	7.08	70.60	5.87	**0**	**0**	0
	96	14.7	153.3	0	7.81	75.70	6.07	**0**	**0**	0
25	0	15.2	186.7	0	5.90	58.60	6.11	**0**	**0**	0
	24	14.9	187.5	0	6.51	64.90	6.61	**1**	**1**	5
	48	14.9	187.6	0	7.04	69.40	6.16	**0**	**1**	5
	96	14.7	180.5	0	6.97	69.00	6.15	**0**	**1**	5
50	0	15.2	235.0	0	6.84	69.00	6.80	**0**	**0**	0
	24	15.1	236.0	0	6.48	64.00	6.61	**0**	**0**	0
	48	14.9	236.0	0	6.50	64.70	6.44	**0**	**0**	0
	96	14.8	230.0	0	7.35	72.10	6.26	**1**	**1**	5
100	0	15.2	316.0	0	6.63	65.60	6.85	**0**	**0**	0
	24	15.0	316.0	0	6.35	63.40	6.62	**0**	**0**	0
	48	14.9	316.0	0	6.69	65.70	6.40	**0**	**0**	0
	96	14.7	322.0	0	7.32	72.90	6.36	**2**	**2**	10
250	0	15.1	614.0	0	6.71	67.40	6.94	**0**	**0**	0
	24	15.0	616.0	0	6.01	59.30	6.62	**19**	**19**	95
	48	15.0	618.0	0	6.50	64.90	6.46	**1**	**20**	100
	96	14.7	619.0	0	7.71	75.10	6.41	**0**	**20**	100
$ZnSO_4$	0	15.1	143.2	0	7.23	72.10	6.64	**0**	**0**	0
	24	15.1	147.6	0	6.25	62.30	6.46	**5**	**5**	33
	48	14.8	149.0	0	6.50	63.90	6.47	**8**	**13**	87
	96	14.7	150.9	0	7.32	72.40	6.44	**2**	**15**	100

Ecotoxicology KCl range test experiment data

Exposure (mg KCl L^{-1})	Exposure time (h)	Temp (^{O}C)	Conductivity (µS cm-1)	Salinity (PSU)	DO (mg L^{-1})	DO (% ASV)	Ph	Cumulative response (immobilisation)	Percent cumulative response
dwc	0	15.1	143.3	0.0	7.9	78.1	5.6		
0	24	15.1	148.3	0.0	6.4	63.9	6.2		
(n=4 reps)	48	14.8	152.0	0.0	5.6	55.8	6.3	1	5%
100	0	15.1	338.5	0.0	7.9	77.9	5.9		
(n=4 reps)	24	15.0	342.8	0.0	6.0	59.0	6.6		
	48	15.0	347.5	0.0	5.3	52.6	6.6	4	20%
250	0	15.1	620.5	0.0	7.2	71.3	6.1		
(n=4 reps)	24	14.8	627.0	0.0	6.0	59.6	6.8		
	48							20	100%
500	0	6.3	1092.5	0.3	6.9	68.4	6.3		
(n=4 reps)	24	6.9	1100.8	0.3	5.7	55.9	6.9		
	48							20	100%
750	0	5.0	1556.3	0.6	6.7	66.5	6.4		
(n=4 reps)	24	5.0	1328.0	0.5	5.7	56.4	7.0		
	48							20	100%
1000	0	15.0	2012.5	0.8	6.6	65.7	6.5		
(n=4 reps)	24	14.8	2027.5	0.9	5.6	55.5	7.0		
	48							20	100%
ZnSO4	0	15.0	150.8	0.0	7.6	75.1	6.2		
(n=3 reps)	24	14.9	155.9	0.0	6.1	59.9	6.7	8	53%
	48	14.9	161.0	0.0	4.7	47.3	6.6	8	53%

Ecotoxicology KCl experiment data

Exposure (mg KCl L^{-1})	Exposure time (h)	Temp (°C)	Conductivity (µS cm^{-1})	Salinity (PSU)	DO (mg L^{-1})	DO (% ASV)	pH	Cumulative response (immobilisation)	Percent cumulative response
0	0	15.1	135.0	0	7.00	68.80	6.03		
	24	14.8	138.6	0	6.34	62.90	6.61	2	10
(n=4 reps)	48	15.1	138.6	0	7.16	70.90	5.88	2	10
	96	14.7	134.6	0	8.01	79.40	6.01	4	20
10	0	15.2	153.1	0	6.25	62.90	6.04		
	24	14.9	153.5	0	6.35	62.50	6.63		
(n=4 reps)	48	15	153.8	0	7.08	70.60	5.87	0	0
	96	14.7	153.3	0	7.81	75.70	6.07	0	0
25	0	15.2	186.7	0	5.90	58.60	6.11		
	24	14.9	187.5	0	6.51	64.90	6.61	1	5
(n=4 reps)	48	14.9	187.6	0	7.04	69.40	6.16	1	5
	96	14.7	180.5	0	6.97	69.00	6.15	1	5
50	0	15.2	235.0	0	6.84	69.00	6.80		
	24	15.1	236.0	0	6.48	64.00	6.61		
(n=4 reps)	48	14.9	236.0	0	6.50	64.70	6.44	0	0
	96	14.8	230.0	0	7.35	72.10	6.26	1	5
100	0	15.2	316.0	0	6.63	65.60	6.85		
	24	15.0	316.0	0	6.35	63.40	6.62		
(n=4 reps)	48	14.9	316.0	0	6.69	65.70	6.40	0	0
	96	14.7	322.0	0	7.32	72.90	6.36	2	10
250	0	15.1	614.0	0	6.71	67.40	6.94		
	24	15.0	616.0	0	6.01	59.30	6.62	4	20
(n=4 reps)	48	15.0	618.0	0	6.50	64.90	6.46	20	100
	96	14.7	619.0	0	7.71	75.10	6.41	20	100
$ZnSO_4$	0	15.1	143.2	0	7.23	72.10	6.64		
(10 mg Zn L^{-1})	24	15.1	147.6	0	6.25	62.30	6.46	5	33
(n=3 reps)	48	14.8	149.0	0	6.50	63.90	6.47	12	80
	96	14.7	150.9	0	7.32	72.40	6.44	15	100

Dilution water = synthetic river water based on ASTM (1980) and Rowett et al (2016).

Appendix 7

SIMCAT model data file for generating K model based on 12 month mean concentration data using 0.07 mg L^{-1} laboratory derived EQS.

```
=================================================================
====
======== SIMCAT data file: K_12 month_mean_SAPFLO.DAT
=================================================================
====
======= Lines beginning with '====' are notes explaining the       =
======= data. These notes are not used by SIMCAT and may be        =
======= removed from the data-file if not needed....               =
=======                                                            =
======= The following sets of data (Data-Sets) are required:       =
=======            [a] General;                                    =
=======            [b] Determinands;                               =
=======            [c] Reaches;                                    =
=======            [d] River Flow;                                 =
=======            [e] River Quality;                              =
=======            [f] Effluent Flow & Quality;                    =
=======            [h] River Quality Targets;                      =
=======            [i] Intermittent Discharges;                    =
=======            [j] Features.                                   =
=======                                                            =
======= For sets [d],[e] and [f] extra data will need to be        =
======= appended if the more unusual distributions are selected.   =
=======                                                            =
======= In the following notes the term, River Chemistry,          =
======= refers to the effect of the fixed set of Rate Constants    =
======= defined below in the Data-Sets for Determinands and        =
======= Reaches. These can be used with the equations written into =
======= SIMCAT to model changes in river quality.                  =
=======                                                            =
```

======= Additionally, or alternatively, changes in river =

======= quality are handled by Auto-Calibration (AC). =

===
====

===
====

======= A descriptive title follows... =

===
====

Inny Potassium Analysis

####

===
====

========[a] General
===

===
====

======= The next 3 variables can be zero or 1 =

===
====

0 set to 1 to exclude confidence limits from output;

0 set to 1 to exclude tables of input data;

0 set to 1 to exclude output for non-effluent features;

===
=====

======= In Mean Mode the calculated values of the mean river quality=

======= will be output to the screen and the River Targets entered =

======= as Set [h] are taken as averages.... =

======= In 95-percentile Mode the calculated values of =

======= 95-percentiles will be output to the screen and the River =

======= Targets (Set [h]) will be taken as 95-percentiles.... =

======= In 90-percentile Mode the calculated values of =

======= 90-percentiles will be output to the screen and the River =

```
======= Targets (Set [h]) will be taken as 90-percentiles....       =
================================================================
=====
   1    set to 1 for mean mode, zero for 95-percentile mode; or
======= 2 for 90-percentile mode;
 365  number of shots (minimum is 5; maximum is 2500);
  10.9    3.5    0.6 river water temperature - mean,SD,correlation.
 'm3/s' units for river and effluent flow (4 characters in quotes)
================================================================
====
   1    set to 1 to insert Diffuse Sources;
   1    set to 1 to include River Chemistry;
   0    set to 1 for Auto-Interpolation;
================================================================
====
========[b] Determinand
============================================
================================================================
====
======= The code number for each determinand is defined by its     =
======= order in the list. There is one line of data for           =
======= each determinand. Each line holds the following:           =
=======  (a) defines the type of determinand and the method of     =
=======      handling River Chemistry and Auto-Calibration (AC);   =
=======      The types are:                                        =
=======        1: the determinand is Conservative; also, all       =
=======           the corrections calculated by AC will be         =
=======           applied as a linear function of river length;    =
=======        2: losses calculated by AC will be applied as an    =
=======           exponential function of river length; gains      =
=======           will be linear;                                  =
=======        3: Dissolved Oxygen; it is assumed that the         =
```

```
=======          second and third pollutants in the list are      =
=======          BOD and Ammonia respectively; the AC            =
=======          corrections are as for type 2;                  =
=======       4: (or any other number) the determinand will be    =
=======          excluded from the run.                          =
======= (b) the name of the determinand;                         =
======= (c) the short name for the determinand;                  =
=======     The names BOD, DO, DOX, AMM, NH4 and NH4 are special  =
=
=======     and trigger the hard wired decay rates and temperature=
=======     coeffiecients for BOD, Dissolved Oxygen and Ammonia   =
======= (d) the unit of measurement;                             =
======= (e) the global rate constant (reciprocal days);          =
======= (f) the minimum quality achievable by exponential        =
=======     decay with above rate constants listed under (c);    =
======= (g) the quality of the diffuse inflows added by AC       =
=======     when fitting river flows;                            =
======= (h) the minimum quality allowed by extrapolation of      =
=======     the extra exponential decay introduced by AC;        =
======= The following variables (h),(i) and (j) are used as      =
======= constraints by Modes 7 & 8; all are 95-percentile        =
======= concentrations; enter zero if not needed:                =
======= In Mean Mode they are means...                           =
======= (i) the worst permissible effluent quality;              =
======= (j) the best feasible effluent quality; and,             =
======= (k) a definition of good effluent quality.               =
=======b==========c======d=====e=======f=====g=====h======i=====
===j======k====
2   'K'       ' K'   'mg/l' 0.00    0.0   0.0   0.0 99999.00   0.00    0.00
4   'BOD'     ' BOD' 'ug/l' 0.00    0.0   0.0   0.0 99999.00   0.00    0.00
2   'SRP'     ' SRP' 'ug/l' 0.00    0.0   0.0   0.0 99999.00   0.00   36.00
```

```
4    'Diss Oxy'  ' DO'  'ug/l' 0.00    0.0   0.0   0.0     1.00  10.00    9.00
*************** indicator of end of determinand data ***************
=================================================================
====
========[c] Reaches
=================================================
=================================================================
====
======= Data on river Reaches follow ...                         =
=================================================================
====
======= For each Reach the following are given:                  =
=======  (a) the code number;                                    =
=======  (b) the name;                                           =
=======  (c) length (km);                                        =
=======  (d) defines the next downstream reach                   =
=======  (e,f) are dummy values used in an earlier Simcat version  =
=======  (g) the flow data-set for any diffuse inflow;           =
=======  (h) the quality data-set for these diffuse inflows;     =
=======  (i) term a for velocity/discharge relation;             =
=======  (j) term b for velocity/discharge relation;             =
=======  The following rate constants, if non-zero, replace the    =
=======  global values given in the determinand data (at (c)).     =
=======  To replace the global value with zero enter '-1.0';       =
=======  (k) the rate constant for the decay of the BOD;           =
=======  (l) the reaeration constant for Dissolved Oxygen;         =
=======  (m) the rate constant for the loss of Ammonia.            =
=======  (n,o) y and x positions of reach symbol on schematic      =
=======  (p,q) y and x positions of end of last reach symbol on schematic
========b=================c====d===e===f===g===h===i===j====k====
=l=====m=====n======o======p======q===
  1 'Tamar1'             7.2   2   x   x  31  57  0.1 0.7  0.03 0.525  0.00  0.050  0.910
```

20	'Lamberal Water'	9.0	2	x	x	31	57	0.2	0.5	0.075	0.38	0.00	0.050	0.880
2	'Tamar2'	3.8	3	x	x	31	57	0.1	0.7	0.075	0.525	0.00	0.115	0.895
21	'Small Brook'	5.2	3	x	x	31	57	0.2	0.5	0.11	0.70	0.00	0.115	0.850
3	'Tamar3'	9.2	4	x	x	31	57	0.1	0.7	0.11	0.525	0.00	0.185	0.875
22	'Derrill Water1'	3.7	23	x	x	31	57	0.2	0.5	0.16	0.765	0.00	0.115	0.820
24	'Pyworthy Br'	1.0	23	x	x	31	57	0.2	0.5	0.205	0.655	0.00	0.115	0.785
23	'Derrill Water2'	4.0	4	x	x	31	57	0.2	0.5	0.16	0.655	0.00	0.185	0.800
4	'Tamar4'	1.9	5	x	x	32	55	0.1	0.7	0.16	0.525	0.00	0.250	0.840
25	'Well Fm Trib'	0.4	5	x	x	32	55	0.2	0.5	0.205	0.405	0.00	0.250	0.755
5	'Tamar5'	0.5	6	x	x	32	55	0.1	0.7	0.205	0.525	0.00	0.315	0.795
26	'Deer1'	1.0	27	x	x	32	55	0.3	0.6	0.245	0.815	0.00	0.250	0.725
28	'Coles Mill Str'	3.5	27	x	x	32	55	0.3	0.6	0.305	0.745	0.00	0.250	0.690
27	'Deer2'	8.0	6	x	x	32	55	0.3	0.6	0.245	0.745	0.00	0.315	0.710
6	'Tamar6'	0.9	7	x	x	32	55	0.1	0.7	0.245	0.525	0.00	0.385	0.750
29	'River Claw'	8.2	7	x	x	32	55	0.2	0.5	0.29	0.695	0.00	0.385	0.660
7	'Tamar7'	12.5	8	x	x	33	55	0.1	0.7	0.29	0.525	0.00	0.450	0.705
30	'Ottery1'	4.4	31	x	x	34	58	0.1	0.6	0.34	0.17	0.00	0.250	0.630
34	'Can Water'	4.6	31	x	x	34	58	0.1	0.6	0.40	0.26	0.00	0.250	0.600
31	'Ottery2'	7.3	32	x	x	34	58	0.1	0.6	0.34	0.26	0.00	0.315	0.615
35	'Caudworthy Water'	9.8	32	x	x	34	58	0.1	0.6	0.255	0.35	0.00	0.315	0.565
32	'Ottery3'	2.5	33	x	x	34	58	0.1	0.6	0.34	0.35	0.00	0.385	0.590
36	'Bolesbridge W.'	8.6	33	x	x	34	58	0.1	0.6	0.265	0.445	0.00	0.385	0.535
33	'Ottery4'	6.7	8	x	x	34	58	0.1	0.6	0.34	0.445	0.00	0.450	0.560
8	'Tamar8'	1.0	9	x	x	33	55	0.1	0.7	0.34	0.525	0.00	0.515	0.635
37	'Carey1'	3.0	38	x	x	35	55	0.3	0.3	0.405	0.875	0.00	0.385	0.505
40	'Halwill Stream'	2.6	38	x	x	35	55	0.3	0.3	0.465	0.765	0.00	0.385	0.470
38	'Carey2'	5.0	39	x	x	35	55	0.3	0.3	0.405	0.765	0.00	0.450	0.490
41	'Ashwater NS'	0.7	39	x	x	35	55	0.3	0.3	0.335	0.685	0.00	0.450	0.440
39	'Carey3'	12.2	9	x	x	35	55	0.3	0.3	0.405	0.685	0.00	0.515	0.465
9	'Tamar9'	0.9	10	x	x	33	55	0.1	0.7	0.405	0.525	0.00	0.585	0.550

42 'River Kensey' 5.9 10 x x 36 62 0.2 0.6 0.46 0.41 0.00 0.585 0.410

10 'Tamar10' 3.1 11 x x 37 55 0.1 0.7 0.46 0.525 0.00 0.650 0.480

43 'Lyd1' 9.2 44 x x 38 60 0.2 0.6 0.59 0.875 0.00 0.450 0.380

47 'River Lew' 9.4 44 x x 38 60 0.2 0.6 0.505 0.75 0.00 0.450 0.345

44 'Lyd2' 2.0 45 x x 38 60 0.2 0.6 0.59 0.75 0.00 0.515 0.360

48 'Quither Br' 6.9 45 x x 38 60 0.2 0.6 0.66 0.685 0.00 0.515 0.315

45 'Lyd3' 4.0 46 x x 38 60 0.2 0.6 0.59 0.685 0.00 0.585 0.340

49 'Thrushel1' 7.8 50 x x 39 59 0.2 0.4 0.44 0.61 0.00 0.450 0.285

52 'Thrushel Str' 3.1 50 x x 39 59 0.2 0.4 0.50 0.685 0.00 0.450 0.250

50 'Thrushel2' 5.2 51 x x 39 59 0.2 0.4 0.50 0.61 0.00 0.515 0.265

53 'River Wolf' 10.8 51 x x 39 59 0.2 0.4 0.55 0.555 0.00 0.515 0.220

51 'Thrushel3' 1.9 46 x x 39 59 0.2 0.4 0.55 0.615 0.00 0.585 0.245

46 'Lyd4' 3.0 11 x x 38 60 0.2 0.6 0.59 0.615 0.00 0.650 0.290

11 'Tamar11' 6.0 12 x x 37 55 0.1 0.7 0.59 0.525 0.00 0.715 0.385

54 'Lowley Brook' 10.2 12 x x 37 55 0.2 0.5 0.645 0.37 0.00 0.715 0.190

12 'Tamar12' 2.8 13 x x 37 55 0.1 0.7 0.645 0.525 0.00 0.785 0.285

55 'Inny1' 17.88 56 x x 40 61 0.5 0.4 0.68 0.295 0.00 0.715 0.155

57 'Penpont Water' 14.68 56 x x 40 61 0.5 0.4 0.725 0.43 0.00 0.715
0.125

56 'Inny2' 15.0 13 x x 40 61 0.5 0.4 0.68 0.43 0.00 0.785 0.140

13 'Tamar13' 1.9 14 x x 37 55 0.1 0.7 0.68 0.525 0.00 0.850 0.215

58 'Milton Abbott St' 2.1 14 x x 37 55 0.2 0.5 0.725 0.715 0.00 0.850 0.095

14 'Tamar14' 6.3 15 x x 37 55 0.1 0.7 0.725 0.525 0.00 0.915 0.155

59 'Luckett1' 2.0 60 x x 37 55 0.2 0.5 0.775 0.275 0.00 0.850 0.065

61 'Stoke Water' 2.0 60 x x 37 55 0.2 0.5 0.71 0.365 0.00 0.850 0.030

60 'Luckett2' 3.0 15 x x 37 55 0.2 0.5 0.775 0.365 0.00 0.915 0.045

15 'Tamar15' 6.7 0 x x 41 55 0.1 0.7 0.775 0.525 0.955 0.985 0.100
1.050 0.100

***************** indicator of end of Reach data ******************

=======[d] River Flow ==

```
=================================================================
====
======= The River Flow Data-Sets follow:                    =
======= One line for each data-set: For each line:            =
=======  (a) the code number of the data-set;                 =
=======  (b) the code number of type of distribution:          =
=======     for Feature types 7 and 9: zero, 1 or 2;           =
=======       0 - constant, uniform flow;                    =
=======       1 - flow follows the Normal Distribution;        =
=======       2 - the Log-Normal Distribution;               =
=======       3 - a Three-Parameter Log-Normal Distribution;     =
=======       4 - non-parametric distributions.              =
=======  (c) the mean flow; except when used by:               =
=======     Feature Type 7 (abstractions): the abstracted flow;   =
=======     Feature Type 9 (river regulation): zero;           =
=======     Distribution Type 3: mean of transformed data        =
=======  (d) the 95-percentile low flow: except when used by:      =
=======     Feature Type 7 (abstractions): the Hands-Off Flow;    =
=======     Feature Type 9 (river regulation): the Maintained     =
=======     Flow                                       =
=======  (e) the shift parameter for distribution types 3:        =
=======     for Distribution Type 0, 1, 2: zero or blank;        =
=======     for Distribution Type 3:                       =
=======       negative; log(flow-shift) is Normal;             =
=======       positive; log(flow+shift) is Normal;             =
=======  (f) reserved for non-standard correlation coefficient     =
=======  (g) the name of the site (this is used only for          =
=======     identification. It is not needed by SIMCAT).         =
=========c========d========e=========f===========g============
========
  1 2    0.016   0.0014    0.00     -9.9   'Carey1 US'
```

2	2	0.0284	0.0023	0.00	-9.9	'Halwill US'
3	2	0.000	0.000	0.00	-9.9	'North Str US'
4	2	0.000	0.000	0.00	-9.9	'Well Farm US'
5	2	0.385	0.028	0.00	-9.9	'Deer1 US'
6	2	0.000	0.000	0.00	-9.9	'Coles Mill US'
7	2	0.360	0.042	0.00	-9.9	'Claw US'
8	1	0.337	0.062	0.00	-9.9	'Inny1 Saputo'
9	2	0.353	0.030	0.00	-9.9	'Penpont Water US'
10	2	0.8313	0.1212	0.00	-9.9	'Kensey US'
11	2	0.000	0.000	0.00	-9.9	'Lowley Brook US'
12	2	0.060	0.012	0.00	-9.9	'Milton Abbot US'
13	2	0.000	0.000	0.00	-9.9	'Luckett1 US'
14	2	0.000	0.000	0.00	-9.9	'Stoke Water US'
15	2	0.491	0.066	0.00	-9.9	'Lyd1 US'
16	2	0.519	0.082	0.00	-9.9	'Lew US'
17	2	0.000	0.000	0.00	-9.9	'Quither Br US'
18	2	0.623	0.073	0.00	-9.9	'Ottery1 US'
19	2	0.000	0.000	0.00	-9.9	'Can Water US'
20	2	0.000	0.000	0.00	-9.9	'Caudworthy US'
21	2	0.000	0.000	0.00	-9.9	'Bolesbridge US'
22	2	0.396	0.053	0.00	-9.9	'Thrushel1 US'
23	2	0.248	0.038	0.00	-9.9	'River Wolf US'
24	2	0.000	0.000	0.00	-9.9	'Comfort River US'
25	2	0.049	0.0067	0.00	-9.9	'Harrow Water US'
26	2	0.0373	0.006	0.00	-9.9	'Metherell US'
27	2	0.034	0.0052	0.00	-9.9	'Bere Alston US'
28	2	0.047	0.007	0.00	-9.9	'St Mellion US'
29	2	0.000	0.000	0.00	-9.9	'Clomoak US'
30	2	0.218	0.015	0.00	-9.9	'Tamar1 US'
31	2	0.043	0.002	0.00	-9.9	'Upper Tamar DF'

```
32 2    0.062    0.002    0.00     -9.9   'Deer&Claw DF'
33 2    0.070    0.006    0.00     -9.9   'Mid Tamar DF'
34 2    0.065    0.002    0.00     -9.9   'Ottery DF'
35 2    0.063    0.003    0.00     -9.9   'Carey DF'
36 2    0.048    0.006    0.00     -9.9   'Kensey DF'
37 2    0.050    0.012    0.00     -9.9   'Low Tamar DF'
38 2    0.063    0.014    0.00     -9.9   'Lyd DF'
39 2    0.063    0.007    0.00     -9.9   'Thrushel DF'
40 2    0.087    0.012    0.00     -9.9   'Inny DF'
41 2    0.140    0.047    0.00     -9.9   'Tidal DF'
42 2    1.860    0.112    0.00     -9.9   'Crowford GS'
43 2   11.340    0.592    0.00     -9.9   'Polson GS'
44 2   23.920    2.810    0.00     -9.9   'Gunnislake GS'
45 2   0.0304   0.0018    0.00     -9.9   'Lamberal W US'
46 2    0.113    0.011    0.00     -9.9   'Small Br US'
47 2    0.036   0.0042    0.00     -9.9   'Derrill Water US'
48 2    0.025   0.0015    0.00     -9.9   'Pyworthy Br US'
49 2    0.000    0.000    0.00     -9.9   'Thrush Str US'
50 2    3.410    0.170    0.00     -9.9   'Werrington Park GS'
51 2    2.440    0.310    0.00     -9.9   'Tinhay GS'
52 2    5.600    0.910    0.00     -9.9   'Lifton Park GS'
53 2    3.520    0.520    0.00     -9.9   'Beals Mill GS'
54 2    0.109   0.0001    0.00     -9.9   'Brook below discharge_T1'
55 2    0.263    0.0452   0.00     -9.9   'LF TPtoUS modelled'
***************** indicator of end of river flow data **************
================================================================
====
========[e] River Quality===========================================
================================================================
====
======= River Quality Data-Sets follow. For each Data-Set there    =
```

```
======= is a line of data for each determinand.                   =
======= For each line the following items are required:           =
=======  (a) the code number of the data-set;                      =
=======  (b) the code number for the determinand;                  =
=======  (c) the code number of type of distribution:              =
=======      for Feature types 7 and 9: zero, 1 or 2;              =
=======         0 - constant, uniform flow;                        =
=======         1 - flow follows the Normal Distribution;          =
=======         2 - the Log-Normal Distribution;                   =
=======         3 - a Three-Parameter Log-Normal Distribution;     =
=======         4 - non-parametric distributions.                  =
=======  (d) the mean concentration;                               =
=======  (e) the standard deviation;                               =
=======  (f) the shift parameter for distribution types 3:         =
=======      for Distribution Type 0, 1 or 2: zero or blank;       =
=======      for Distribution Type 3:                              =
=======         negative; log(flow-shift) is Normal;               =
=======         positive; log(flow+shift) is Normal;               =
=======  (g) reserved for non-standard correlation coefficient     =
=======
=======  (h) number of samples used to compute the mean;           =
=======  (i) the name of the site (this is used for                =
=======      identification. It is not needed by SIMCAT).          =
========c====d======e=====f========g====h=======i================
=====
  1   1 2  37.00  14.00  0.0     -9.9  36 '81201106'
  1   2 2   1703 751.00  0.0     -9.9  36 ''
  1   3 2  74.00  69.00  0.0     -9.9  36 ''
  1   4 1  10553   1293  0.0     -9.9  36 ''
  2   1 2  48.00  25.00  0.0     -9.9  36 '81201166'
  2   2 2   1692 762.00  0.0     -9.9  36 ''
```

2 3 2 64.00 43.00 0.0 -9.9 36 ''

2 4 1 10383 1379 0.0 -9.9 36 ''

3 1 2 209.00 170.00 0.0 -9.9 36 '81201402'

3 2 2 2219 1181 0.0 -9.9 36 ''

3 3 2 127.00 115.00 0.0 -9.9 36 ''

3 4 1 10319 1243 0.0 -9.9 36 ''

4 1 2 90.00 41.00 0.0 -9.9 36 '81201470'

4 2 2 2008 939.00 0.0 -9.9 36 ''

4 3 2 116.00 104.00 0.0 -9.9 36 ''

4 4 1 10441 1121 0.0 -9.9 36 ''

5 1 2 1133 1095 0.0 -9.9 36 '81201602'

5 2 2 1756 847.00 0.0 -9.9 36 ''

5 3 2 80.00 71.00 0.0 -9.9 36 ''

5 4 1 10251 1291 0.0 -9.9 36 ''

6 1 2 54.00 26.00 0.0 -9.9 35 '81250174'

6 2 2 1880 1428 0.0 -9.9 35 ''

6 3 2 52.00 49.00 0.0 -9.9 35 ''

6 4 1 10585 1089 0.0 -9.9 35 ''

7 1 2 56.00 26.00 0.0 -9.9 36 '81250239'

7 2 2 1739 761.00 0.0 -9.9 36 ''

7 3 2 52.00 49.00 0.0 -9.9 36 ''

7 4 1 10546 1107 0.0 -9.9 36 ''

8 1 2 52.00 26.00 0.0 -9.9 36 '81250277'

8 2 2 1803 827.00 0.0 -9.9 36 ''

8 3 2 58.00 50.00 0.0 -9.9 36 ''

8 4 1 10471 1143 0.0 -9.9 36 ''

9 1 2 40.00 20.00 0.0 -9.9 35 '81252104'

9 2 2 1560 795.00 0.0 -9.9 35 ''

9 3 2 43.00 26.00 0.0 -9.9 35 ''

9 4 1 10566 1059 0.0 -9.9 35 ''

10 1 2 38.00 15.00 0.0 -9.9 36 '81261102'

10 2 2 1419 704.00 0.0 -9.9 36 ''

10 3 2 42.00 19.00 0.0 -9.9 36 ''

10 4 1 10599 849.00 0.0 -9.9 36 ''

11 1 2 32.00 27.00 0.0 -9.9 36 '81261111'

11 2 2 1881 1430 0.0 -9.9 36 ''

11 3 2 58.00 73.00 0.0 -9.9 36 ''

11 4 1 10713 935.00 0.0 -9.9 36 ''

12 1 2 23.00 11.00 0.0 -9.9 36 '81261152'

12 2 2 1236 420.00 0.0 -9.9 36 ''

12 3 2 37.00 17.00 0.0 -9.9 36 ''

12 4 1 10717 806.00 0.0 -9.9 36 ''

13 1 2 19.00 10.00 0.0 -9.9 36 '81261180'

13 2 2 1122 240.00 0.0 -9.9 36 ''

13 3 2 30.00 1.00 0.0 -9.9 36 ''

13 4 1 10808 902.00 0.0 -9.9 36 ''

14 1 2 27.00 16.00 0.0 -9.9 36 '81261402'

14 2 2 1664 1170 0.0 -9.9 36 ''

14 3 2 51.00 47.00 0.0 -9.9 36 ''

14 4 1 10637 805.00 0.0 -9.9 36 ''

15 1 2 43.00 24.00 0.0 -9.9 36 '81261439'

15 2 2 1489 909.00 0.0 -9.9 36 ''

15 3 2 51.00 77.00 0.0 -9.9 36 ''

15 4 1 10704 874.00 0.0 -9.9 36 ''

16 1 2 25.00 15.00 0.0 -9.9 36 '81271202'

16 2 2 1775 1383 0.0 -9.9 36 ''

16 3 2 53.00 66.00 0.0 -9.9 36 ''

16 4 1 10656 1014 0.0 -9.9 36 ''

17 1 2 35.00 34.00 0.0 -9.9 36 '81271225'

17 2 2 1956 1619 0.0 -9.9 36 ''

17 3 2 92.00 135.00 0.0 -9.9 36 ''
17 4 1 10667 984.00 0.0 -9.9 36 ''
18 1 2 33.00 20.00 0.0 -9.9 36 '81271266'
18 2 2 1797 1401 0.0 -9.9 36 ''
18 3 2 94.00 150.00 0.0 -9.9 36 ''
18 4 1 10590 1030 0.0 -9.9 36 ''
19 1 2 27.00 34.00 0.0 -9.9 36 '81271502'
19 2 2 1836 1560 0.0 -9.9 36 ''
19 3 2 51.00 53.00 0.0 -9.9 36 ''
19 4 1 10589 999.00 0.0 -9.9 36 ''
20 1 2 20.00 15.00 0.0 -9.9 36 '81271510'
20 2 2 1417 411.00 0.0 -9.9 36 ''
20 3 2 39.00 17.00 0.0 -9.9 36 ''
20 4 1 10468 1011 0.0 -9.9 36 ''
21 1 2 23.00 24.00 0.0 -9.9 36 '81271526'
21 2 2 1353 322.00 0.0 -9.9 36 ''
21 3 2 50.00 24.00 0.0 -9.9 36 ''
21 4 1 10428 1051 0.0 -9.9 36 ''
22 1 2 30.00 22.00 0.0 -9.9 36 '81271593'
22 2 2 1800 1098 0.0 -9.9 36 ''
22 3 2 68.00 67.00 0.0 -9.9 36 ''
22 4 1 10750 941.00 0.0 -9.9 36 ''
23 1 2 46.00 16.00 0.0 -9.9 36 '81281105'
23 2 2 1953 1358 0.0 -9.9 36 ''
23 3 2 77.00 95.00 0.0 -9.9 36 ''
23 4 1 10573 1266 0.0 -9.9 36 ''
24 1 2 52.00 19.00 0.0 -9.9 36 '81281111'
24 2 2 1892 1391 0.0 -9.9 36 ''
24 3 2 92.00 135.00 0.0 -9.9 36 ''
24 4 1 10571 1257 0.0 -9.9 36 ''

25	1	2	58.00	29.00	0.0	-9.9	36	'81281161'
25	2	2	1861	1088	0.0	-9.9	36	'"
25	3	2	79.00	73.00	0.0	-9.9	36	'"
25	4	1	10693	1123	0.0	-9.9	36	'"
26	1	2	75.00	50.00	0.0	-9.9	36	'81290111'
26	2	2	2164	1009	0.0	-9.9	36	'"
26	3	2	60.00	51.00	0.0	-9.9	36	'"
26	4	1	10632	1092	0.0	-9.9	36	'"
27	1	2	54.00	39.00	0.0	-9.9	36	'81290141'
27	2	2	2289	1132	0.0	-9.9	36	'"
27	3	2	72.00	64.00	0.0	-9.9	36	'"
27	4	1	10546	1205	0.0	-9.9	36	'"
28	1	2	72.00	27.00	0.0	-9.9	36	'81290191'
28	2	2	2639	1292	0.0	-9.9	36	'"
28	3	2	95.00	72.00	0.0	-9.9	36	'"
28	4	1	10348	1125	0.0	-9.9	36	'"
29	1	2	110.00	63.00	0.0	-9.9	34	'91210127'
29	2	2	2726	1477	0.0	-9.9	34	'"
29	3	2	104.00	90.00	0.0	-9.9	34	'"
29	4	1	10306	1164	0.0	-9.9	34	'"
30	1	2	65.00	26.00	0.0	-9.9	36	'91210131'
30	2	2	2614	1314	0.0	-9.9	36	'"
30	3	2	84.00	67.00	0.0	-9.9	36	'"
30	4	1	10235	1258	0.0	-9.9	36	'"
31	1	2	75.00	38.00	0.0	-9.9	36	'91210168'
31	2	2	3183	2308	0.0	-9.9	36	'"
31	3	2	168.00	369.00	0.0	-9.9	36	'"
31	4	1	10147	1198	0.0	-9.9	36	'"
32	1	2	53.00	28.00	0.0	-9.9	35	'91210233'
32	2	2	2723	1456	0.0	-9.9	35	'"

32	3	2	85.00	80.00	0.0	-9.9	35	''
32	4	1	10378	1121	0.0	-9.9	35	''
33	1	2	32.00	20.00	0.0	-9.9	36	'91210269'
33	2	2	4453	3015	0.0	-9.9	36	''
33	3	2	137.00	167.00	0.0	-9.9	36	''
33	4	1	10604	1326	0.0	-9.9	36	''
34	1	2	50.00	39.00	0.0	-9.9	35	'91210355'
34	2	2	2323	2030	0.0	-9.9	35	''
34	3	2	163.00	197.00	0.0	-9.9	35	''
34	4	1	10558	948.00	0.0	-9.9	35	''
35	1	2	112.00	47.00	0.0	-9.9	36	'91211328'
35	2	2	2006	788.00	0.0	-9.9	36	''
35	3	2	118.00	111.00	0.0	-9.9	36	''
35	4	1	10153	1300	0.0	-9.9	36	''
36	1	2	72.00	50.00	0.0	-9.9	36	'91212023'
36	2	2	1672	791.00	0.0	-9.9	36	''
36	3	2	136.00	209.00	0.0	-9.9	36	''
36	4	1	10243	1304	0.0	-9.9	36	''
37	1	2	67.00	32.00	0.0	-9.9	36	'91212027'
37	2	2	1722	774.00	0.0	-9.9	36	''
37	3	2	119.00	150.00	0.0	-9.9	36	''
37	4	1	10301	1155	0.0	-9.9	36	''
38	1	2	37.00	21.00	0.0	-9.9	36	'91221108'
38	2	2	1708	1242	0.0	-9.9	36	''
38	3	2	66.00	72.00	0.0	-9.9	36	''
38	4	1	10411	1214	0.0	-9.9	36	''
39	1	2	40.00	26.00	0.0	-9.9	36	'91221137'
39	2	2	1692	1125	0.0	-9.9	36	''
39	3	2	75.00	73.00	0.0	-9.9	36	''
39	4	1	10461	1140	0.0	-9.9	36	''

40 1 2 28.00 18.00 0.0 -9.9 36 '91221170'

40 2 2 1647 943.00 0.0 -9.9 36 ''

40 3 2 85.00 108.00 0.0 -9.9 36 ''

40 4 1 10505 1094 0.0 -9.9 36 ''

41 1 2 33.00 44.00 0.0 -9.9 36 '91221180'

41 2 2 1578 1027 0.0 -9.9 36 ''

41 3 2 76.00 86.00 0.0 -9.9 36 ''

41 4 1 10662 1016 0.0 -9.9 36 ''

42 1 2 45.00 24.00 0.0 -9.9 36 '91221520'

42 2 2 2019 1309 0.0 -9.9 36 ''

42 3 2 95.00 110.00 0.0 -9.9 36 ''

42 4 1 10148 1372 0.0 -9.9 36 ''

43 1 2 52.00 30.00 0.0 -9.9 36 '91221702'

43 2 2 1922 1498 0.0 -9.9 36 ''

43 3 2 100.00 121.00 0.0 -9.9 36 ''

43 4 1 10223 1296 0.0 -9.9 36 ''

44 1 2 40.00 27.00 0.0 -9.9 36 '91222208'

44 2 2 1614 942.00 0.0 -9.9 36 ''

44 3 2 120.00 144.00 0.0 -9.9 36 ''

44 4 1 10499 1085 0.0 -9.9 36 ''

45 1 2 25.00 13.00 0.0 -9.9 35 '91231102'

45 2 2 1423 617.00 0.0 -9.9 35 ''

45 3 2 40.00 19.00 0.0 -9.9 35 ''

45 4 1 10622 1118 0.0 -9.9 35 ''

46 1 2 28.00 23.00 0.0 -9.9 36 '91231113'

46 2 2 1442 884.00 0.0 -9.9 36 ''

46 3 2 44.00 39.00 0.0 -9.9 36 ''

46 4 1 10667 914.00 0.0 -9.9 36 ''

47 1 2 24.00 9.00 0.0 -9.9 36 '91231134'

47 2 2 1336 592.00 0.0 -9.9 36 ''

47 3 2 43.00 24.00 0.0 -9.9 36 ''

47 4 1 10642 907.00 0.0 -9.9 36 ''

48 1 2 116.00 86.00 0.0 -9.9 36 '91241113'

48 2 2 1483 650.00 0.0 -9.9 36 ''

48 3 2 41.00 25.00 0.0 -9.9 36 ''

48 4 1 10850 820.00 0.0 -9.9 36 ''

49 1 2 114.00 93.00 0.0 -9.9 36 '91241119'

49 2 2 1464 688.00 0.0 -9.9 36 ''

49 3 2 47.00 37.00 0.0 -9.9 36 ''

49 4 1 10791 804.00 0.0 -9.9 36 ''

50 1 2 50.40 43.65 0.0 -9.9 11 '91241146_2BI'

50 2 2 1542 972.00 0.0 -9.9 36 ''

50 3 2 42.00 34.00 0.0 -9.9 36 ''

50 4 1 10747 868.00 0.0 -9.9 36 ''

51 1 2 41.14 42.84 0.0 -9.9 11 '91241162_StC'

51 2 2 1547 1054 0.0 -9.9 36 ''

51 3 2 46.00 73.00 0.0 -9.9 36 ''

51 4 1 10597 904.00 0.0 -9.9 36 ''

52 1 2 1.65 0.83 0.0 -9.9 12 '91241191_InnyV'

52 2 2 2017 2541 0.0 -9.9 36 ''

52 3 2 43.00 96.00 0.0 -9.9 36 ''

52 4 1 10226 672.00 0.0 -9.9 36 ''

53 1 2 1.81 0.38 0.0 -9.9 36 '91241709_2BPP'

53 2 2 1408 781.00 0.0 -9.9 36 ''

53 3 2 55.00 41.00 0.0 -9.9 36 ''

53 4 1 10698 790.00 0.0 -9.9 36 ''

54 1 2 33.00 60.00 0.0 -9.9 36 '91241770'

54 2 2 1347 1192 0.0 -9.9 36 ''

54 3 2 39.00 28.00 0.0 -9.9 36 ''

54 4 1 10438 846.00 0.0 -9.9 36 ''

```
55   1 2  35.00  25.00  0.0      9.9  30 'Diffuse Inputs'
55   2 2   2000 666.00  0.0     -9.9  30 ''
55   3 2 100.00  33.00  0.0     -9.9  30 ''
55   4 1  10000   3333  0.0     -9.9  30 ''
56   1 2  30.00  25.00  0.0    -9.9  30 'US Boundaries'
56   2 2   2000 666.00  0.0     -9.9  30 ''
56   3 2 100.00  33.00  0.0     -9.9  30 ''
56   4 1  10000   3333  0.0     -9.9  30 ''
57   1 2  60.00  60.00  0.0    -9.9  30 'Upper Tamar Dif'
57   2 2   2000 666.00  0.0     -9.9  30 ''
57   3 2 100.00  33.00  0.0     -9.9  30 ''
57   4 1  10000   3333  0.0     -9.9  30 ''
58   1 2  30.00  45.00  0.0    -9.9  30 'Ottery Dif'
58   2 2   2000 666.00  0.0     -9.9  30 ''
58   3 2 100.00  33.00  0.0     -9.9  30 ''
58   4 1  10000   3333  0.0     -9.9  30 ''
59   1 2  20.00  30.00  0.0    -9.9  30 'Thrushel Dif'
59   2 2   2000 666.00  0.0     -9.9  30 ''
59   3 2 100.00  33.00  0.0     -9.9  30 ''
59   4 1  10000   3333  0.0     -9.9  30 ''
60   1 2  25.00  30.00  0.0    -9.9  30 'Lyd Dif'
60   2 2   2000 666.00  0.0     -9.9  30 ''
60   3 2 100.00  33.00  0.0     -9.9  30 ''
60   4 1  10000   3333  0.0     -9.9  30 ''
61   1 2  1.65    0.83  0.0    -9.9  12 'Inny Dif'
61   2 2   2000 666.00  0.0     -9.9  30 ''
61   3 2 100.00  33.00  0.0     -9.9  30 ''
61   4 1  10000   3333  0.0     -9.9  30 ''
62   1 2  25.00  15.00  0.0    -9.9  30 'Kensey dif'
62   2 2   2000 666.00  0.0     -9.9  30 ''
```

```
62   3 2 100.00  33.00  0.0     -9.9  30 ''
62   4 2  10000   3333  0.0     -9.9  30 ''
63   1 2   1.65   0.83  0.0     -9.9 12 'RG Top'
63   2 2   2000 666.00  0.0     -9.9  30 ''
63   3 2  43.00  69.00  0.0     -9.9  24 ''
63   4 1  10000   3333  0.0     -9.9  30 ''
64   1 2  8.72   4.12   0.0     -9.9  12 'RG US Davidstow discharge'
64   2 2   2000 666.00  0.0     -9.9  30 ''
64   3 2  33.00  22.00  0.0     -9.9  24 ''
64   4 1  10000   3333  0.0     -9.9  30 ''
65   1 2 135.78 129.02  0.0     -9.9  12 'RG DS Davidstow discharge'
65   2 2   2000 666.00  0.0     -9.9  30 ''
65   3 2 140.00 191.00  0.0     -9.9  24 ''
65   4 1  10000   3333  0.0     -9.9  30 ''
66   1 2  112.78 89.15  0.0     -9.9  12 'RG Trewinnow Bridge'
66   2 2   2000 666.00  0.0     -9.9  30 ''
66   3 2 102.00 139.00  0.0     -9.9  24 ''
66   4 1  10000   3333  0.0     -9.9  30 ''
67   1 2   2.12   0.98  0.0     -9.9  12 'Brook below discharge_T1'
67   2 2   0.00   0.00  0.0     -9.9  12 ''
67   3 2  15.00  13.00  0.0     -9.9  24 ''
67   4 2   0.00   0.00  0.0     -9.9  12 ''
68   1 2   17.53 31.22  0.0     -9.9  12 'Brook around works_T2'
68   2 2   0.00   0.00  0.0     -9.9  23 ''
68   3 2  25.00  10.00  0.0     -9.9  23 ''
68   4 2   0.00   0.00  0.0     -9.9  23 ''
69   1 2  41.14  42.84  0.0     -9.9  11 'StCletherBridge'
69   2 2   0.00   0.00  0.0     -9.9  24 ''
69   3 2  46.00  43.00  0.0     -9.9  24 ''
69   4 2   0.00   0.00  0.0     -9.9  24 ''
```

```
 70   1 2  50.40  43.65  0.0     -9.9  11 'Inny_2Bridges'
 70   2 2   0.00   0.00  0.0     -9.9  22 ''
 70   3 2  42.00  34.00  0.0     -9.9  22 ''
 70   4 2   0.00   0.00  0.0     -9.9  22 ''
****************** indicator of end of river quality data **********
=================================================================
===
========[f] Effluent Flow & Quality ===============================
=================================================================
===
======= Effluent Flow and Quality Data-Sets follow. For each      =
======= Data-Set there is a line for the flow and a line for      =
======= each determinand in turn:                                 =
======= For each line the following are entered:                  =
=======  (a) the code number of the data-set;                     =
=======      (this will be referred to in the Feature Data)       =
=======  (b) the code number for the determinand;                 =
=======  (c) the code number of type of distribution:             =
=======      for Feature types 7 and 9: zero, 1 or 2;             =
=======         0 - constant, uniform flow;                       =
=======         1 - flow follows the Normal Distribution;         =
=======         2 - the Log-Normal Distribution;                  =
=======         3 - a Three-Parameter Log-Normal Distribution;    =
=======         4 - non-parametric distributions.                 =
=======  (d) the mean value;                                      =
=======  (e) the standard deviation;                              =
=======  (f) the shift parameter for distribution types 3:        =
=======      for Distribution Type 0, 1 or 2: zero or blank;      =
=======      for Distribution Type 3:                             =
=======         negative; log(flow-shift) is Normal;              =
=======         positive; log(flow+shift) is Normal;              =
```

```
=======  (g) reserved for non-standard correlation coefficient    =
=======
=======  (h) number of samples used to compute the mean;          =
=======  (i) the name of the discharge (this is used for          =
=======      identification. It is not needed by SIMCAT).         =
========c========d========e=====f=========g====h=====i=========
======
  1   0 2     0.0291   0.0097   0.00     -9.9  30 'Launceston STW'
  1   1 2    3860.00  2420.00   0.00     -9.9  30 ''
  1   2 2    6360.00  7070.00   0.00     -9.9  81 ''
  1   3 2     350.00   250.00   0.00     -9.9  45 ''
  1   4 1    5000.00  1666.00   0.00     -9.9  30 ''
  2   0 2     0.0174  0.00374   0.00     -9.9  30 'Davidstow C.'
  2   1 2     797.20   246.67   0.00     -9.9  11 ''
  2   2 2    1620.00   450.00   0.00     -9.9  34 ''
  2   3 2     460.00   432.00   0.00     -9.9  21 ''
  2   4 1    5000.00  1666.00   0.00     -9.9  30 ''
  3   0 2     0.0087   0.0029   0.00     -9.9  30 'Holsworthy STW'
  3   1 2    5700.00  3400.00   0.00     -9.9  30 ''
  3   2 2    2060.00  1770.00   0.00     -9.9  44 ''
  3   3 2     310.00   250.00   0.00     -9.9  44 ''
  3   4 1    5000.00  1666.00   0.00     -9.9  30 ''
  4   0 2      0.006    0.002   0.00     -9.9  30 'Bere Alston STW'
  4   1 2    5000.00  1667.00   0.00     -9.9  30 ''
  4   2 2       0.00     0.00   0.00     -9.9   0 ''
  4   3 2       0.00     0.00   0.00     -9.9   0 ''
  4   4 1       0.00     0.00   0.00     -9.9   0 ''
  5   0 2   0.005787  0.00193   0.00     -9.9  30 'Ambrosia Cream'
  5   1 2     930.00  2120.00   0.00     -9.9  30 ''
  5   2 2    3940.00  2640.00   0.00     -9.9  42 ''
  5   3 2     270.00    70.00   0.00     -9.9  42 ''
```

5	4	1	5000.00	1666.00	0.00	-9.9	30	''
6	0	2	0.00382	0.00127	0.00	-9.9	30	'Gunnislake STW'
6	1	2	5000.00	1667.00	0.00	-9.9	30	''
6	2	2	0.00	0.00	0.00	-9.9	0	''
6	3	2	0.00	0.00	0.00	-9.9	0	''
6	4	1	0.00	0.00	0.00	-9.9	0	''
7	0	2	0.00347	0.00116	0.00	-9.9	30	'Lifton STW'
7	1	2	5000.00	1667.00	0.00	-9.9	30	''
7	2	2	5580.00	5530.00	0.00	-9.9	43	''
7	3	2	7060.00	6630.00	0.00	-9.9	30	''
7	4	1	5000.00	1666.00	0.00	-9.9	30	''
8	0	2	0.003	0.001	0.00	-9.9	30	'Calstock STW'
8	1	2	5000.00	1667.00	0.00	-9.9	30	''
8	2	2	0.00	0.00	0.00	-9.9	0	''
8	3	2	0.00	0.00	0.00	-9.9	0	''
8	4	1	0.00	0.00	0.00	-9.9	0	''
9	0	2	0.00243	0.00081	0.00	-9.9	30	'St Mellion STW'
9	1	2	5000.00	1667.00	0.00	-9.9	30	''
9	2	2	0.00	0.00	0.00	-9.9	0	''
9	3	2	0.00	0.00	0.00	-9.9	0	''
9	4	1	0.00	0.00	0.00	-9.9	0	''
10	0	2	0.00196	0.00065	0.00	-9.9	30	'Stoke Climsland STW'
10	1	2	5000.00	1667.00	0.00	-9.9	30	''
10	2	2	11210.00	4870.00	0.00	-9.9	44	''
10	3	2	9000.00	5240.00	0.00	-9.9	44	''
10	4	1	5000.00	1666.00	0.00	-9.9	30	''
11	0	2	0.00137	0.00046	0.00	-9.9	30	'St Dominick STW'
11	1	2	5000.00	1667.00	0.00	-9.9	30	''
11	2	2	0.00	0.00	0.00	-9.9	0	''
11	3	2	0.00	0.00	0.00	-9.9	0	''

11	4 1	0.00	0.00	0.00	-9.9	0	''
12	0 2	0.00116	0.00039	0.00	-9.9	30	'Cargreen STW'
12	1 2	5000.00	1667.00	0.00	-9.9	30	''
12	2 2	0.00	0.00	0.00	-9.9	0	''
12	3 2	0.00	0.00	0.00	-9.9	0	''
12	4 1	0.00	0.00	0.00	-9.9	0	''
13	0 2	0.00105	0.00035	0.00	-9.9	30	'St Giles STW'
13	1 2	5000.00	1667.00	0.00	-9.9	30	''
13	2 2	15990.00	51230.00	0.00	-9.9	40	''
13	3 2	9650.00	11470.00	0.00	-9.9	40	''
13	4 1	5000.00	1666.00	0.00	-9.9	30	''
14	0 2	0.001	0.00033	0.00	-9.9	30	'Metherell STW'
14	1 2	5000.00	1667.00	0.00	-9.9	30	''
14	2 2	0.00	0.00	0.00	-9.9	0	''
14	3 2	0.00	0.00	0.00	-9.9	0	''
14	4 1	0.00	0.00	0.00	-9.9	0	''
15	0 2	0.00096	0.00032	0.00	-9.9	30	'Harrowbarrow STW'
15	1 2	5000.00	1667.00	0.00	-9.9	30	''
15	2 2	0.00	0.00	0.00	-9.9	0	''
15	3 2	0.00	0.00	0.00	-9.9	0	''
15	4 1	0.00	0.00	0.00	-9.9	0	''
16	0 2	0.00093	0.00031	0.00	-9.9	30	'Lewannick STW'
16	1 2	5000.00	1667.00	0.00	-9.9	30	''
16	2 2	27410.00	1888.00	0.00	-9.9	43	''
16	3 2	12410.00	8400.00	0.00	-9.9	43	''
16	4 1	5000.00	1666.00	0.00	-9.9	30	''
17	0 2	0.00085	0.00028	0.00	-9.9	30	'Bridgerule STW'
17	1 2	5000.00	1667.00	0.00	-9.9	30	''
17	2 2	4440.00	4690.00	0.00	-9.9	38	''
17	3 2	4070.00	7490.00	0.00	-9.9	38	''

17	4	1	5000.00	1666.00	0.00	-9.9	30	''
18	0	2	0.00081	0.00027	0.00	-9.9	30	'Bridestow STW'
18	1	2	5000.00	1667.00	0.00	-9.9	30	''
18	2	2	4940.00	3130.00	0.00	-9.9	42	''
18	3	2	700.00	910.00	0.00	-9.9	42	''
18	4	1	5000.00	1666.00	0.00	-9.9	30	''
19	0	2	0.00081	0.00027	0.00	-9.9	30	'Halwill STW'
19	1	2	5000.00	1667.00	0.00	-9.9	30	''
19	2	2	1860.00	930.00	0.00	-9.9	44	''
19	3	2	870.00	1160.00	0.00	-9.9	44	''
19	4	1	5000.00	1666.00	0.00	-9.9	30	''
20	0	2	0.00081	0.00027	0.00	-9.9	30	'Pyworthy STW'
20	1	2	5000.00	1667.00	0.00	-9.9	30	''
20	2	2	14130.00	44240.00	0.00	-9.9	38	''
20	3	2	3840.00	5540.00	0.00	-9.9	38	''
20	4	1	5000.00	1666.00	0.00	-9.9	30	''
21	0	2	0.00075	0.00025	0.00	-9.9	30	'Beals Mill STW'
21	1	2	5000.00	1667.00	0.00	-9.9	30	''
21	2	2	8290.00	16720.00	0.00	-9.9	41	''
21	3	2	4210.00	6410.00	0.00	-9.9	41	''
21	4	1	5000.00	1666.00	0.00	-9.9	30	''
22	0	2	0.00072	0.00024	0.00	-9.9	30	'North Petherwin STW'
22	1	2	5000.00	1667.00	0.00	-9.9	30	''
22	2	2	10840.00	6440.00	0.00	-9.9	39	''
22	3	2	3900.00	2810.00	0.00	-9.9	39	''
22	4	1	5000.00	1666.00	0.00	-9.9	30	''
23	0	2	0.00069	0.00023	0.00	-9.9	30	'Milton Abbot STW'
23	1	2	5000.00	1667.00	0.00	-9.9	30	''
23	2	2	20230.00	99660.00	0.00	-9.9	39	''
23	3	2	1580.00	3210.00	0.00	-9.9	38	''

```
 23   4 1    5000.00  1666.00   0.00     -9.9  30 ''
 24   0 2    0.00054  0.00018   0.00     -9.9  30 'Lewdown STW'
 24   1 2    5000.00  1666.00   0.00     -9.9  30 ''
 24   2 2    2310.00  4620.00   0.00     -9.9  43 ''
 24   3 2     580.00  1020.00   0.00     -9.9  43 ''
 24   4 1    5000.00  1666.00   0.00     -9.9  30 ''
 25   0 2    0.00042  0.00014   0.00     -9.9  30 'Altarnun STW'
 25   1 2    5000.00  1666.00   0.00     -9.9  30 ''
 25   2 2   29300.00 25830.00   0.00     -9.9  36 ''
 25   3 2   11790.00  9470.00   0.00     -9.9  37 ''
 25   4 1    5000.00  1666.00   0.00     -9.9  30 ''
 26   0 2    0.00042  0.00014   0.00     -9.9  30 'Ashwater STW'
 26   1 2    5000.00  1667.00   0.00     -9.9  30 ''
 26   2 2    6480.00  3130.00   0.00     -9.9  38 ''
 26   3 2    2800.00  6430.00   0.00     -9.9  38 ''
 26   4 1    5000.00  1666.00   0.00     -9.9  30 ''
 27   0 2    0.00036  0.00012   0.00     -9.9  30 'Well Farm STW'
 27   1 2    5000.00  1667.00   0.00     -9.9  30 ''
 27   2 2   10000.00 15000.00   0.00     -9.9  30 ''
 27   3 2    4700.00  4700.00   0.00     -9.9  30 ''
 27   4 1    5000.00  1666.00   0.00     -9.9  30 ''
 28   0 2    0.00036  0.00012   0.00     -9.9  30 'Chillaton STW'
 28   1 2    5000.00  1667.00   0.00     -9.9  30 ''
 28   2 2   10000.00 15000.00   0.00     -9.9  30 ''
 28   3 2    4700.00  4700.00   0.00     -9.9  30 ''
 28   4 1    5000.00  1667.00   0.00     -9.9  30 ''
************ indicator of end of effluent flow and quality data ****
=================================================================
====
========[g] River Quality Targets ==================================
```

===
====

======= The data sets for River Quality Targets follow. There is =

======= one line for each set containing: =

======= (a) the code number cited in the Feature data; =

======= The targets follow. These are 95-percentiles except in =

======= Mean Mode when they are taken as averages: =

======= (b-k) the targets for up to 10 determinands. =

======= Zero indicates that no target is to be applied. =

======a======b========c========d========e========f========g========h========i========j========k

1	0.07	2000.00	28.00	8.00
2	0.07	2000.00	30.00	8.00
3	0.07	2000.00	30.00	8.00
4	0.07	2000.00	41.00	8.00
5	0.07	2000.00	28.00	8.00
6	0.07	2000.00	30.00	8.00
7	0.07	2000.00	42.00	8.00
8	0.07	2000.00	29.00	8.00
9	0.07	2000.00	46.00	8.00

************* indicator of end of data on river quality targets ****

===
====

========[i] Features ==

===
====

======= The Data-Sets for Features follow. There is one line for =

======= each feature. Each line holds: =

======= (a) the name of the Feature; =

======= (b) the code for the type of Feature; these are: =

======= 1 - monitoring station; =

======= 2 - stream or tributary; =

```
=======          3 - sewage works or sewage discharge;     =
=======          4 - river flow gauge;                     =
=======          5 - industrial effluent discharge;        =
=======          6 - plotting point;                       =
=======          7 - abstraction (of flow);                =
=======          8 - weir;                                 =
=======              (must be at head of Reach);           =
=======          9 - river flow regulation point;          =
=======              (switched on only in Modes 3-8)       =
=======         10 - upstream river boundary;              =
=======         11 - bifurcation                           =
=======              (must be at head of Reach);           =
=======         13 - start point for diffuse pollution;    =
=======         14 - end point for diffuse pollution;      =
=======              (river type)                          =
=======         15 - start point for diffuse pollution;    =
=======         16 - end point for diffuse pollution;      =
=======              (effluent type)                       =
=======         17 - a feature that has no flow, eg. a future=
=======              effluent discharge in a current model to=
=======              prevent a consent calculation in Run  =
=======              Modes 7 & 8                           =
=======         18 - an abstraction which removes a set    =
=======              distribution of flow feature.  A sort =
=======              of negative discharge.  The           =
=======              distribution to be abstracted is      =
=======              entered with the river flow data sets =
=======         19 - as 18 but the distribution to be      =
=======              abstracted is entered with the effluent =
=======              data sets                             =
```

```
=======          (c) the code number of the Reach on which the    =
=======             Feature is located;                        =
=======          (d) distance from the head of the reach (km);    =
=======          (e) the code number of the river flow Data-Set;  =
=======             (discharged from Feature Types 2 & 13)       =
=======             (recorded at Feature Type 4)                =
=======             (abstracted at Feature Type 7 or 18)         =
=======          (f) the code number for the river quality        =
=======             Data-Set or the effluent flow/quality        =
=======             Data-Set;(non-zero for Feature Types 2,3,5,  =
=======             13 and 15, 19);                        =
=======             (data-set for quality produced by Weir;      =
=======          (g) the code number of any river flow Data-Set   =
=======             to be fitted in Auto-Calibration;           =
=======             Prefixing a minus sign will suppress         =
=======             downstream extrapolation;                   =
================================================================
====
=======             Defining the Feature to be at the Head of a  =
=======             Reach will suppress upstream interpolation.  =
=======             In this way the Feature acts as a Quality    =
=======             Adjustment Point and can model the effects   =
=======             of unusual discharges.                      =
================================================================
====
=======          (h) the code number for any river quality        =
=======             Data-Set to be fitted by Auto-Calibration;   =
=======             Prefixing a minus sign will suppress         =
=======             downstream extrapolation;                   =
=======             For Feature Type 8: the code number for the  =
=======             river quality Data-Set defining quality      =
```

======= downstream of the Weir =

==
====

======= Defining the Feature to be at the Head of a =

======= Reach will suppress upstream interpolation. =

======= In this way the Feature acts as a Flow =

======= Adjustment Point and can model the effects of=

======= unusual abstractions and discharges. =

==
====

======= (i) the code number for any Data-set of river =

======= quality targets. =

===========a===================================b===c=====d=====e===f=
==g===h=i

'TamarUS' 10 1 0.0 30 34 0 0 1

'91210355' 1 1 0.0 0 34 0 0 1

'91210269' 1 1 4.9 0 33 0 0 1

'LamberalUS' 10 20 0.0 45 56 0 0 1

'91210233' 1 2 3.1 0 32 0 0 1

'Small BrookUS' 10 21 0.0 46 36 0 0 1

'91212023' 1 21 0.0 0 36 0 0 1

'91212027' 1 21 2.6 0 37 0 0 1

'Bridgerule STW' 3 3 3.0 0 17 0 0 1

'91210168' 1 3 7.4 0 31 0 0 1

'Crowford GS' 4 3 7.9 42 0 0 0 1

'Derrill WaterUS' 10 22 0.0 47 56 0 0 1

'Pyworthy Br US' 10 24 0.0 48 56 0 0 1

'Pyworthy STW' 3 24 0.0 0 20 0 0 1

'91211328' 1 23 2.0 0 35 0 0 1

'Well Farm Trib US' 10 25 0.0 4 56 0 0 1

'Well Farm STW' 3 25 0.2 0 27 0 0 1

'91210131'	1	5	0.4	0	30	0	0	1
'Deer US'	10	26	0.0	5	4	0	0	1
'81201470'	1	26	0.0	0	4	0	0	1
'Coles Mill St US'	10	28	0.0	6	56	0	0	1
'Holsworthy STW'	3	28	2.0	0	3	0	0	1
'81201602'	1	28	2.5	0	5	0	0	1
'81201402'	1	27	7.9	0	3	0	0	1
'91210127'	1	6	0.1	0	29	0	0	1
'Claw US'	10	29	0.0	7	2	0	0	1
'81201166'	1	29	0.0	0	2	0	0	1
'81201106'	1	29	7.3	0	1	0	0	1
'81290191'	1	7	4.9	0	28	0	0	1
'Ottery US'	10	30	0.0	18	41	0	0	1
'91221180'	1	30	0.0	0	41	0	0	1
'91221170'	1	30	4.2	0	40	0	0	1
'Can Water US'	10	34	0.0	19	56	0	0	1
'91222208'	1	34	4.2	0	44	0	0	1
'Caudworthy Water US'	10	35	0.0	20	56	0	0	1
'91221702'	1	35	9.7	0	43	0	0	1
'91221137'	1	32	1.4	0	39	0	0	1
'Bolesbridge Water US'	10	36	0.0	21	56	0	0	1
'91221520'	1	36	6.6	0	42	0	0	1
'North Petherwin STW'	3	36	6.7	0	22	0	0	1
'Werrington GS'	4	33	5.5	50	0	0	0	1
'91221108'	1	33	6.1	0	38	0	0	1
'81290141'	1	8	0.2	0	28	0	0	1
'Carey US'	10	37	0.0	1	56	0	0	1
'Halwill Str US'	10	40	0.0	2	56	0	0	1
'Halwill STW'	3	40	0.0	0	19	0	0	1
'81281161'	1	38	4.9	0	25	0	0	1

'Ashwater NS US'	10	41	0.0	3	56	0	0	1
'Ashwater STW'	3	41	0.0	0	26	0	0	1
'St Giles STW'	3	39	6.6	0	13	0	0	1
'81281111'	1	39	8.3	0	24	0	0	1
'81281105'	1	39	11.1	0	23	0	0	1
'Launceston STW'	3	9	0.8	0	1	0	0	1
'Kensey US'	10	42	0.0	10	47	0	0	1
'91231134'	1	42	0.0	0	47	0	0	1
'91231113'	1	42	3.0	0	46	0	0	1
'91231102'	1	42	5.7	0	45	0	0	1
'Polson GS'	4	10	0.1	43	0	0	0	1
'81290111'	1	10	0.4	0	26	0	0	1
'Lyd US'	10	43	0.0	15	13	0	0	1
'81261180'	1	43	0.0	0	13	0	0	1
'81261152'	1	43	8.8	0	12	0	0	1
'Lew US'	10	47	0.0	16	56	0	0	1
'Bridestow STW'	3	47	0.0	0	18	0	0	1
'81261439'	1	47	2.5	0	15	0	0	1
'81261402'	1	47	9.3	0	14	0	0	1
'Quither Br US'	10	48	0.0	17	56	0	0	1
'Chillaton STW'	3	48	4.9	0	28	0	0	1
'81261102'	1	48	6.8	0	10	0	0	1
'Ambrosia'	3	45	3.5	0	5	0	0	1
'Thrushel US'	10	49	0.0	22	18	0	0	1
'81271266'	1	49	0.0	0	18	0	0	1
'Thrushelton Str US'	10	52	0.0	49	56	0	0	1
'Lewdown STW'	3	52	0.0	0	24	0	0	1
'81271225'	1	50	1.7	0	17	0	0	1
'Wolf US'	10	53	0.0	23	22	0	0	1
'81271593'	1	53	0.0	0	22	0	0	1

'81271526'	1	53	5.8	0	21	0	0	1
'81271510'	1	53	7.6	0	20	0	0	1
'81271502'	1	53	10.5	0	19	0	0	1
'Tinhay'	4	51	1.2	51	0	0	0	1
'81271202'	1	51	1.6	0	16	0	0	1
'Lifton STW'	3	51	1.8	0	7	0	0	1
'81261111'	1	46	0.5	0	11	0	0	1
'Lifton Park'	4	46	1.4	52	0	0	0	1
'81250277'	1	11	4.0	0	8	0	0	1
'Lowley Br US'	10	54	0.0	11	56	0	0	1
'81252104'	1	54	9.5	0	9	0	0	1
'Inny US'	10	55	0.0	55	68	0	0	1
'RG Top'	1	55	0.2	0	63	0	0	1
'Brook around works_T2'	2	55	0.89	0	68	0	0	1
'91241191_InnyVale'	1	55	1.0	0	68	0	63	1
'RG US Davidstow discharge'	1	55	2.24	0	64	0	64	1
'Inny1 Saputo Flow'	4	55	2.25	8	0	8	0	1
'Davidstow Creamery'	5	55	2.26	0	2	0	0	1
'RG DS Davidstow discharge'	1	55	2.3	0	65	0	65	1
'Brook below discharge_T1'	2	55	2.35	0	67	0	0	1
'RG Trewinnow Bridge'	1	55	2.45	0	66	0	66	1
'91241162_StC'	1	55	6.9	0	69	0	0	1
'St Clether Bridge'	1	55	8.13	8	69	0	69	1
'Penpont Water_Two Br'	1	55	14.58	0	0	0	0	1
'91241146_2BI'	1	55	14.9	0	70	0	0	1
'Inny_Two Bridges'	1	55	17.73	8	70	0	70	1
'Penpont WaterUS'	10	57	0.0	9	54	0	0	1
'91241770'	1	57	0.0	0	54	0	0	1
'Altarnun STW'	3	57	3.5	0	25	0	0	1
'Lewannick'	3	57	9.2	0	16	0	0	1

'91241709' 1 57 9.4 0 53 0 0 1

'91241119' 1 56 9.9 0 49 0 0 1

'91241113' 1 56 12.4 0 48 0 0 1

'Beals Mill GS' 4 56 12.5 53 0 0 0 1

'Beals Mill STW' 3 56 12.5 0 21 0 0 1

'Milton Abbott Str US' 10 58 0.0 12 56 0 0 1

'Milton Abbot STW' 3 58 0.0 0 23 0 0 1

'81250239' 1 14 5.0 0 7 0 0 1

'Luckett US' 10 59 0.0 13 56 0 0 1

'Stoke WaterUS' 10 61 0.0 14 56 0 0 1

'Stoke Climsland STW' 3 61 0.9 0 10 0 0 1

'Gunnislake GS' 4 15 4.7 44 0 0 0 1

'81250174' 1 15 4.7 0 6 0 0 1

*************** indicator of end of data *************************concentration data