CLEAN

Catchment Level Environmental Action Network

AFON NYFER RIVER NEVERN

Thriving waterways support flourishing communities, robust businesses and healthy environments.

Ariennir gan **Lywodraeth Cymru**
Funded by **Welsh Government**

Compiled and written by Richard Sylvester Additional material and editing Adam Dawson

Executive Summary

In the uncertain months of February and March 2021 the CLEAN project, undaunted by the restrictions of the COVID pandemic, enlisted a handful of volunteers to conduct a catchment-wide survey of water quality and the ecological health of the Afon Nyfer, the rather beautiful river flowing through the relatively unspoilt but economically valuable pasturelands and intimate wooded valleys of north Pembrokeshire, South West Wales.

The Afon Nyfer wends its way from its source near Crymych on the slopes of the Preseli Hills in the east, to the estuary at its mouth in Newport/Trefdraeth to the west. From the bare slopes and wide views of Frenni Fawr, 395m above sea level, the Afon Nyfer descends swiftly through the tightly packed fields of Blaenffos, Pontglasier, and Crosswell, then on into the wooded valley that characterises much of its route to the sea.

Despite its largely rural character, large sections of the Nyfer catchment fail to achieve 'Good' status, required by the Water Framework Directive. Sadly, this is far from the exception – less than half of rivers in Wales are in good ecological health. There is understandable concern about the poor health of the country's waterbodies and the CLEAN project provides some timely and important insight into the complex causes of poor water quality in our rivers, streams and springs.

Driven by Growing Better Connections, a Cwm Arian Renewable Energy initiative, with support and funding from Pembrokeshire Coast National Park Authority, West Wales Rivers Trust, Pembrokeshire Nature Partnership, Newport Area Environment Group (NAEG), Newport Town Council, Nevern Community Council, and others, the project used the invaluable power of citizen science and committed volunteers to provide the feet on the ground, a sharp eye and a sampling tube.

Over three sampling periods 23 individuals surveyed 82 points and tested nearly 300 water samples from the myriad small rivers, tributaries, streams, ditches, and springs across the Afon Nyfer's six sub-catchments, most of which are rarely, if ever, visited by monitoring authorities.

The results show high levels of nutrient pollution – nearly 60% showed High or Very High levels of Nitrate pollution, and almost a quarter (22.3%) showed High or Very High levels of Phosphate pollution, this latter appearing closely related to the higher rainfall at the start of the sampling period.

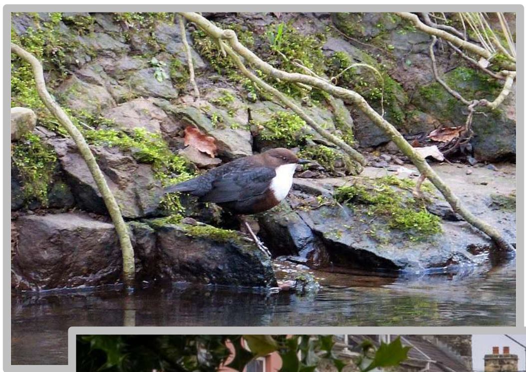
In addition, the volunteers gathered information regarding adjacent land use, Invasive Non-native plants, observations of litter and possible pollution, providing a rare and detailed record of the catchment.

Arguably, it is the nutrient levels that is the most eye-catching component of the survey. There seems little doubt that the pollution levels across the catchment are a cause for concern and further investigation. The presence of several Dŵr Cymru/Welsh Water treatment plants and their associated discharge points merit further investigation, and the contribution of point and diffuse pollution, from agricultural run-off and intensive livestock management practices is widely recognised.

The Nyfer catchment is dominated by improved grassland sward and dairy cattle, rough pasture and roaming sheep. Statistics record a significant increase in the size of the dairy herd in recent years, and a marked intensification of dairy farming. This, in turn, has brought land management challenges, particularly with slurry storage and management, and a likely increase on nutrient loads and run-off, ultimately impacting water quality.

The farming sector is an important contributor the local and national economy, but the battle to maintain margins in an ever more challenging food supply system comes at a cost, often caried by the environment. As discussed in the report, a long-standing, UK-wide policy of cheap food has come at a price to farmers, rural communities, and, above all, the environment.

The results from the CLEAN project demonstrate an urgent need for further investigation and a solution-focussed second phase. The final section of the report provides recommendations for a second phase of the CLEAN project; actions to enhance the Afon Nyfer, working across the whole catchment to restore habitats and maximise the benefits for both communities and wildlife.



Acknowledgements

Thanks must firstly go to the volunteers, without whose time this project would not have happened at all – your efforts are much appreciated. Hopefully see you all for Phase 2.

Thank you to Sue Burton and the SWEPT team for the inspiration and the gift of PackTest Nitrogen Kits and NRW for providing the phosphate test kits. Credit is also due to Sue also for allowing the use of so many SWEPT materials and excerpts from the SWEPT report.

Thanks to Paul Harries who convened the first meeting to discuss this project with community councillors and NAEG and invited Growing Better Connections to get involved.

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Credit is due to Growing Better Connections hosted by Cwm Arian Renewable Energy for co-ordinating the project, developing a methodology to deliver it despite COVID restrictions, preparing the survey materials, gathering data and feedback, supervision and editing of this report.

Finally, thanks to the members of the Steering Group, for their time, experience, proof-reading and recommendations as well as general support and good sense.

Acknowledgement must also be made to QGIS, Ordnance Survey and the OS Data Hub (https://osdatahub.os.uk/), and http://lle.gov.wales/home for GIS and maps.

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Other photos provided by Richard Sylvester and the project volunteers.

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Introduction

The declining ecological health of rivers has been of long-standing concern, brought into focus in recent years by the Water Framework Directive, which introduced a comprehensive river basin management planning system to monitor and help protect and improve the ecological health of rivers, lakes, estuaries, coastal waters and groundwaters[1]. A recent report from Natural Resource Wales (NRW) found that less than half of rivers in the country were in good ecological health. The reasons behind the poor ecological status of rivers are many and complex but in order to tackle the causes of this decline a full picture of river catchments and all that impacts them is required.

As a rule, river catchments are large, hydrological matters are complex and resources are limited, meaning that the root causes of ecological deterioration can be hard to pin down. Despite long-term monitoring by NRW and others, for the most part only the larger waterbodies in Wales are regularly monitored, with the result that there are large gaps in our knowledge. The myriad streams that carry waters from the land, meeting and combining, flowing together and becoming one, ultimately to meet the sea – many of these are unnamed and rarely visited, and yet they collect, on their way, all that is dropped and left, spread and sprayed, leached, leaked and lost from the land. Without some understanding of, and data from, these many small waterbodies, we will not be able to address the issues that affect the freshwater environment.

Citizen science, defined as the collaboration of scientists and members of the public in data monitoring and collection, has long been recognised as an effective means of gathering information about the environment, often from sources far beyond the scope of statutory authorities. Citizen science projects are increasingly used as a way to address knowledge gaps and raise awareness of environmental issues.

In 2018-19 a citizen science-led project was undertaken in the Milford Haven Waterway. The SWEPT (Surveying the Waterway Environment for Pollution Threats) project aimed to provide 'localised information on nutrient pollution entering the Milford Haven waterway' and 'improve awareness of the impacts of land run-off on the marine environment'[2].

The project was soon recognised as being transferrable to other waterways and catchments and was of particular interest to Newport Town Council, and environmental and community groups in and around Newport, Pembrokeshire. The historic and popular coast town of Newport/Trefdraeth nestles alongside the estuary and the old port of Parrog, fed by the swift-running waters of the Afon Nyfer (River Nevern). From the bare uplands at the Nyfer's source to the wooded valleys of its lower reaches, to the tidal mudflats and beaches at the river's mouth, the Afon Nyfer is at the heart of the town and its surrounds.

Although stretches of the Afon Nyfer are reported as being in good health, large parts are ecologically degraded and under pressure[3]. In response to the challenge of restoring and enhancing healthy

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[1] *Water Framework Directive implementation in England and Wales*, DEFRA and the Welsh Government, May 2014 (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/307788/river-basin-planning-standards.pdf)

[2] SWEPT Report, 2019

[3] *Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary,* Natural Resources Wales, 2016

habitats in and along the Afon Nyfer, a network of nature conservation and community organisations was formed, co-ordinated through the Growing Better Connections project. This network included Community Councillors and representatives from Pembrokeshire Coast National Park, West Wales Rivers Trust, Pembrokeshire Nature Partnership, Newport Area Environment Group (NAEG), chaired by Cwm Arian Renewable Energy (CARE).

The members of the network recognised that more could be achieved by working together towards common aims. Towards the end of 2020 a Steering Group was formed that would create and drive a new project, the Catchment Level Environmental Action Network (CLEAN), with a focus in the Afon Nyfer.

It is intended that the project will be delivered in two phases and provide opportunities for local volunteers to get involved:

Phase 1: Consult with local groups and individuals who have an interest in the river, and survey to establish baseline information about its current state of ecological health.

Phase 2: Develop a strategy, and secure funding, to support landowners to implement nature-based solutions that will aim to improve habitats in the long term. This will include more comprehensive surveying, including kick-testing to assess invertebrate populations (an important indicator of long term ecological health); initiatives to reduce litter and pollution; monitoring and controlling invasive non-native species; tree planting, buffer strips, wetlands and habitat management.

This report is the product of Phase 1 of the CLEAN project.

1 Why this project

The water quality and overall ecological health of waterbodies in Wales has come increasingly to the fore in recent years, with a raft of monitoring initiatives, sector-specific reports, policies and regulations, most recently the Control of Agricultural Pollution Regulations, announced in January 2021, and coming into force in April 2021.

Natural Resources Wales, as the statutory agency responsible for administering the Water Framework Directive (WFD – see Section 3.1), conduct regular monitoring of the larger rivers, lakes and tidal waters of Wales, assessing water quality and ecological health. Indeed, a 'walkover survey' of the Afon Nyfer, including some of its main tributaries, has recently been carried out by Afonydd Cymru and West Wales Rivers Trust on behalf of NRW[4]. The survey was undertaken to identify issues and assist with the preparation of fisheries restoration plans, in particular identifying opportunities for habitat and catchment management improvements aiming to improve salmonid numbers.

Such surveys are essential to provide crucial information on the health of waterbodies and would ideally be carried out regularly across the whole river system. However, NRW resources are limited and most of the smaller waterbodies within the freshwater system of Wales are rarely, if ever, visited.

The health of any waterbody is a direct result of the waters flowing into it. Waters draining from the land, via groundwater and run-off, will carry all the sediment, nutrients, chemicals, litter, all the

[4] *Nevern Fisheries Habitat Report* (Working Title), Afonydd Cymru on behalf of Natural Resources Wales, 2021 (Draft, not yet published, or indeed seen by the author at the time of writing.)

detritus of modern-day life and living, via rivers and estuaries to the sea, ultimately affecting the quality of the bathing waters and beaches at the river's mouth.

Understanding the health of the waterbodies that fall under the auspices of the WFD is therefore dependent on understanding the health of the myriad small streams and springs, seepages, drains, pipes, ditches and culverts, that empty, bright and urgent, slow and stagnant, seasonal, permanent, perennial, flashy and ever-changing, into waters ever larger, until they come to the notice of the monitors with their electronic equipment and test tubes.

The CLEAN project, following in the footsteps of the Earthwatch's FreshWater Watch project[5], the Freshwater Habitats Trust's Clean Water for Wildlife[6] and, most pertinently, the SWEPT project, was developed to gather data and observations of these smaller rivers, streams, ditches and outflows, and provide some understanding of water quality across the whole catchment of the Afon Nyfer, from its source in the uplands of the Preseli Hills to the estuary at Newport/Trefdraeth.

For the stakeholders involved in the project, a key objective was to provide a baseline for the nutrient levels (Nitrate and Phosphate) in the waters of the Nyfer catchment. But with a group of volunteers, other useful information about the waterways could be collected. The benefit of the citizen science model is having local, committed and enthusiastic 'feet on the ground', who are able to use their local knowledge and time, a sharp eye and a sampling tube, to provide observations from the smallest of streams – the landscapes, wildlife and activities that characterise and form them. Other observations of interest were therefore included in the survey in order to build a more detailed and informative picture of the rivers, streams and ditches of the catchment.

The information gathered is, hopefully, the start of a catchment level database; information that could help to restore river health and habitats and enable all of us to maximise the benefits to wildlife and the communities within it.

One further point to be made is perhaps a little subjective: the Afon Nyfer is a rather beautiful little river flowing through a relatively unspoilt yet economically valuable part of South West Wales. For all that, it is often rather neglected in the literature, either being lumped with its sister river the Afon Gwaun, or given a brief mention after its bigger brethren, the Eastern and Western Cleddau. There is relatively little written about the Afon Nyfer, and some might say it merits a little more attention.

2 What are the main issues?

2.1 WFD and Ecosystem Health

The Water Framework Directive (WFD) is the main legislative tool for monitoring and improving the ecological status and functioning of UK waterbodies, coming into force in December 2000 and incorporated into UK law in 2003.

NRW is the agency responsible for administering the WFD in Wales, with the aim of

- protecting the water environment from deterioration
- achieving the wider objectives of other European Directives

[5] https://freshwaterwatch.thewaterhub.org/

[6] https://freshwaterhabitats.org.uk/projects/clean-water/

- aiming to achieve good overall status for surface and ground waters.

The framework seeks to reduce pollution, improve the condition of aquatic ecosystems, promote the sustainable use of water and reduce the effects of floods and droughts. It has introduced a consistent approach to water management and applies to all surface freshwater bodies, including lakes, streams and rivers as well as estuaries and coastal waters out to one mile from low water. The WFD establishes a target for all waters, with a number of parameters, including insects, plants and fish, water chemistry and other markers of a healthy and robust ecosystem.

The WFD classification system for water quality is based on five classes – High, Good, Moderate, Poor and Bad. Despite improvements in water quality over the last 25 years, not least due to improvements in sewage discharges, 63% of freshwater waterbodies defined by the WFD were not achieving 'Good' status in 2015. None were 'High' – see Figure 1 below[7].

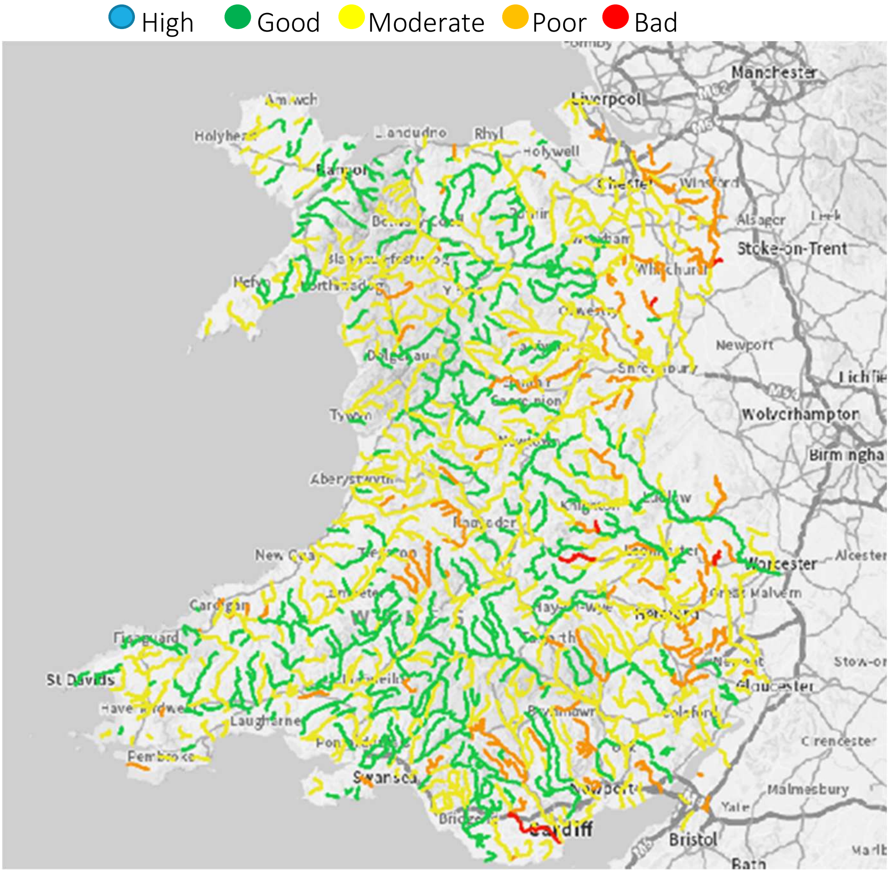

Figure 1: Water Framework Directive Status of Welsh Rivers - 2018

There are a number of reasons a waterbody may fail to achieve 'Good' status, some, including modification of the waterway, not directly connected to water quality. However, the majority are directly or indirectly associated with various types of pollution, although tellingly, a high number of Reasons for Not Achieving Good Status (RNAGS) are either unknown (pending investigation) or due to suspect data[8].

[7] http://lle.gov.wales/catalogue/item/WaterFrameworkDirectiveWFDManagementCatchmentCycle2?lang=en

[8] *Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary* https://cdn.cyfoethnaturiol.cymru/media/679390/2016-updated-pembrokeshire_catchment_summary_nrw.pdf?mode=pad&rnd=131596369400000000

Water quality and flow in freshwater habitats corresponds closely to the condition of, and activities in the surrounding terrestrial habitats - any developments and land management activities that occur within a river's catchment will affect the ecological health and quality of the water therein.

The prime source of poor water quality is, unsurprisingly, pollution, both point source and diffuse: point source pollution enters a waterbody at a specific site such as a pipe discharge from a specific source: a factory, mine or water treatment works; diffuse pollution occurs when potentially polluting substances leach into surface waters and groundwater as a result of rainfall, infiltration and surface runoff.

Over recent years efforts to identify and control point source pollution have been relatively successful, but diffuse pollution remains a significant and increasing problem. According to NRW, 'As our control of regulated discharges has become increasingly effective, the significance of other sources of pollution has become more evident.'[9]

Identifying and reducing diffuse pollution is difficult – individual sources can be limited or minor and take place over large areas; when it comes to pollution of groundwater, it can happen over long timescales. However, when taken collectively, diffuse pollution has a significant impact on water quality and the ecological health of our rivers. In January 2013, NRW estimated that at least 35% of WFD waterbodies in Wales were failing due to diffuse pollutants.[10]

2.1.1 Sources of Diffuse Pollution

Sources of pollutants can be both agricultural and non-agricultural activities. Non-agricultural pollution comes from many sources and is made up of a large number of pollutants, not just Nitrate and Phosphate. According to NRW, the main sources of diffuse pollution are, in no particular order:

- industrial estates
- small, private sewage discharges
- drainage misconnections
- surface water drainage from developed areas
- livestock management
- land management
- storage (slurry, fuel, oils, chemicals)
- mine waters

According to the report, *Diffuse Water Pollution in Wales*, there are over 50,000 known septic tanks in Wales discharging partially treated waste into the ground. Figures from NRW's Consented Discharges into Controlled Waters dataset indicate that there are 22 permitted discharge sites in the Nyfer catchment, 8 Dŵr Cymru/Welsh Water sites (Sewage Treatment Works, Combined Sewer Overflows (CSO) and wastewater treatment works), and 14 private sites. (Note - their inclusion here does not imply any specific pollution risk.)

Drainage misconnections are considered a major source of urban diffuse pollution. As a rule, they are problematic in sewage systems where foul water and stormwater are transported in separate systems

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[9] *Diffuse Water Pollution in Wales: Issues, solutions and engagement for action*, NRW
[10] Ibid, p3

– foul water to sewage treatment works, stormwater emptying into rivers and streams via gutters, downpipes and roadside storm drains.

If, for example, a new *en suite* bathroom or washing machine is erroneously connected to the stormwater system, the foul water, or grey water, emptying from them, which should be sent for treatment at the local sewage works, instead empties into the nearby river via a drainpipe or storm drain. This is a misconnection.

It must be said that, in the context of the CLEAN project, most of the area is served by a combined sewer system (CSS). A CSS collects rainwater runoff, domestic sewage, and industrial wastewater into one pipe, and, under normal conditions, transports it to a sewage treatment plant for treatment before it is discharged to a water body. Therefore, misconnections may not be such a serious a problem in the Nyfer catchment. However, combined sewer systems can cause point source pollution: in times of intense or prolonged rainfall these systems may become overwhelmed, with the result that the combined stormwater and foul water is discharged untreated into the river system through Combined Sewer Overflows (CSO). Discharges from CSOs operate (for the most part) under permits from NRW and are monitored. They are, however, still a potential source of poor water quality, especially as the climate changes and intense rainfall events become more common, resulting in the potential for the system to be overwhelmed more frequently.

Other diffuse sources include more general run-off activities (including car washing, car and other transport contaminants and pollutants, salting of roads in winter, use of herbicides and pesticides on domestic and municipal property, faeces from pets and other non-livestock animals[11], pet flea treatments[12]) as well as construction sites, industrial estates, contaminated land and contaminated urban rivers.

Given the rural character and the significance of the agricultural sector in much of Wales and not least, in Pembrokeshire, pollution from rural areas, including livestock and poor land management practices, is the largest source of diffuse pollution in the Cleddau and Pembrokeshire Rivers catchment[13] and is covered in more detail below.

2.1.2 Nitrate and Phosphate

Polluting substances are many and varied, and many different chemicals can be found in our waterbodies. Detecting most of these chemicals requires laboratory analysis and was beyond the scope of the CLEAN project. However, it is possible to detect two significant (and often indicative) pollutants, Nitrate and Phosphate, quickly and cheaply with a simple test kit. Nitrate and Phosphate are two of the more important and widespread pollutants associated with diffuse pollution. A focus on Nitrate and Phosphate levels across the Nyfer catchment was, therefore, one of the main objectives of the CLEAN project.

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[11] The author recalls a conversation with the conservation manager at Wimbledon Common some years ago, who related that water quality in the river flowing through the Common suffered a significant spike in Nitrate and Phosphate levels after a heavy rainfall event as a result of the dog mess washing into the river.

[12] http://www.sussex.ac.uk/broadcast/read/53897

[13] *Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary* https://cdn.cyfoethnaturiol.cymru/media/679390/2016-updated-pembrokeshire_catchment_summary_nrw.pdf?mode=pad&rnd=131596369400000000

Nitrate and Phosphate are, it must be said, essential for plant growth and thus all terrestrial life, so to label them as pollutants is a little simplistic – they are nutrients. However, when found in excessive quantities they profoundly change the freshwater environment. At this point they should be regarded as pollutants. Waters with excess levels of nutrients are referred to as eutrophic.

Sources of Nitrate and Phosphate

Nitrate is easily dissolved and transported in surface water and groundwater. Sources include animal wastes, sewage effluent, fertilisers, and the primary source of nitrate pollution is agriculture and land management practices.

Sources of Phosphate include sewage sludge and treated water from sewage treatment works (primarily from food waste, urine and excreta, and detergents) – generally point sources. Diffuse sources include animal waste and slurry, and particulate and soluble phosphorus fertilisers. Phosphorus freely attaches to soil particles and will end up in field run-off, and in field drains and ditches, especially during wet weather.

Use of sewage sludge, animal wastes and slurry as fertilisers is a good use of a readily available resource, an otherwise waste product. However, as improvements are made to the quality of sewage effluent discharges, the relative contribution of diffuse agricultural sources of phosphorus increases in importance and focus is turning to nutrient management and the use of animal wastes and fertilisers.[14]

Why are Nitrate and Phosphate a problem?

As already stated, Nitrate and Phosphate are plant nutrients and essential for plant growth, including crops and grass pastures. In excess however, these nutrients cause increased and often unwelcome plant growth, especially of plants like duckweed and algae, a large group of simple, non-flowering, and typically aquatic plants. Most of the algae we come upon are seaweeds, green scums and the filamentous blanket weeds in ponds and rivers and that smother mudflats, visible at low tide. Often of more concern are the toxic, vibrant blue-green algae (technically a cyano-bacteria) that cause the temporary closure of parks and reservoirs.

Under the right temperature and nutrient levels, excessive blooms of algae can occur that reduce light levels beneath the surface, affecting plant and invertebrate life on the stream bed. As the algae dies and decomposes, the decomposing organisms use up the oxygen in the water, leading to de-oxygenation, severely impacting fish and other aquatic organisms. At their worst, mass fish kills can result from these de-oxygenation events.

The Senedd is taking action to reduce diffuse pollution. For example, £4.5m has been announced to tackle pollution from mine water sources and a Diffuse Water Pollution in Wales plan has been produced by NRW. However, increasingly, agricultural practices have come under the spotlight.

In December 2017, the Cabinet Secretary for Energy, Planning and Rural Affairs indicated that nitrate pollution from agriculture needed to be tackled to improve water quality. This would comprise a balance of 'comprehensive regulatory measures, voluntary measures and investment'. The Ministerial Statement indicated that agricultural use of nitrates, while vital to help plants and crops to grow, is a

[14] Foundation for Water Research: https://fwrinformationcentre.co.uk/html/sources-of-pollution---diffuse-pollution.html

major source of water pollution and that 'poor nutrient management is still a major problem across Wales'.[15]

Most recently, in January 2021, the Control of Agricultural Pollution Regulations were announced by Lesley Griffiths, Minister for Environment, Energy and Rural Affairs. The Water Resources (Control of Agricultural Pollution) (Wales) Regulations 2021 establish good practice requirements for nutrient management and are intended to reduce losses of pollutants from agriculture. They set rules for practices such as silage making, storage of silage effluent and for slurry storage systems.[16]

3 Agriculture and Land-use in Pembrokeshire

Water quality is intimately connected with the condition of the surrounding terrestrial habitats. Around 85% of Welsh land is used for agriculture or forestry or is common land, by far the biggest influence on land and land use in Wales.

Agriculture is a vital sector and a significant component of the Welsh economy. Agriculture in Wales generated an estimated Gross Value Added (GVA) of £457 million in 2017 (GVA = value of output – intermediate consumption + net tax.) This represented 0.8% of the total GVA for Wales for that year and 4% of the total UK GVA for agriculture. Agriculture represents a higher percentage of the Welsh economy than it does for the UK as a whole (0.6%)[17]

In terms of employment, the 2013 June Agricultural Survey estimated there were 2,279 active farms in Pembrokeshire, with 1,700 full-time principal farmers and 2,086 part-time principal farmers. In addition, farmers employed 780 regular workers and 643 casual workers. There are a further 400 jobs in land-based support activities, hunting and fishing, wholesale of agricultural machinery, equipment, and supplies, and retail of flowers, plants, seeds, fertiliser, etc.[18]

Pembrokeshire is among the more rural of Welsh counties, fourth in terms of population density behind Powys, Ceredigion and Gwynedd, and approximately half the national average.

Agriculture is the dominant land use in the region – the three counties that make up south west Wales (Ceredigion, Pembrokeshire and Carmarthenshire) collectively have around one third (just under 360,000 ha) of the permanent grass in Wales[19]. The area farmed is approximately 140,000 ha, up from approximately 125,000 ha in 2002, of which 12% is used for crops and horticulture. The remainder, 88% is grassland – permanent pasture, rotational grassland or rough pasture – which supports 308,000 sheep and 175,000 cattle, 80% of which are used primarily for dairy production.[20]

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[15] https://gov.wales/written-statement-nvz-consultation

[16] https://gov.wales/sites/default/files/publications/2021-03/water-resources-control-of-agricultural-pollution-wales-regulations-2021-guidance-for-farmers-and-landmanagers.pdf

[17] *Agriculture in Wales 2019*, Welsh Government, 2019 https://gov.wales/sites/default/files/publications/2021-03/agriculture-in-wales-evidence.pdf

[18] *Economic Profile of Pembrokeshire Final Report*, 2015, PACEC/Pembrokeshire County Council

[19] *Agriculture in Wales*, Welsh Government, 2019.

[20] *Agriculture in Wales*, Welsh Government, 2019. https://gov.wales/sites/default/files/publications/2021-03/agriculture-in-wales-evidence.pdf

Regional Distribution of Agricultural land in Wales ('000ha) – from *Agriculture in Wales 2019*

	Arable	Permanent grass	Rough grazing (sole rights)	Rough grazing (commons)	All other land on agricultural holdings	Total
North West Wales	28.3	150.0	82.6	21.2	15.7	297.7
North East Wales	42.5	147.6	39.5	21.8	10.8	262.1
Powys	50.4	272.7	69.0	70.4	25.3	487.8
Ceredigion	20.4	102.9	26.2	12.0	9.5	173.4
Pembrokeshire	42.3	96.9	8.5	5.8	17.5	162.9
Carmarthenshire	23.9	159.6	11.0	15.1	13.7	227.0
South Wales	39.3	136.0	23.4	34.0	104.2	246.5
TOTAL Wales	**247.1**	**1,065.6**	**260.2**	**180.3**	**154.2**	**1,857.4**

Early potato growing is locally important (the county produces 50% of Welsh potatoes), but sheep rearing and dairy farming dominate. Dairy farming in particular plays an important part in the local economy – milk contributes 31% of total Welsh agricultural output, 25% of which is produced in Pembrokeshire.

The importance of the dairy sector in both Wales as a whole, and Pembrokeshire in particular, is undoubted. However, recent years have seen an increase in agricultural intensification across the country, not least in response to increasing market pressures and falling profit margins. Numbers of livestock and herd size are increasing – the size of the Welsh dairy herd increased by 12.5% between 2012 and 2017, while the number of producers declined by 9.4% over the same period. The average herd size has doubled.[21] Understandably, this change has been particularly marked in areas suited to dairy production, including South West Wales (see Figure 2, below – the darker blue indicates higher density, shown as dairy cows per sq. km[22]).

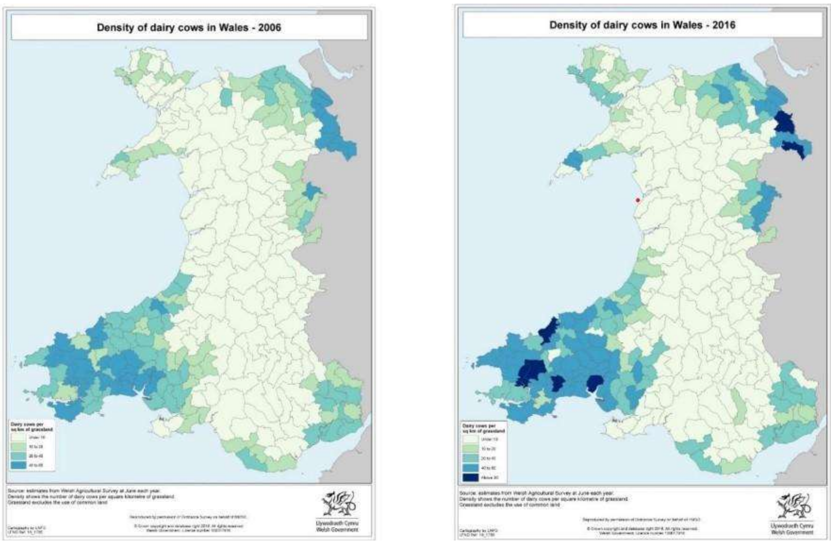

Figure 2: Density of dairy cows 2006-2016 (from Tackling Agricultural Pollution, WLMF, 2018)

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[21] Ibid

[22] *Tackling Agricultural Pollution,* Progress report by the Wales Land Management Forum (WLMF) sub-group on agricultural pollution*,* April 2018

Between 2007 and 2017, cattle numbers in Pembrokeshire increased by a little over 1500 head. However, closer inspection reveals that, although net change in cattle numbers is small, there has been a significant shift from beef to dairy farming. The last decade has seen an increase of nearly 20,000 dairy animals, with a likely corresponding increase in slurry and in fertiliser use as pasture comes under greater pressure. This herd expansion has, in some cases, occurred without providing equivalent slurry storage, and with a lack of understanding of the true impacts of agricultural pollution.[23] In addition, there has been a 50% increase in sheep numbers, from 119,000 to 301,473, albeit down from 580,00 in 2016.

Intensification of dairy farming has seen significant land management changes and, to a lesser extent, changes in cropping. For example, larger amounts of slurry and manure may be applied within a smaller area, and dairy farms are increasingly planting maize as a forage source, a potential cause of soil erosion and increased sediment in waterbodies, although more research is advocated on this issue[24]. Secondly, increased stocking rates and land management activity tend to increase soil compaction, with a corresponding increase in soil run-off after intense or prolonged rainfall events.

The intensification of agriculture also comes at a price to the integrity and resilience of the natural environment. The vast majority of grassland in Wales (over a million hectares) is agriculturally improved, with only about 192,000 ha semi-natural grassland (9% of the land cover of Wales.) Although the rate of loss of semi-natural grassland is thought to have slowed, 97% of dry lowland grassland habitat has been lost since the 1930s and has become highly fragmented in many areas[25].

4 The Afon Nyfer (River Nevern)

For the purposes of river management in Wales, the Nyfer Catchment is part of the Cleddau and Pembrokeshire Coastal Rivers Management Catchment, an area of high conservation and landscape value, with several Special Areas of Conservation (SAC) and Sites of Special Scientific Interest (SSSI), as well as Special Protection Areas (SPAs) along the coast. The catchment is predominantly rural in nature, with a strong sense of place and of great value aesthetically and economically. The agriculture and tourism sectors are of particular importance.

In March 2014 a Cleddau and Pembrokeshire Coastal Rivers Management Catchment workshop captured the perceived benefits of the Pembrokeshire rivers and their catchments, including the natural beauty of the coastline and landscape, the wildlife, and biodiversity, but also the vibrant rural community and economy[26]. The catchment of the Afon Nyfer encapsulates these perfectly.

The Afon Nyfer wends its way from its source near Crymych on the slopes of the Preseli Hills in the east to the estuary at its mouth in Newport/Trefdraeth to the west. From the bare slopes and wide views of Frenni Fawr, 395m above sea level, the Afon Nyfer descends swiftly through the tightly

[23] *Tackling Agricultural Pollution,* Progress report by the Wales Land Management Forum (WLMF) sub-group on agricultural pollution, April 2018, p9
[24] *Ibid.* p30
[25] *State of Natural Resources Report (SoNaRR): Assessment of the Sustainable Management of Natural Resources. Technical Report.* Natural Resources Wales.
[26] *Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary 2016,* NRW

packed fields of Blaenffos, Pontglasier, and Crosswell, then on into the wooded valley that characterises much of its route to the sea.

The Nevern Valley, along with the Gwaun Valley to the south and west, forms part of an extensive lowland wooded valley system, narrow and enclosed, often characterised as intimate. Said to be some of the best examples of semi-natural oak woodland in the region, much of it is ancient woodland (i.e. woodland that has persisted for at least 400 years), often wet, and dominated by alder, sessile oak and willow. The wooded valley sides are interspersed with small agricultural fields, predominantly improved and semi-improved pasturelands on the lower slopes, merging to rough pasture on the higher ground.[27]

In essence, the catchment encapsulates the natural beauty of the area.

Figure 3: The landscape of the lower Nyfer catchment, looking toward Newport/Trefdraeth

At the mouth of the Afon Nyfer lies the small town of Newport/Trefdraeth – an important local commercial centre and tourist hub, bustling in summer, popular as a tourist destination, its beach and estuary being a draw for locals and day-trippers, birdwatchers and coast path walkers. As such, the beaches and bathing waters of Newport are an important consideration when it comes to the status of the Afon Nyfer.

As discussed, streams and rivers are typically affected by sewage and industrial discharges and vulnerable to diffuse pollution, all of which may reduce water quality at the receiving bathing water. The Afon Nyfer is known to have an impact on bathing water quality at Newport. Other than the River Nyfer, there are several other small streams which drain into the bay. Following heavy rain, high flows in these rivers and streams may magnify the impact of diffuse pollution sources to this bathing water.

[27] *Pembrokeshire Coast National Park LCA 26 - Cwm Gwaun/Afon Nyfer*, PCNP 2011

Owing to its relative size the River Nyfer is likely to be the dominant source of faecal indicator organisms at Newport Beach following rainfall.

Currently, Newport beach does not have Blue Flag status, and is one of only three beaches in Pembrokeshire achieving ‘Good’ rather than ‘Excellent’ status, according to compliance with revised Bathing Waters Directive, 2015.[28]

The river is one of three Salmonid rivers in Pembrokeshire and the Nevern Angling Association is an active and important stakeholder in the valley. According to the NRW catchment summary[29], the streams and rivers are abundant with brown trout, although whether this is true of all the streams in the Nyfer catchment is less clear and a more detailed analysis of juvenile fish monitoring / electro fishing data (where it is available) would be beneficial. Some evidence, including observations from anglers relating to catch returns, would suggest a decline in fish species generally but further monitoring is required to establish the current status of fish populations in the Nyfer system.

A note on soils

Soils provide ecosystem services such as retaining and releasing clean water within river catchments, and buffering, filtering and transforming and storing contaminants. The soils of a large proportion of the Nyfer catchment are free-draining loamy soils, but with significant areas of slowly permeable seasonally wet soils with relatively high clay content scattered throughout[30]. As such, run-off is significant in wet weather, making the Afon Nyfer a so-called spate river, meaning its level rises and falls very quickly after heavy or prolonged rain, and also that water quality is particularly affected by rainfall events.

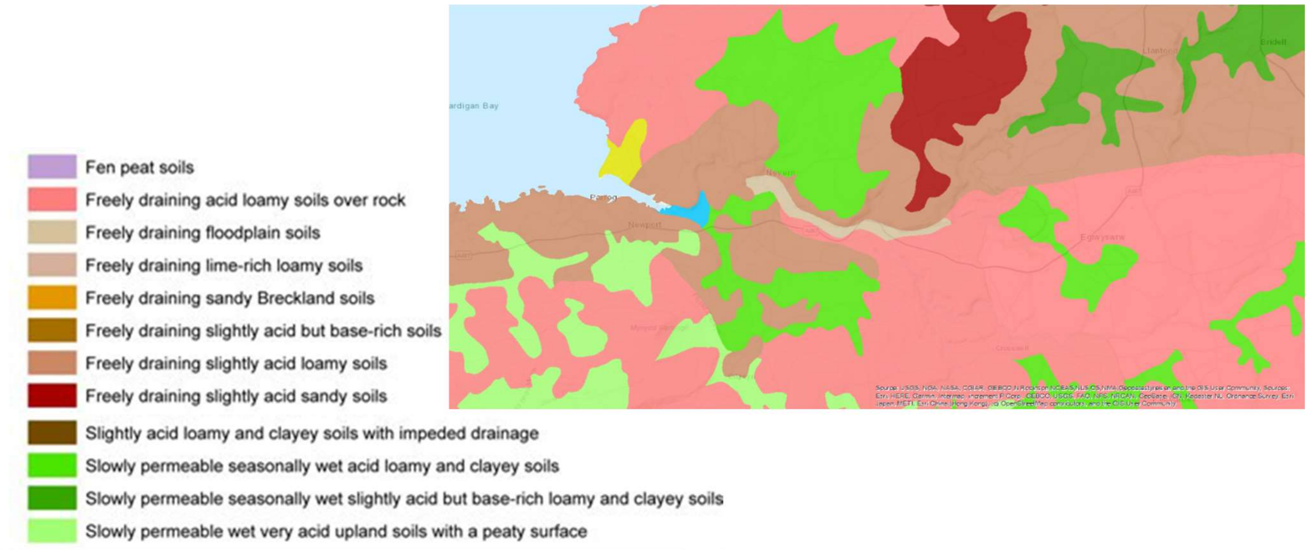

Figure 4: Soil types of the Nyfer catchment

4.1 The health of the Afon Nyfer

The Water Framework Directive (WFD), as already stated, provides the major overarching framework for river basin management in the UK and is implemented through River Basin Management Plans. Investigations are conducted to assess the general ecological health of each of the waterbodies within

[28] https://waterwatchwales.naturalresourceswales.gov.uk/en/

[29] *Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary*, NRW, p5

[30] http://mapapps2.bgs.ac.uk/ukso/home.html

the catchment. Standards for water plants, invertebrates and fish are reported on, along with other elements like sediment, ammonia and dissolved inorganic Nitrogen, and indicators of the impact of a range of known/suspected pressures on rivers, such as nutrient enrichment, toxic pollution, oxygen depletion, acidification, barriers to fish migration, and damage to river habitats caused by modifications to riverbeds and banks are also documented.

There are three River Basin Districts in Wales, each responsible for developing a River Basin Management Plan. The Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary supports the wider Western Wales River Basin Management Plan and details the status of each of the rivers in the county.

The most recent report (2015-2021) states that, within the Cleddau and Pembrokeshire Rivers Catchment, 42% of surface waterbodies have 'Good' status, 51% are 'Moderate', 5% are 'Poor' and 2% are recorded as 'Bad'. There are no water bodies with 'High' status.

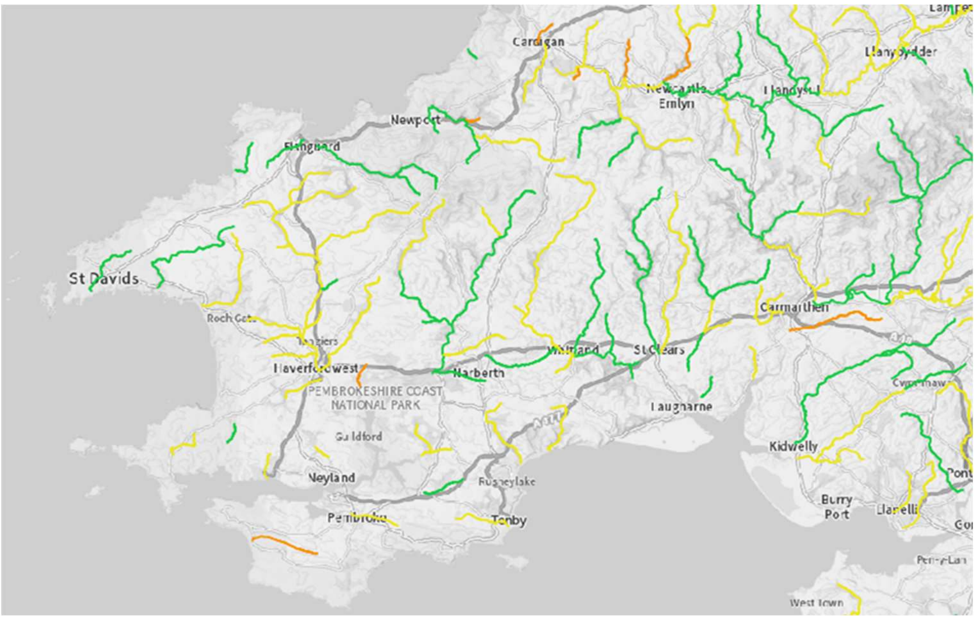

Figure 5: Water Framework Directive Status of Pembrokeshire rivers

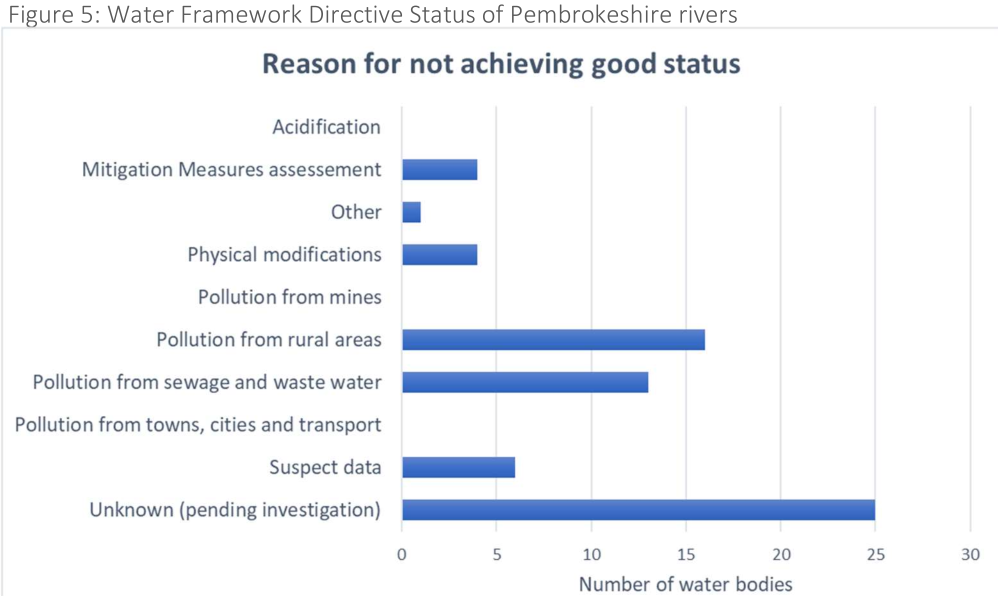

Figure 6: Reason for Not Achieving Good Status – Cleddau and Pembrokeshire Coastal Rivers

The table overleaf (Fig.6) shows the reasons for not achieving 'Good' status[31]. Tellingly, a large proportion of the reasons are either unknown (pending investigation), or a result of so-called mitigation measures. Despite the WFD aim to achieve 'Good' status for all rivers, in a number of cases it has been decided that this is not possible within the timeframe of the relevant management plan. In these instances, the waterbody fails due to mitigation measures. The Nant Duad is one such river.

The Afon Nyfer, along with the Western Cleddau and the Syfynwy, is reported as failing to achieve good status due to agriculture and rural land management. Notably, eleven other rivers in the county are thought to be failing for the same reason.

The WFD currently divides the Nyfer catchment into five sub-catchments. From the source to the estuary, they are: the Headwaters to the confluence with the Brynberian, the Brynberian, the Nant Duad, the Clydach, and the Nyfer, from the confluence with the Nant Duad to the tidal limit. The final part of the study area is the Nyfer Estuary and streams running to the coast. Each is subject to separate assessment as part of the WFD based on a limited number of waterways sampled.

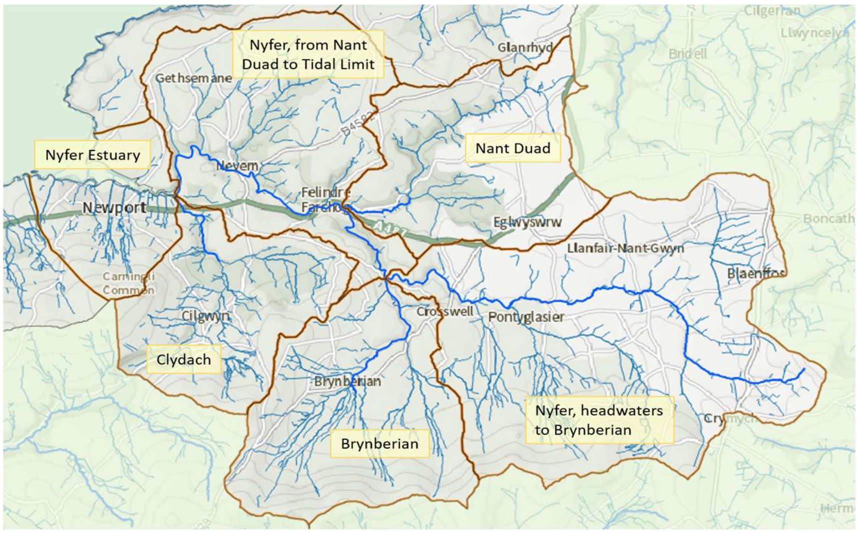

Figure 7: Afon Nyfer sub-catchments

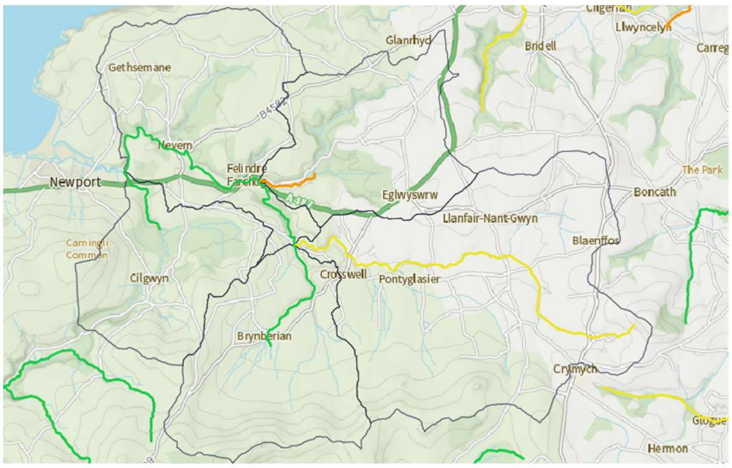

Figure 8: Water Framework Directive Status of Afon Nyfer sub-catchments

[31] *Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary*, NRW, p5 https://cdn.cyfoethnaturiol.cymru/media/679390/2016-updated-pembrokeshire_catchment_summary_nrw.pdf?mode=pad&rnd=131596369400000000

Figure 9: Afon Nyfer and its tributaries. Note: 'Nyfer in spate' was taken before survey period (Photos by CLEAN volunteers)

The status of the Nyfer sub-catchments, as per the 2018 interim figures,[32] are shown below. Of the five river catchments, three receive 'Good' status (Brynberian, Clydach, Nyfer, from the Nant Duad to the tidal limit), one 'Moderate' (Headwaters to the Brynberian), and one 'Poor' (Nant Duad). The Nyfer Estuary and tidal waters is assessed as 'Moderate'.

However, it is worth mentioning that the rivers of the Nyfer catchment changed status between the 2013 interim classification (below left, from the document linked on the NRW website [33]), and the updated report in 2015 (below right, from the Water Watch Wales website[34]).

Of particular note is the change in status for the 'Nyfer from the Nant Duad to the tidal limit' from 'Poor' in 2013 to 'Good' in the 2018, the 'Nyfer headwaters to confluence with Brynberian' from Good' in 2013 to 'Moderate' in 2018, and the Nant Duad was 'Moderate' in 2013 but classified as 'Poor' in 2018.

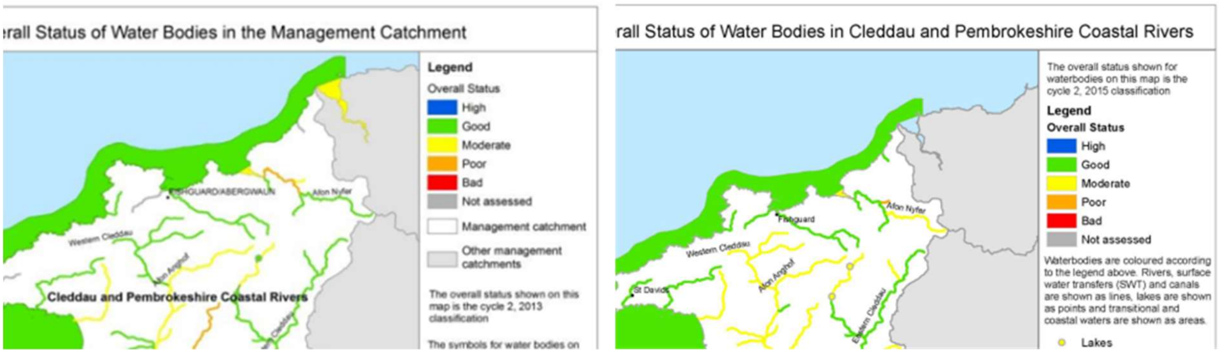

Figure 10: Changes of WFD status, 2013-2018

[32] https://waterwatchwales.naturalresourceswales.gov.uk/en/

[33] https://naturalresources.wales/media/3207/cleddau-and-pembrokeshire-coastal-rivers-management-catchment.pdf

[34] https://cdn.cyfoethnaturiol.cymru/media/679390/2016-updated-pembrokeshire_catchment_summary_nrw.pdf?mode=pad&rnd=131596369400000000

In addition, a document from 2014 has the Nevern catchment split into six river stretches and one transitional (estuarial) water body, the additional one being the ‘Nyfer, confluence with Brynberian to confluence with Duad’. This may have been done to separate out the respective influences on the Nyfer of the inputs from the Brynberian and the Duad. In this document, this short stretch was assessed as ‘Moderate’, with fish species being the failing element. This section appears to have been subsumed into the main ‘Nyfer, from Nant Duad to tidal waters’ sub-catchment, but does explain why this sub-catchment, despite its name, includes the section of river from the Brynberian to the Nant Duad on the maps.

The WFD analyses the reasons for each of the sub-catchments failing to reach ‘Good’ status, including reasons for the ‘Afon Nyfer, from Nant Duad to Tidal Limit’ sub-catchment, despite the 2015 update classifying this section as ‘Good’ (see above).

Catchment	Status (2015 classification)	RFNAG* - 2020 Update	Reasons for Not Achieving Good status (Summarised from 2016 Catchment Report)		
Headwaters to Brynberian	Moderate	Phosphate, Fish	2015 - Phosphate (unknown source, pending investigation)	2015 - Fish spp (unknown, pending investigation)	
Brynberian	Good	N/A			
Nant Duad	Poor	Fish, Macrophytes and Phytobenthos Combined, Phosphate	2015 - Phosphate (3 instances - point source from sewage discharge; diffuse source, pending investigation)	2014 - Fish spp (excess sediment from bank poaching)	2014 - Macrophytes and Phytobenthos spp** (pending investigation)
Clydach	Good	N/A			
Nyfer, from Nant Duad to tidal limit	Good (although the summary lists RNAG)		2013 - Fish spp (Ammonia - diffuse pollution from farm infrastructure)	2013 - Fish spp (suspect data)	
Nyfer Estuary	Moderate	Infaunal Quality Index***, Dissolved Inorganic Nitrogen, Invertebrates, Mercury and its compounds	2015 - Dissolved Inorganic Nitrogen (diffuse from farm infrastructure and point source from sewage discharge)	2015 - Chemical pollution (Mercury, pending investigation)	2015 - Invertebrate spp (pending investigation)

* Reasons For Not Achieving Good status
**Macrophytes (Vascular Plants) and Phytobenthos (mostly algae/seaweeds,etc.)
***Infaunal Quality Index - The abundance, diversity and the presence and/or absence of pollution-tolerant and disturbance-sensitive benthic (bottom-dwelling) invertebrates.

Figure 11: Reasons for Not Achieving Good status – Nyfer sub-catchments.

The most common reasons for failure are listed as Fish, and Phosphate (either from point source sewage discharge or diffuse pollution), with other reasons being high levels of Dissolved Inorganic Nitrogen, and impacted plant and invertebrate populations.

In summary, the latest data from the WFD investigations suggest that there are significant issues regarding the ecosystem health of the Nyfer catchment; issues that merit a closer look. All but two of the six sub-catchments are, or have been (in the case of the Nyfer, Nant Duad to Tidal Limit), recorded as failing to achieve minimum standards required by the WFD. And one, the Nant Duad, will continue to do so after the 2027 deadline for waters to achieve ‘Good’ status, having been ascribed so-called Less Stringent Objectives.

The CLEAN project is the first step towards restoring and enhancing healthy habitats in and along the Afon Nyfer.

5 Project Design

The CLEAN project was inspired by the success of the SWEPT project in the Milford Haven Waterway in 2018-19:

"SWEPT took its methodology from the inspiring Freshwater Habitats Trust Clean Water for Wildlife project (2015-2017) and the Earthwatch 'FreshWater Watch' citizen-led water quality monitoring programmes (see Biggs et al., 2016 and McGoff et al., 2017) using cheap and easy to use Kyoritsu PackTest kits. … To add value, surveys included recording of all pollution concerns, non-native species, and general things of interest." Excerpt from the SWEPT Project Final Report, March 2020.

It was soon recognised that the SWEPT project was transferrable to other catchments. Conversations about the possibilities and remit of the project took place with Sue Burton, SAC Officer, Pembrokeshire Marine Special Area of Conservation, with input and support from Newport Town Council, Nevern Community Council, Newport Area Environment Group (NAEG) and Growing Better Connections (GBC).

Growing Better Connections took forward the project, issuing invitations and chairing a project Steering Group consisting of the above organisations, plus the West Wales Rivers Trust, the Pembrokeshire Coast National Park Authority and the Pembrokeshire Nature Partnership. As the project progressed GBC lead on publicity and developed the methodology in compliance with the restrictions due to COVID 19. GBC prepared the survey materials, co-ordinated the volunteers, and gathered data and feedback from them. Richard Sylvester was commissioned as a consultant to prepare a training video and to develop the mechanisms to collate and interpret the data. He contributed his experience and further research in writing this report. Sue Burton secured funding for the consultancy from PCNPA and provided practical and moral support, including supplying the pack test kits with help from NRW.

The project was seen from the start as being a first, small-scale, pilot phase that would hopefully lead to a more comprehensive second phase, encompassing a broader set of aims and objectives. Phase 1 of the project set out to:

- Gather baseline of data that would establish the need for a more comprehensive second phase.
- Generate useful data to fill evidence gaps and help inform management of nutrient pollution.
- Support immediate NRW pollution prevention reporting.
- Raise awareness of nutrient pollution amongst communities within the Nyfer Catchment.
- Promote increased community engagement with the environment, health and wellbeing.

Nutrient pollution would be surveyed using Kyoritsu PackTest kits (simple Nitrate and Phosphate testing kits – see below). A number of the kits that had been supplied to the SWEPT project had gone unused, and GBC were able to secure these before they passed their best-before date. This allowed the project to go ahead, although meant there were limited kits available and limited time to use them. Phosphate kits were then sourced from NRW.

Learning from SWEPT and other projects before it, CLEAN was designed to complement, and not duplicate, existing initiatives already underway within the Nyfer catchment. The aim of the CLEAN project was to gain an understanding of the ecological health of the whole catchment through accessing the smaller tributaries and steams that are not routinely monitored by other agencies.

6 Methodology

The CLEAN project relied heavily on volunteers to survey selected waterbodies and take key observations and simple chemical tests.

Volunteers were asked to visit a pre-allocated area of the catchment on three occasions, at approximately fortnightly intervals – the end of February, the middle of March and end of March 2021. For reasons of safety and wellbeing, they were asked to work in pairs and, due to COVID restrictions, to restrict that pair to their 'bubble' travelling on foot from their home or work.

For each stretch of river, observations would be taken at each water input into the main stream that the volunteer came upon – a smaller stream, ditch, spring or outflow. These observations included information thought to be relevant in assessing the general state of the river and providing some possible insight into water quality: the surrounding land use and a description of the bank, any adjacent buildings or development, any litter or signs of fly-tipping, any signs of Invasive Non-native Species (INNS), possible pollution sources and any other observations of interest. Volunteers were asked to take photographs upstream and downstream of the water input and of any observations.

In addition, they were asked to take a sample of water, collected in a suitable container, in order to test Nitrate and Phosphate levels, two of the most significant contaminants of fresh water. Containers were rinsed to remove any contamination from previous samples. The majority of the sample points were inputs into the main river of whichever sub-catchment was being surveyed, but volunteers were asked to take a sample of their respective main stream at the end of their survey area.

Given time and resources, it was decided to sample on three separate occasions over 5-6 weeks, in the hope that different weather and flow rates may provide a representative average of results.

Overall, CLEAN was able to source 293 Nitrate kits and 200 Phosphate kits. Therefore, with three sample periods, each requiring a Nitrate kit for each sample point, a total of 97 or so sample points was theoretically possible. Less Phosphate kits were available, so volunteers were asked to sample for Phosphate only if the Nitrate result was above 1mg L^{-1}.

Kits were distributed according to the size of each volunteers' survey area and the anticipated number of sample points the volunteer was likely to cover.

6.1 Volunteer recruitment

The initial approach to volunteer recruitment was through a blog posted on the CARE website. This was circulated through CARE's social media channels and shared 29 times to other Facebook pages/profiles.

In addition, the Parish and Town Councils within the catchment were approached. Representatives of the NFU, NRW, PSAN (Pembrokeshire Sustainable Agriculture Network) and Young Farmers were also reached out to but did not respond.

A third communication was sent out by the various members of the Steering Committee to their respective membership lists.

The actual number of those reached with information about the project is unknown as no data was gathered about how many shared and forwarded details of the project.

Sadly, COVID restrictions and the small number of kits meant limiting the number of participants. However, by the start of the project 25 people answered the call to volunteer, of which 7 were unable to join due to the inability to travel during the lockdown period or because kits had already been allocated. There was a concentration of contacts based in and around Newport – the project was well-represented here, but less so higher up the catchment.

In the end, 18 volunteers were invited to take part, and maps allocated accordingly (see below). Some worked with survey buddies from their family bubbles. Surveys were undertaken, and results received, from all but one of these volunteers. A limited sweep of one missing section was undertaken by project staff at the end of the sampling period.

Ultimately, despite the limited number of kits and the COVID lockdown, most of the catchment was covered, albeit to varying degrees.

6.2 Selection of survey areas

The advantage of the citizen science model is that surveys can be done of a large number of small streams and outflows, many beyond the reach and resources of statutory agencies. For the survey, volunteers were asked to walk a stretch of river or stream and record observations of each inflow as they came upon them.

The selection of the areas to be surveyed was largely dictated by their accessibility to the volunteer, particularly given COVID restrictions that prevented anything but very local travel. For most, this required the surveys to be conducted within a brief walk from their house, or on their own land. In addition, a number of 'professional' volunteers (i.e. those who could legally travel a little further afield to undertake the sampling as part of their work) were allocated more remote or unrepresented areas to better cover as much of the catchment as possible.

A further consideration was to allocate areas that would be of interest to the volunteers. For example, members of the Newport Boat Club were asked to sample along the tidal waters upstream to the Iron Bridge; and members of the Nevern Angling Association were invited to visit stretches of river indicated in the maps on their website.

A significant limitation with the volunteer approach is the inability to access private land. Volunteers were instructed to access waterbodies only from safe and publicly accessible sample points. In several cases, it was also not possible to access smaller tributaries before they joined the main flow without landowner consent. In these cases, tests of the main channel at points below the confluence had to serve as a proxy for the additional nutrients or dilution contributed by that tributary.

Each of the volunteers was provided with a map of their survey area, and a brief outline of suggested target streams and confluences. The inability to offer a more comprehensive training day due to COVID restrictions, meant that volunteers were asked to use their initiative based on this relatively brief guidance, which resulted in some areas being missed. This was only noticed after the data had been collected. However, given the relatively small number of volunteers and kits, combined with lockdown restrictions, a pleasing spread of the catchment was achieved. A total of 18 survey areas were allocated (see Figure 12, below).

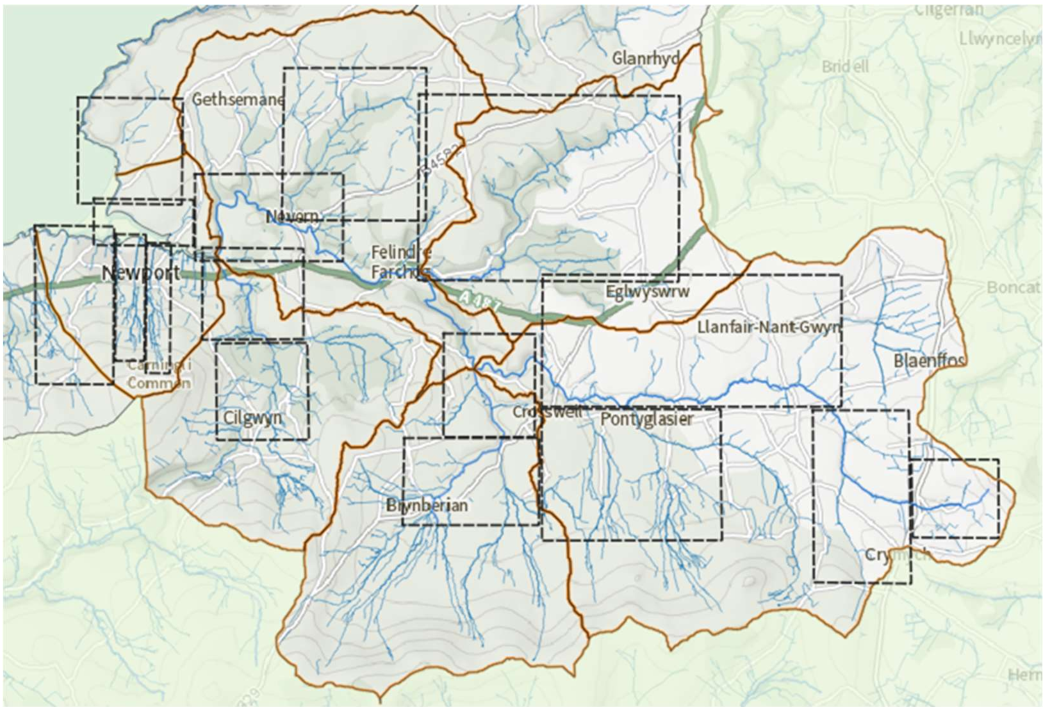

Figure 12: CLEAN Project Survey Areas

6.3 Volunteer training

Unfortunately, due to COVID restrictions, a training day was not possible. In lieu of a physical gathering a 19-minute video talking through and demonstrating the methodology was made and uploaded to the CARE YouTube channel. The video also included instructions on safety and wellbeing while collecting the water sample.

In addition, permission was gained to use the materials used by the Freshwater Habitats Trust's Clean Water for Wildlife and the SWEPT project. These were edited as appropriate and sent out as both electronic and hard copies with the test packs. As already mentioned, maps and some brief guidance in terms of the best and safest places to attempt to sample were given. In the main, the survey area allocated to each volunteer was on their 'home turf', which meant most had prior knowledge of the sample areas and their accessibility.

Many citizen science projects provide comprehensive training days for their volunteers. This has numerous benefits, both for the project and for the volunteer. Citizen science projects provide a fantastic opportunity to raise awareness, both about the specific interests of the project but also about the broader relevant environmental issues. Challenges facing conservation and environmental agencies can be discussed, and the value of the citizen science approach and contribution of the volunteers highlighted. This is incredibly valuable in ensuring the success of the project and can illicit longer-term behaviour change. Fully understanding the context and reasons why the data is important also helps to ensure that the data is collected as accurately as possible.

6.4 Water quality testing

At each sampling point, a sample of water was taken and tested, in situ, for two important nutrients, Nitrate and Phosphate. Simple Kyoritsu PackTest kits were used – small plastic tubes containing a small amount of chemical re-agent. The PackTest kits, WAK-PO4(D) and WAK-N03 respectively, measure phosphate-phosphorus with a minimum detection limit of 0.02 mg L^{-1} and nitrate-nitrogen with a minimum detection limit of 0.5 mg L^{-1}. The tests are based on colourimetry and judged by eye against a colour chart. The Phosphate test takes 5 minutes and the Nitrate test, 3 minutes.

Water samples were judged to have no evidence of pollution, or some, high or very high levels of pollution (see Figure 1, below). The CLEAN project based its results on the categories used by the Freshwater Habitats Trust during their Clean Water for Wildlife project.[35]

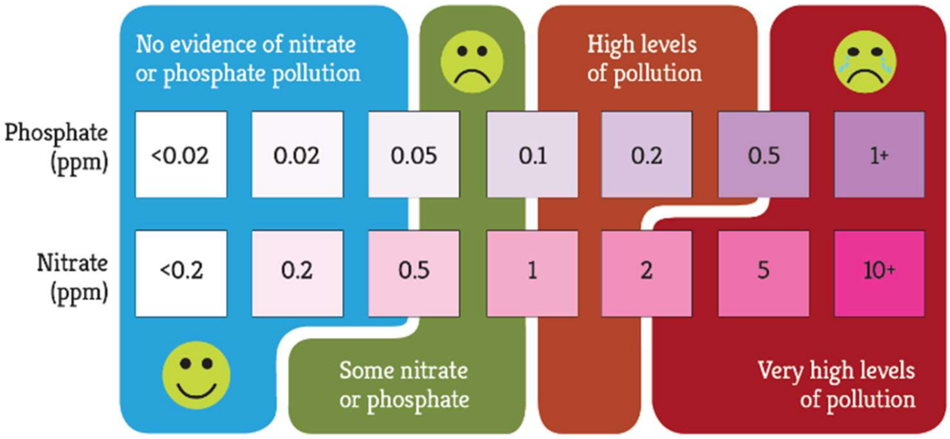

Figure 13: Relating nutrient levels to pollution category

6.5 Reliability of the Kyoritsu PackTests

Any opportunity to compare the Kyoritsu PackTests with laboratory testing was beyond the scope of the CLEAN project. However, several comparisons have been made in the past, both by the SWEPT project and by the Freshwater Habitats Trust as part of Earthwatch's Freshwater Watch project.

At the start of the Earthwatch Freshwater Watch project (2012-16) concerns were raised that such simple testing methods would not prove a reliable substitute for laboratory water testing. While it is acknowledged that there are some limitations with the PackTest kits used, the study conducted by Freshwater Habitats Trust revealed that, in fact, 'the kits can separate clean and polluted sites with sufficient reliability.' This was particularly true at the more extreme ends of the spectrum. Samples where the kits show no colour change are, indeed, very likely to have low nutrient levels (98% for phosphate, 81% for nitrate), and similarly, a sample displaying a strong colour change were likely to be polluted (95% for phosphate, 98% for nitrate)[36].

The tests proved less reliable for the waterbodies that tested as mildly polluted, with nutrient levels between 0.02 and 0.05 mg L^{-1} for Phosphate and in the range 0.2-0.5 mg L^{-1} for Nitrate. At these levels the kits were likely to over-estimate the number of least-polluted sites.

Overall, however, the research concluded that the kits performed well, broadly matching the results of laboratory analysed samples. They are 'highly unlikely to over-estimate the level of either phosphate or nitrate pollution in waterbodies'; and are 'a simple, rapid and cost-effective way to identify nutrient pollution, especially in large landscape-wide surveys where the costs of laboratory analysis are likely to be prohibitive[37].

[35] https://freshwaterhabitats.org.uk/projects/clean-water/

[36 ,37]Biggs, J., McGoff, E., Ewald, N., Williams, P., Dunn, F. and Nicolet, P. 2016. *Clean Water for Wildlife technical manual. Evaluating PackTest nitrate and phosphate test kits to find clean water and assess the extent of pollution*. Freshwater Habitats Trust, Oxford

A comprehensive comparison was also conducted as part of the SWEPT project – see Box 1 below:

Box 1: Water quality data – Laboratory versus SWEPT results

Alongside SWEPT sampling for the final survey in February 2019, three volunteer pairs also collected some water samples to be sent in to NRW for laboratory analysis. A total of 12 water samples were analysed and results are given alongside *in situ* SWEPT testing in Appendix 12. In addition to this small test comparison, NRW arranged for their monitoring team members to use SWEPT methodology and Kyoritsu PackTests alongside water collection during statutory monitoring between May and July 2019. A total of 25 samples were taken, and the results are presented alongside their simultaneous laboratory tests in Appendix 12.

Results showed some differences in the laboratory versus PackTest test results. Laboratory tests are assumed to be more accurate than in field PackTest kit results. For the purposes of SWEPT, the importance in the field is to ascertain whether a freshwater source is 'polluted' or not (nitrate above 1 mg/l and phosphate above 0.1 mg/l).

Some statistical tests were applied to see if differences were significant or if there was a pattern discernible. When analysed within the ranges of clean water, some evidence of pollution, and polluted (see section 3.4) the data is found to be normally distributed. Pearson's test shows a significant positive correlation at 5% between PackTest and laboratory nitrate data. Figure 12 illustrates the results of each sample pair comparison. For those comparisons where there was not a match in result, the PackTest kit is seen to consistently record a lower concentration.

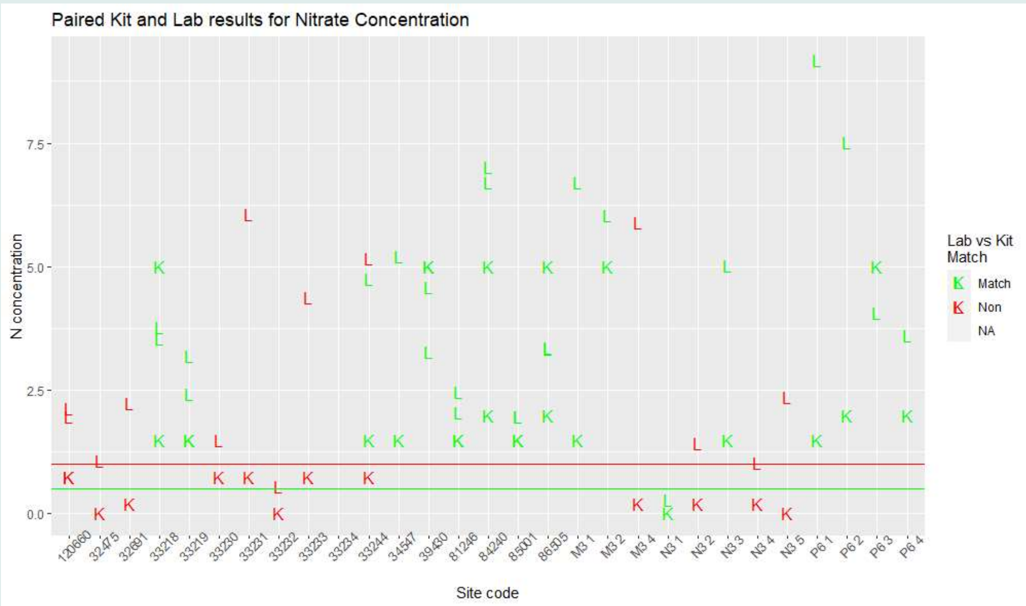

Figure 12: R Statistics analysis directly comparing Kit (PackTest) and Laboratory sample results for nitrate. Each column gives the results comparisons of a sample pair (K and L) or more at a single site. Results are compared according to whether they are in the categories of clean water (<0.5 mg/l), some evidence of pollution (0.5-1mg/l marked by the green line) or polluted (>1mg/l marked by the red line). If green, the pair shows a match. If red the pair is unmatched (e.g. kit is within the unpolluted range, but the lab result is in the range indicating some pollution).

Phosphate samples followed a similar pattern, although due to the very small concentrations of phosphate found, and the subsequent very small range in result, analysis would not have been meaningful.

Excerpt from the SWEPT Project Final Report, p37

It is also important to note two things – firstly, the judgement as to the colour change is somewhat subjective. To help mitigate this, volunteers were asked to record the range that the colour change corresponded to, rather than a specific number.

Nitrate ppm	<0.2	0.2-0.5	0.5-1	1-2	2-5	5-10	10+
Phosphate ppm	<0.02	0.02-0.05	0.05-0.1	0.1-0.2	0.2-0.5	0.5-1	1+

Secondly, the colour change can be compromised if the water sample is discoloured by sediment or other particles in the water column. Although clarity of the water was not tested as part of this project (using a Secchi disk, or similar), volunteers were asked to judge the clarity of the water by eye – only 10 of the 197 (5.1%) waterbodies from which data was recorded were judged to be anything other than clear.

6.6 Data submission and collation

The primary method for submitting data at the start of the project was via a Google form created to capture the data on the paper datasheets sent to volunteer at the start of the sampling period. A number of advantages were inherent in the Google form, including a standardised format for many of the fields through the use of dropdown boxes, and the ability to upload photographs straight into the form. However, not all volunteers could access or successfully enter data into the Google form so other methods were offered, including entering results into an Excel spreadsheet, sending photographs of the datasheet for transcription, or posting datasheets to the office.

The advantage of this approach was that everyone who collected data was able to send results in. The downside was that a huge amount of time was spent entering, copying and pasting, editing and tidying data, particularly since, in some cases, the spreadsheet and Google form did not have the same columns or consistent formatting. The survey forms can be found in Appendix 2.

Photos were sent via Google form, emailed, or sent via data transfer software such as WeTransfer. Data collation occurred as data came in following surveys and was carried out by the project team .

A checklist of completed surveys was maintained, and group emails sent out on a number of occasions reminding volunteers of the next sampling week and encouraging data to be uploaded or sent in. At the end of the sampling period emails were sent to individual volunteers to check all surveys had been completed and to ensure no data had gone astray.

6.7 Data Analysis

The CLEAN project was able to cover a large proportion of the Nyfer catchment and collected a significant amount of data, providing an invaluable initial record of nutrient levels of the Afon Nyfer, its tributaries and the many streams of its catchment. It also provided a great deal of fine detail, such as adjacent land-use, bank vegetation, occurrence of litter, INNS and much else.

The survey was conceived as the first phase of a larger project and had a relatively small amount of time, resources and volunteers. As a result, the data are spread fairly thinly across the catchment, with, for example, only seven data points being recorded for Nant Duad catchment. This being the case, it is difficult to draw any solid conclusions from the data and no robust statistical analysis of the data has been undertaken. However, the data has been mapped and some initial observations have been made.

Given the extensive sampling area and the level of detailed data recorded at each location and date (e.g. stream size and flow, Nitrate and Phosphate levels, etc), the data certainly merit a more detailed analysis and are available should further funding and resources allow.

7 Results

Data was collated into a spreadsheet and checked for any missing or obvious erroneous location points. Some considerable time was spent standardising entries, particularly due to the large number of people who entered their data into spreadsheets rather than using the Google form. Locations were converted from UK Grid References to digital degrees using the Grid Reference Finder website's Batch Converter[37], which saved a considerable amount of time. QGIS was then used for mapping the data, and creating additional maps, for example the survey areas, or the observations of INNS.

In addition, Excel spreadsheets were used to tabulate the data. Detailed analysis of the data is beyond the scope of this project, but a very basic level of sorting and analysis was attempted.

Data was collected from all the 18 survey areas over three sample periods – a total of 203 individual data points over the three sampling periods:

Sample Period 1 – 17 data sets, comprising 72 sample points

Sample Period 2 – 14 data sets, comprising 59 sample points

Sample Period 3 – 18 data sets, comprising 72 sample points

In most cases, reasons for not being able to complete a survey were COVID-related – either self-isolating or the burden of excess work and child-care responsibilities being the main reasons.

All but two points also included a PackTest sample result at some point in the sampling period – the two that did not were small streams that were not tested due to a limited number of testing packs.

In total, there were 82 different sample sites across all 6 of the sub-catchment areas, although due to different numbers of volunteers and differing number of inputs tested in each survey area, the number of sample points in each sub-catchment varied.

Sub Catchment	No. of Sample Points
Nyfer - headwaters to confluence with Brynberian	18
Brynberian - headwaters to confluence with Nyfer	12
Nant Duad - headwaters to confluence with Nyfer	7
Nyfer - Confluence with Nant Duad to tidal limit	14
Clydach - headwaters to confluence with Nyfer	15
Nyfer estuary and Coast	16
TOTAL	**82**

Figure 14: Number of sample points per sub-catchment

[37] https://gridreferencefinder.com/batchConvert/batchConvert.php

A little over half (46 out of 82) were small or medium sized streams flowing into either the Afon Nyfer itself or, in most cases, one of the main tributaries (e.g. the Brynberian, Nant Duad, Gammon, Clydach.) Seventeen of the sample points are on larger tributaries, mostly named and, broadly speaking, 2nd or 3rd order waterbodies[38], and a further nine from the Afon Nyfer itself, at various stages of its journey. Also described were four springs and one outflow from a marsh, two pipes, three ditches and a culvert.

Figure 15. The beauty and variety of the Nyfer catchment – Sample points, as captured by the CLEAN volunteers

[38] *As per* Hacks stream order, whereby the Afon Nyfer is Stream Order 1, a stream flowing into the Nyfer, e.g. the Nant Duad or Afon Gammon is Stream Order 2, a steam flowing into the Nant Duad is order 3, etc.

Time spent by each volunteer varied enormously, with some taking up to 3 hours to walk their section, some less than 30 minutes. Assuming another 30-60 minutes for people entering data, an average of 2.5 hours has been taken as an average time spent by each volunteer, for each sampling period. Over the course of the three sampling periods, the 17 participants were joined by 10 assistants and, between them, amassed approximately 162 volunteer hours of time.

7.1 Nitrate and Phosphate

As already mentioned, in assessing the nutrient levels, the PackTest kit ranges and thresholds for Nitrate and Phosphate used by the Freshwater Habitats Trust Clean Water for Wildlife project were used[39].

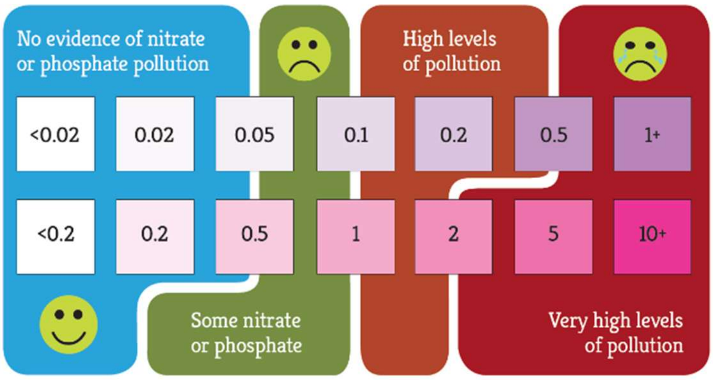

Figure 16: Testing for Nitrate

Of 103 samples tested for Phosphate, 23 (22.3%) showed High or Very High levels of pollution, with a further 18 (17.5%) showing some level of pollution. 62 (60.2%) showed no evidence of Phosphate pollution. Only 8 of 103 samples registered the higher levels (0.2-0.5 and 0.5-1mg L^{-1}), and none were more than 1mg L^{-1}. Notably, these high levels were found only in the first sampling period, soon after rainfall and when water levels were highest.

Phosphate was less of an issue than Nitrate in the Nyfer catchment, albeit it was tested for less often, due to there being less Phosphate kits available. This echoed results from the SWEPT survey on the Milford Haven Waterway.

It is clear from the results that the catchment as a whole suffers from significant Nitrate pollution levels. Of 195 Nitrate tests performed, 114 (58.5%) showed High or Very High levels of Nitrate pollution, with a further 27 (13.8%) showing some Nitrate pollution. Less than a third, 54 (27.7%) showed no evidence of Nitrate pollution.

For the full results, for each sample period, see maps below.

[39] https://freshwaterhabitats.org.uk/projects/clean-water/

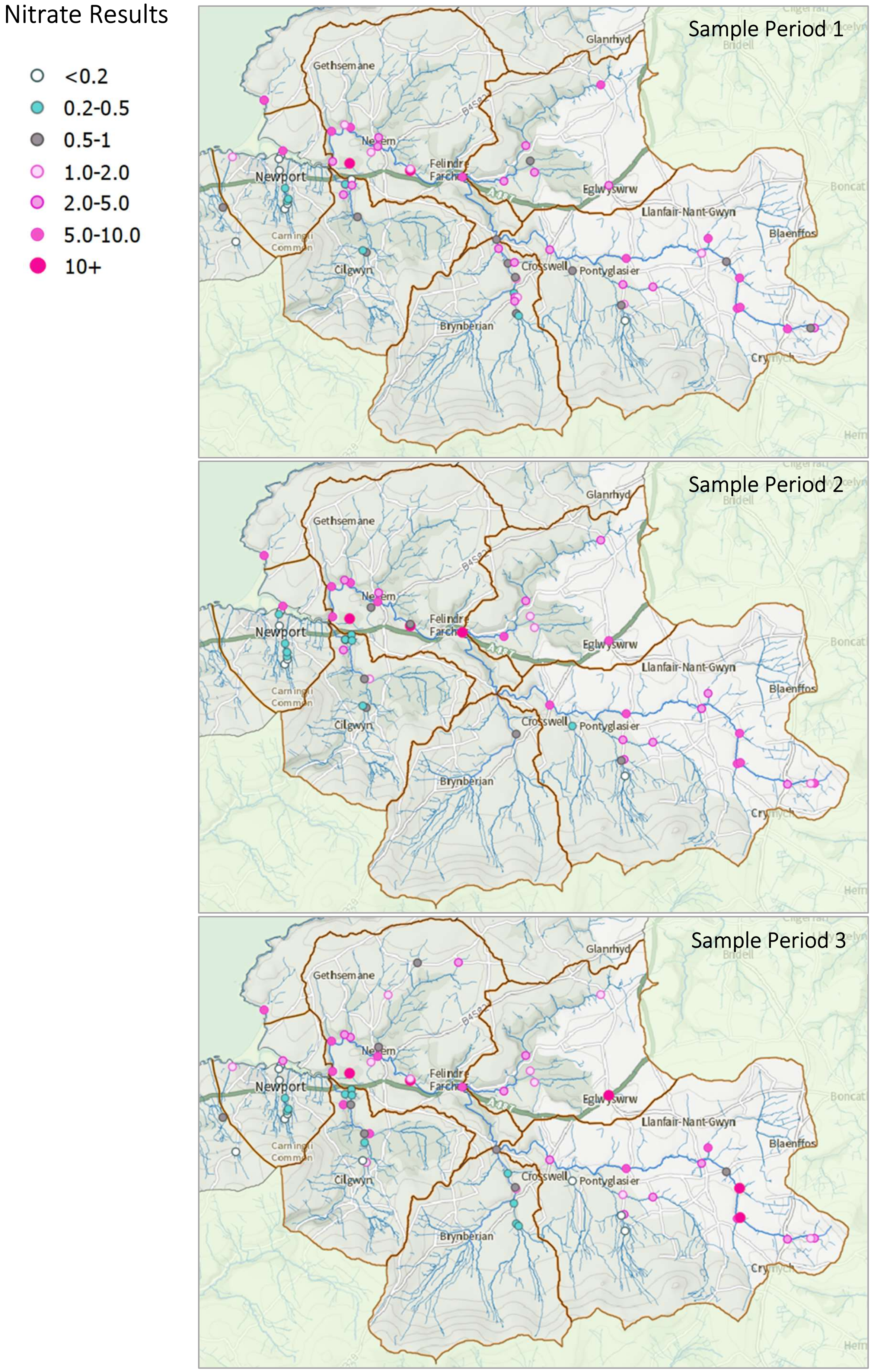

Figure 17: Nitrate results

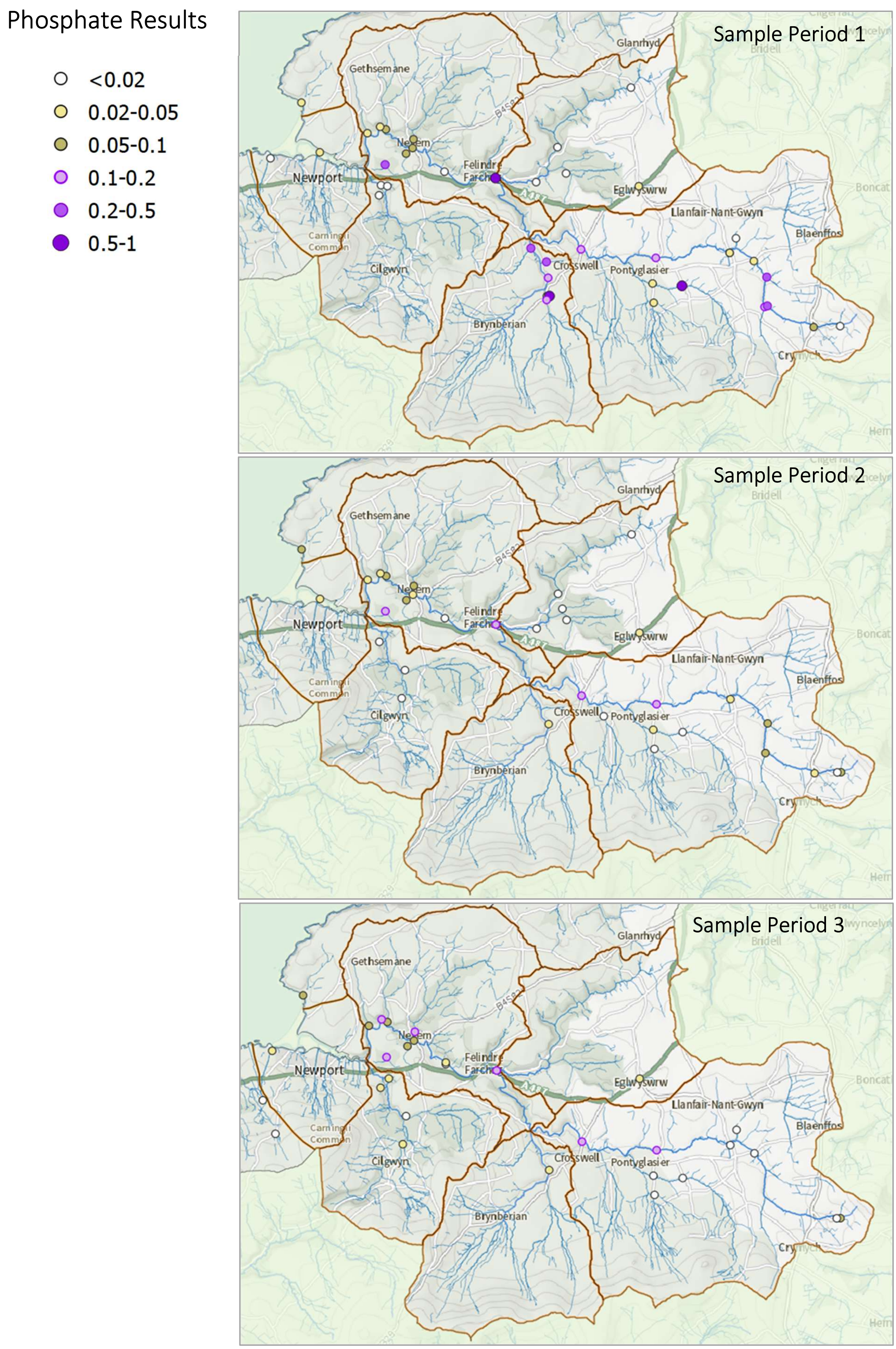

Figure 18: Phosphate results

It is noticeable that Nitrate pollution does vary significantly across the different sub-catchments and although a detailed analysis has not been undertaken, it seems fair to observe that, the results broadly correspond to the WFD status of the respective waterways.

Cursory analysis shows that the sub-catchments that did not achieve 'Good' status, the Headwaters to the Brynberian and the Nant Duad, show the highest records of High or Very High Nitrate pollution – 76.9%, 95.2%. For the 'Nyfer, from the Nant Duad to the Tidal Limit' sub-catchment, recorded as having 'Good' status in 2018 but 'Poor' Status in the interim figures from 2013, 88.2% of samples taken record a High or Very High level of Nitrate pollution.

Those catchments listed as 'Good' in the WFD Catchment Summary, the Brynberian and the Clydach, recorded the least levels of Nitrate pollution – 30% and 46.4% recording no Nitrate pollution, respectively. In the Clydach sub-catchment, 28.6% of sample sites had High or Very High Nitrate levels, relatively low compared to the rest of the catchment.

It must be said, however, that the small number of records in the Brynberian and Nant Duad sub-catchments make any reliable judgement unwise – 20 and 21 respectively, with only one record in the second Sample Period on the Brynberian sub-catchment.

The Estuary and Coast sub-catchment includes several small streams that run from the slopes of Carn Ingli and tumble to the sea between the streets and houses of Newport town. These streams almost exclusively recorded low or no Nitrate pollution. The estuary itself, the waters from the whole catchment spilling out into the sea, did record high levels of Nitrate, as did sample taken up the coast, north of the river mouth, although again, very few samples were taken here unfortunately.

A breakdown of the samples can be seen in Table 1. In this table the samples are listed by sub-catchment, each sub-catchment roughly in order, source to sea. Within each sub-catchment, samples are again ordered, from the 'top' of the sub-catchment to 'bottom'. A full breakdown, by sub-catchment can be found in Annex 1.

Wb ID	Catchment	Description	Adjacent Land Use	Sample 1		Sample 2		Sample 3	
				N	P	N	P	N	P
41	Nyfer - headwaters to confluence with Brynberian	Stream	Grazing, Wooded	2.0-5.0	<0.02	5.0-10.0	0.05-0.1	2.0-5.0	0.05-0.1
42		Stream	Grazing	0.5-1		1.0-2.0	<0.02	1.0-2.0	<0.02
43		Stream	Semi-urban	5.0-10.0	0.05-0.1	2.0-5.0	0.02-0.05	2.0-5.0	
21		Stream	Grazing, Wooded	5.0-10.0	0.1-0.2	5.0-10.0	0.05-0.1	5.0-10.0	
22		Afon Nyfer	Grazing, Wooded	5.0-10.0	0.2-0.5	5.0-10.0		10+	
23		Stream	Grazing, Wooded	5.0-10.0	0.2-0.5	5.0-10.0	0.05-0.1	10+	
11		Stream	Grazing, Wooded	1.0-2.0	<0.02	1.0-2.0	0.02-0.05	2.0-5.0	<0.02
12		Afon Nyfer	Grazing, Wooded	1.0-2.0	0.02-0.05	2.0-5.0			
13		Stream	Grazing	0.5-1	0.02-0.05			0.5-1	<0.02
14		Afon Banon	Grazing	2.0-5.0	0.5-1	2.0-5.0	<0.02	2.0-5.0	<0.02
15		Stream	Grazing	1.0-2.0	0.02-0.05	2.0-5.0	<0.02	2.0-5.0	<0.02
16		Afon Glynmaen	Grazing, Wooded	0.5-1		0.5-1		<0.2	
17		Stream	Grazing, Wooded	2.0-5.0	0.02-0.05	2.0-5.0	0.02-0.05	1.0-2.0	<0.02
18		Afon Tryllach	Grazing, Wooded	0.5-1		0.2-0.5	<0.02	<0.2	
2		Afon Nyfer	Grazing, Wooded, Garden	2.0-5.0	0.1-0.2	5.0-10.0	0.1-0.2	2.0-5.0	0.1-0.2
3		Afon Nyfer	Grazing, Wooded	5.0-10.0	0.1-0.2	5.0-10.0	0.1-0.2	5.0-10.0	0.1-0.2
4		Stream	Grazing, Wooded	<0.2		<0.2		<0.2	
5		Stream	Grazing, Wooded	5.0-10.0	<0.02	2.0-5.0		5.0-10.0	<0.02
72	Brynberian - headwaters to confluence with Nyfer	Tributary of Afon Brynber	Wooded	0.2-0.5				0.2-0.5	
73		Spring	Grazing, Wooded	2.0-5.0	0.02-0.05				
74		Outflow from marsh	Grazing	1.0-2.0	0.5-1				
75		Stream	Wooded	2.0-5.0	0.1-0.2				
76		Stream	Grazing, Wooded	0.5-1				0.2-0.5	
77		Stream	Grazing, Natural	0.2-0.5				0.2-0.5	
78		Afon Brynberian	Grazing, Natural	0.5-1				0.5-1	
79		Afon Brynberian	Grazing, Wooded	0.5-1				0.2-0.5	
81		Stream	Grazing, Wooded	2.0-5.0	0.2-0.5				
82		Stream	Grazing, Wooded	2.0-5.0	0.2-0.5				
80		Afon Brynberian	Grazing, Wooded	0.5-1				0.5-1	
56		Afon Brynberian	Natural	1.0-2.0	0.1-0.2	0.5-1	0.02-0.05	1.0-2.0	0.02-0.05
1	Nant Duad - headwaters to confluence with Nyfer	Stream	Grazing, Wooded, Semi-urban	2.0-5.0	0.02-0.05	5.0-10.0	0.02-0.05	10+	0.02-0.05
6		Stream	Grazing, Wooded	5.0-10.0	<0.02	2.0-5.0	<0.02	1.0-2.0	
7		Nant Duad	Wooded	2.0-5.0	<0.02	2.0-5.0	<0.02	2.0-5.0	
8		Afon Hafren	Wooded	2.0-5.0	<0.02	1.0-2.0	<0.02	1.0-2.0	
9		Stream	Wooded	0.5-1		1.0-2.0	<0.02	1.0-2.0	
10		Nant Duad	Grazing, Wooded	2.0-5.0	<0.02	5.0-10.0	<0.02	2.0-5.0	
55		Nant Duad	Natural	5.0-10.0	0.5-1	10+	0.1-0.2	5.0-10.0	0.1-0.2
44	Nyfer - Confluence with Nant Duad to tidal limit	Stream	Grazing, Wooded, Garden	10+	<0.02	10+	<0.02	10+	<0.02
45		Afon Nyfer	Grazing, Wooded	1.0-2.0		0.5-1		1.0-2.0	0.02-0.05
68		Stream	Grazing, Wooded, Garden					0.5-1	
69		Stream	Grazing, Wooded					1.0-2.0	
70		Stream	Grazing, Natural					0.5-1	
71		Stream	Grazing, Natural					2.0-5.0	
60		Afon Nyfer	Grazing, Semi-urban	2.0-5.0	0.05-0.1	5.0-10.0	0.02-0.05	5.0-10.0	0.05-0.1
61		Stream	Grazing, Wooded	1.0-2.0	0.05-0.1	0.5-1	0.05-0.1	1.0-2.0	0.05-0.1
62		Stream	Grazing, Wooded	10+	0.2-0.5	10+	0.1-0.2	10+	0.1-0.2
63		Afon Gamman	Semi-urban	2.0-5.0	0.05-0.1	2.0-5.0	0.05-0.1	2.0-5.0	0.1-0.2
64		River (Tributary)	Grazing, Wooded, Semi-urban	5.0-10.0	0.05-0.1	5.0-10.0	0.05-0.1	2.0-5.0	0.05-0.1
65		Afon Nyfer	Grazing, Wooded	1.0-2.0	0.02-0.05	2.0-5.0	0.02-0.05	2.0-5.0	0.1-0.2
66		River (Tributary)	Wooded, Garden	5.0-10.0	0.02-0.05	5.0-10.0	0.02-0.05	5.0-10.0	0.05-0.1
67		Afon Nyfer		2.0-5.0		5.0-10.0		5.0-10.0	
46	Clydach - headwaters to confluence with Nyfer	Stream	Wooded					<0.2	
47		Afon Clydach	Wooded	0.5-1		0.5-1	<0.02	1.0-2.0	0.02-0.05
48		Stream	Grazing, Wooded	0.2-0.5		0.2-0.5		<0.2	
49		Stream	Wooded						
50		Stream	Wooded						
51		Stream	Wooded					0.2-0.5	
52		Stream	Wooded	0.5-1					
53		Stream	Wooded			1.0-2.0	<0.02	5.0-10.0	<0.02
54		Afon Clydach	Wooded			0.5-1		0.5-1	
24		Stream	Grazing, Wooded	1.0-2.0	<0.02	0.5-1		0.2-0.5	
25		Afon Clydach	Grazing, Wooded	0.2-0.5		0.2-0.5			
26		Spring	Grazing, Wooded	2.0-5.0	<0.02	2.0-5.0	<0.02	5.0-10.0	0.02-0.05
27		Pipe	Wooded	<0.2		0.2-0.5		0.2-0.5	
28		Spring	Grazing, Wooded	2.0-5.0	<0.02	0.2-0.5		0.2-0.5	0.02-0.05
29		Spring	Wooded, Garden					0.5-1	
30	Nyfer Estuary and Coast	Stream	Grazing, Wooded	<0.2		0.2-0.5		<0.2	
31		Culvert	Urban	<0.2		<0.2		<0.2	
32		Stream	Wooded	<0.2		<0.2		<0.2	
33		Stream	Grazing, Wooded	<0.2		<0.2		<0.2	
34		Ditch	Grazing	<0.2		<0.2		<0.2	
35		Ditch	Grazing, Wooded	0.2-0.5		0.2-0.5		0.2-0.5	
36		Pipe	Grazing			0.2-0.5			
37		Ditch	Grazing, Wooded	0.2-0.5				0.2-0.5	
38		Afon Ysgolheigion	Semi-urban	0.2-0.5		0.2-0.5		0.2-0.5	
19		Stream	Wooded	<0.2		<0.2		<0.2	
20		Afon Nyfer	Grazing	5.0-10.0	0.02-0.05	5.0-10.0	0.02-0.05	2.0-5.0	
57		Stream	Grazing, Natural	1.0-2.0	<0.02			1.0-2.0	0.02-0.05
58		Stream	Grazing, Wooded	0.5-1				0.5-1	<0.02
59		Stream	Grazing, Wooded	<0.2				<0.2	<0.02
39		Beach below waterfall	Grazing	5.0-10.0					
40		Beach below waterfall	Natural	5.0-10.0	0.02-0.05	5.0-10.0	0.05-0.1	5.0-10.0	0.05-0.1

Table 1: Results of Nitrate and Phosphate tests, by sub-catchment

Although unable to claim any statistical significance, there is a small but notable reduction in the levels of both pollutants over the sample period, perhaps related to the rainfall and river levels (relatively high at the start of the period, to relatively low in Sample Period 3.) High or Very High Nitrate levels went from 60% to 55.7% (although the occurrence of Very High levels did increase from 3 to 5). High Phosphate levels went from 32.5% to 20% (there were no Very High Phosphate records across the sample period.)

In the tables below: 'n' is the number of samples recorded of each range in each sample period, followed by the percentage of the total. For each sample period, the third column is the combined percentage, namely No Pollution, Some Pollution, and High or Very High Pollution levels, as described above, p23.

Whole Catchment - Nitrate

	Sample Period 1			Sample Period 2			Sample Period 3		
	n	%	%	n	%	%	n	%	%
<0.2	9	12.9		6	10.9		12	17.1	
0.2-0.5	7	10.0	**22.9**	9	16.4	**27.3**	11	15.7	**32.9**
0.5-1	12	17.1	**17.1**	7	12.7	**12.7**	8	11.4	**11.4**
1.0-2.0	10	14.3		5	9.1		11	15.7	
2.0-5.0	17	24.3		11	20.0		13	18.6	
5.0-10.0	13	18.6		14	25.5		10	14.3	
10+	2	2.9	**60.0**	3	5.5	**60.0**	5	7.1	**55.7**
	70	**100**		**55**	**100**		**70**	**100**	

Whole Catchment - Phosphate

	Sample Period 1			Sample Period 2			Sample Period 3		
	n	%	%	n	%	%	n	%	%
<0.02	12	30.0		13	39.4		11	36.7	
0.02-0.05	10	25.0	**55.0**	9	27.3	**66.7**	7	23.3	**60.0**
0.05-0.1	5	12.5	**12.5**	7	21.2	**21.2**	6	20.0	**20.0**
0.1-0.2	5	12.5		4	12.1		6	20.0	
0.2-0.5	5	12.5		0	0.0		0	0.0	
0.5-1	3	7.5		0	0.0		0	0.0	
1+	0	0.0	**32.5**	0	0.0	**12.1**	0	0.0	**20.0**
	40	**100**		**33**	**100**		**30**	**100**	

Tables 2 and 3: Breakdown of Nitrate (top) and Phosphate (bottom) results across the whole catchment

7.2 Waterbody type

A brief look at Nitrate pollution levels in each waterbody type has been done, although this is of limited significance since it is a complex combination of stream order[40], waterbody type, size and flow, which would need considerably more robust analysis. Plus, it depends on volunteers' individual perception and use of terminology, which was not specified in the instructions (e.g. 'if it is less than 3m wide, call it a stream'.) However, for what it's worth:

Waterbody Type	No of Sample Sites	No. of Samples	Polluted	Some Pollution	No pollution	% Polluted
Spring/'Outflow from marsh'	5	9	6	1	2	**67**
Pipe	2	4	0	0	4	**0**
Ditch	3	8	0	0	8	**0**
Stream/Culvert*	46	102	56	12	34	**55**
Small river (usu. named tributary**)	17	46	27	13	6	**59**
Afon Nyfer	9	26	25	1	0	**96**
Total	**82**	**195**	**114**	**27**	**54**	**58.5**

*Includes the Afon Ysgolheigion (1.2m wide) and the two sample sites referred to as 'On the beach below waterfall'
**Includes two sample sites just referred as 'River (tributary)' but not Afon Ysgolheigion

Table 4: Nitrate and Phosphate results by waterbody type

All but one of the samples taken from the main Afon Nyfer were recorded as having High or Very High Nitrate pollution. More than half of the smaller, named tributaries and streams also recorded High or Very High levels of Nitrate pollution (59% and 55% respectively).

Interestingly, pollution levels were also high in the few 'spring' samples, suggesting some amount of groundwater pollution.

7.3 Pollution sources

Volunteers were asked to provide observation on perceived pollution sources – somewhat vague and subjective, and not to be regarded as proof of pollution, but a number of useful comments were made:

Four volunteers reported slurry being present, and two more that slurry was sprayed on occasion. In the WFD report, poaching[41] is one of the most common sources of water quality issues. Of the observation made by CLEAN volunteers, one observed grazing above the source and 22 suggested that livestock had access to the waterbody. That said, only one actually reported an incident of poaching of the riverbank. In addition, there were three comments regarding possible road run-off and an observation of white foam or froth.

[40] As per Hacks stream order, whereby the Afon Nyfer is Stream Order 1, a stream flowing into the Nyfer, e.g. the Nant Duad or Afon Gammon is Stream Order 2, a steam flowing into the Nant Duad is order 3, etc.

[41] Poaching is the name for damage done to grass and the underlying soil by livestock that have been allowed to stand and walk on it for prolonged periods in wet conditions. Commonly this occurs around unfenced rivers and streams as livestock come to drink, leading to soil erosion and impacting water quality. https://www.fas.scot/downloads/poaching-information-document/

7.4 Other observations

A key part of any citizen science project is the volunteers' presence on the ground – they are able to collect data and make observations of a large number of sites 'in the moment'. In keeping with the Earthwatch and SWEPT projects, CLEAN asked for observations on surrounding land use, bank vegetation, possible livestock access to the water, any nearby development, litter and any cases of fly-tipping, and sightings of Invasive Non-Native Species (INNS).

In most cases the volunteers recorded no change between each visit, although some variation in language was evident when recording land-use, bank side vegetation, etc.

Observations of INNS did vary, given the season – the sampling period coincided with the first signs of Himalayan Balsam and Japanese Knotweed. Similarly, the occurrence of litter did vary for each period, but it is quite likely the same litter may have been observed each time – records for the total number of sites with signs of litter rather than the number of individual observations is recorded.

7.4.1 Land use

Nutrient levels in waterbodies are invariably a factor of catchment size and surrounding land-use, with even low levels of land use change having an effect on water quality. As already mentioned, the majority of land in Pembrokeshire is improved grassland pasture, and this is echoed in the data – of the 82 sample sites, 56 recorded grazing land or agriculture as an adjacent land use. The lower reaches of the Nyfer catchment, particularly stretches of the Nant Duad, Brynberian, Clydach and the main Nevern Valley itself, are characterised by lowland oak and alder woodland. Again, this is reflected in the data – 59 of the sample sites recorded woodland or wooded habitats as an adjacent land use or bank vegetation. Most were recorded as a mix of natural vegetation and grazing land, with 14 having exclusively natural habitats directly adjacent. Only 7 were urban or semi-urban in nature.

Figure 20: The Nyfer catchment is characterised by wooded valleys and pasture

7.4.2 Invasive Non-Native Species

Invasive Non-Native Species (INNS) are exotic species, in this case plant species, introduced, either deliberately or accidentally, into the wild where, by their nature and having few native species to control them, they can become dominant. They are recognised as one of the main threats to biodiversity worldwide and cost the UK an estimated £1.7 billion annually[42].

The most widespread invasive, non-native plants in Wales are Himalayan Balsam *(Impatiens glandulifera*), Japanese Knotweed (*Fallopia japonica*) and Rhododendron (*Rhododendron ponticum*). These species can quickly outcompete native species and establish monoculture stands. They can compete with wildflowers for pollination, as their showy flowers attract bees away from smaller, less prolific species. Large stands of Himalayan Balsam and Japanese Knotweed on riverbanks break up native habitat connectivity, shading out other plants in the growing season and leaving bare soil in winter, which then becomes susceptible to erosion. Bank erosion in turn leads to sedimentation, which impacts aquatic habitat and therefore threatens aquatic life.

The Nature Action Recovery Plan for Pembrokeshire identifies INNS as one of six main threats leading to a decline in the condition and extent of existing habitats and species in the county. Objective 4.5 of the Recovery Plan is to 'encourage collaborative projects to tackle INNS at appropriate scales such as river catchments.'[43]

Past survey work on the Afon Nyfer undertaken by the Pembrokeshire Coast National Park (PCNP) and Newport Paths Group show that INNS are present along the entire river catchment. Some work has been undertaken to remove Himalayan Balsam on certain tributaries (e.g. the Clydach). The CLEAN project adds to the picture of the occurrence of INNS across the catchment.

Volunteers were provided with an illustrated guide to help with the identification of the main INNS (new growth as well as last years' growth/remains) and reminded to keep an eye out during the last survey period since at this point Himalayan Balsam and Japanese Knotweed were both beginning to sprout.

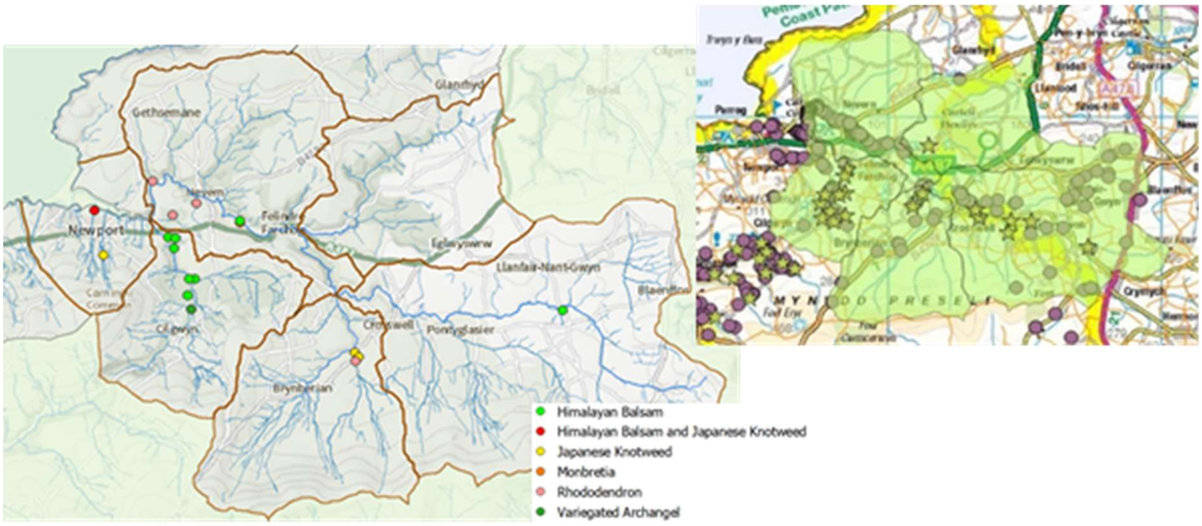

Figure 21: Map of INNS observed (Inset: map of INNS recorded by PCNP officers – purple circles indicate Himalayan Balsam)

[42] https://www.ceh.ac.uk/case-studies/case-study-invasive-non-native-species-monitoring-detection-and-prevention, accessed 30/10/2020

[43] Nature Action Recovery Plan for Pembrokeshire Part 1: Our Strategy for Nature Recovery, Pembrokeshire Nature Partnership, 2018

In the survey, INNS were recorded at 18 of the sample sites, mostly Himalayan Balsam and Japanese Knotweed, with five records of Rhododendron and one each of Montbretia and Variegated Archangel. This is very likely to be an under-estimation of the occurrence of INNS, even within the sites surveyed, let alone the catchment as a whole, partly because of the time of year, and partly because no specific training was given in terms of identification of INNS, or which species should be recorded. This is, perhaps, particularly the case for Montbretia and Variegated Archangel, both less recognised as being INNS. Certainly, surveys done by the PCNP show that Himalayan Balsam is widespread throughout the Nyfer catchment. (see inset map, below right – the purple circles indicate presence of Himalayan Balsam)

7.4.3 Litter

There were relatively few records of litter on the river sections of the catchment – two-thirds of volunteer visits (124 of 203) recording None/rare sightings of litter and another 17 describing litter as occasional, although clearly this is somewhat subjective. It should also be said that these may the same litter items recorded on each visit. Within the various sub-catchments only one volunteer described seeing anything approaching significant amount of litter, although the sample on the beach found much more, presumably washed up on the shore.

It should, of course, be noted that the project was carried out in the late winter/early spring and in COVID lockdown, thus without the usual local visitors, tourists and second-home owners swelling the population of the area. This is **not** to suggest that they are habitual litterers, merely that the less people there are, the less litter is likely to occur – it seems quite likely that this will have had an impact on the amount of litter generated and observed.

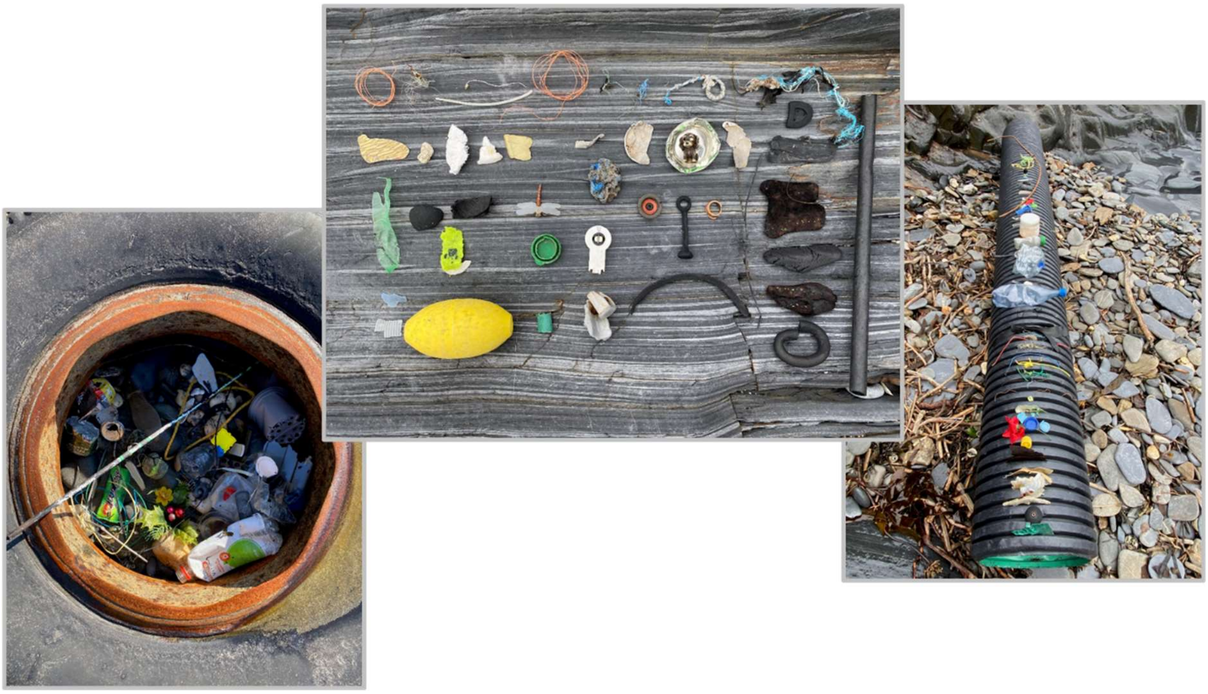

Figure 22: Litter collected from Newport Beach

8 Discussion

The aim of the CLEAN project was to provide a snapshot of a selection of indicators of the health of the Nyfer catchment's rivers and streams over a few weeks in the spring of 2021. Given the relatively limited resources available, and the restrictions imposed due to COVID-19, the coverage across the catchment was good. Volunteers visited 18 survey sections and returned data from 82 individual sample sites, although some of the sub-catchments were less well covered than others, notably the Estuary and the Nant Duad catchment.

It is worth noting that, even for a relatively small catchment, the sample is small, both temporally and numerically, for a full picture of the water quality and possible sources of nutrient pollution.

That said, given the relatively few volunteers, samples and observations were taken at a great many streams and water inputs that are unlikely to have been investigated before. As such, this small pilot was a success. It is hoped that a more detailed exploration of the waters of the Nyfer will follow. It certainly seems necessary.

There seems little doubt that the ecological health of the waters of the Nyfer catchment merit further investigation and discussion. The NRW catchment reports and maps state that the health of much of the catchment is good. However, from this initial survey, and purely in terms of Nitrate and Phosphate pollution, there are, perhaps, reasons for concern – just shy of 60% of the samples tested by the volunteers were recorded as having High or Very High levels of Nitrate pollution. In terms of Phosphate, levels were also High in certain parts of the catchment, particularly after the wetter weather of the early part of the sampling period.

The weather over the sample period went from very wet in the days before the sample period (to the extent that the weekend before the test kits were sent out the Afon Nyfer was 'bank-full' – see photographs below), to very dry by the end of the sampling period in late March/early April.

Figure 23: Photos of the same stretch of the Afon Nyfer taken at the beginning of the survey period, end February (left), and the end, early April (right)

This stark variation in rainfall and river levels offers a useful comparison of nutrient levels and run-off, although no analysis of this component of the data has been undertaken at this point.

Nutrient levels will vary according to the amount of run-off and the related measure of the flow of a waterbody – the observations taken at each sample point included an estimate of the width and depth and a subjective view of the flow. Volunteers were also asked for a view on the clarity of the water and whether there was any smell.

The majority of inputs were judged to be clear – all but 10 of the 202 (5.1%) samples taken, and few volunteers reported any smell, although in a few cases slurry smell was noted (7 of the 197 data sets, 4 of which also reported a brown or cloudy appearance.)

8.1.1 Phosphate levels

Potential sources of Phosphate pollution include both discharges from water treatment works and diffuse pollution from land management practises and infrastructure, including slurry spraying and storage. The CLEAN results show a short-term occurrence of higher Phosphate pollution in some sub-catchments, notably the Nyfer Headwaters – higher at the end of February/ beginning of March, lower at the end of March/beginning of April. Rainfall figures from the Aberporth weather station record the rainfall for the months of February, March and April as 119mm, 38.8mm, 10.6mm respectively. There was little, if any, rainfall between the Sample Period 2 and Sample Period 3 and river flows reduced noticeably over that period (see Figure 20 above.) This suggests a relationship between Phosphate levels and rainfall, perhaps as a result of a greater occurrence of stormwater spillages from Dŵr Cymru discharge points and/or increased agricultural run-off. The latter would generally be accompanied by an increase in turbidity, but since this was not part of the data collection this cannot be confirmed.

To recap, according to NRW research[44], within the Cleddau and Pembrokeshire Rivers catchment, the biggest point source of pollution affecting water quality is discharges from sewage treatment works and the biggest source of diffuse pollution is agricultural land management.

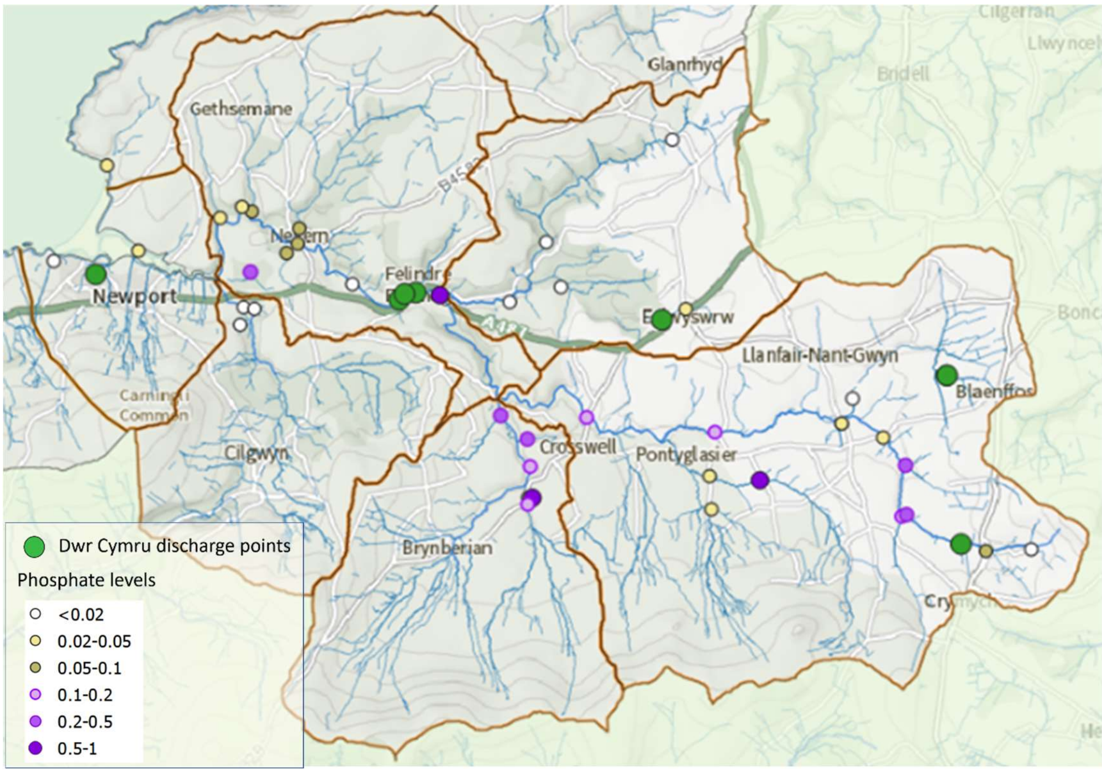

Figure 24: Map showing Phosphate levels for Sample Period 1 and sites of Dŵr Cymru discharge points

[44] *Cleddau and Pembrokeshire Coastal Rivers Management Catchment Summary Updated*, 2016, NRW

As to the former, there was no objective or intention to choose sample points close to the Dŵr Cymru water treatment works and Combined Sewer Overflows in the catchment, and no data was gathered with that in mind. In fact, as Figure 24 above indicates, there were no sample points near any of the discharge points – the nearest are two points on the Afon Nyfer north-west of Crymych, but they are some distance downstream.

However, Sewer Storm Overflow EDM Spill Duration Data for Wales are published as a list on the Dŵr Cymru/Welsh Water website, and sites of treated sewage discharges are available from the Consented Discharges to Controlled Waters with Conditions database, via lle.gov.wales. These data are collated by the Rivers Trust as part of their *'Is my river fit to play in?'* webpage[45] (see Figure 22, below).

Figure 25: Map of sewage discharge points (from Rivers Trust website, '*Is my river fit to play in?*'

According to the Rivers Trust map, there are 8 water company storm sewage overflows that empty into the Nyfer catchment, three without event duration monitoring. Of those that do monitor event durations, in 2020:

- Felindre Farchog Stw sewer storm overflow spilled 132 times for a duration of 2779 hours
- Blaenffos Wwtw sewer storm overflow spilled 107 times for a duration of 1608 hours
- Crymych Stw sewer storm overflow spilled 24 times for a duration of 292 hours
- Eglywswrw Wwtw sewer storm overflow spilled 20 times for a duration of 330 hours
- Parrog SWO spilled 0 times

In addition, there are 13 recorded treated sewage discharges from both sewage treatment works and smaller domestic sewage treatment plants.

[45] https://experience.arcgis.com/experience/e834e261b53740eba2fe6736e37bbc7b/page/home/?org=theriverstrust

According to research by Afonydd Cymru[46], there is 'clear and worrying evidence' of such regular and prolonged discharges from CSOs throughout Wales, discharges that fall outside existing consent conditions. NRW have issued Dŵr Cymru with 11 Compliance Assessment Reports, and yet 43%, equating to some 890 of reported CSOs, exceeded 40 spills in 2020. Worse, there seems little account made of spill duration and volume, just that a spill has occurred. Tellingly, Afonydd Cymru report a lack of data and evidence of the impact of CSOs, and that there is an assumption that such spills only occur at times of high rainfall (as, it must be said, has been stated in this report.) 'Unfortunately, the evidence is that this is not always the case and untreated sewage can be discharged under lower flow conditions.'[47] Investigations are currently being carried out as part of the Storm Overflow Assessment Framework.

It has been said that monitoring of point source pollution has much improved in recent years, thus displacing some of the focus to diffuse sources, but there are clearly issues with combined sewer overflows. These issues are only likely to get worse as rainfall patterns change and more pressure is put on already overburdened water treatment infrastructure.

Unfortunately, there were fewer Phosphate kits available to volunteers, so they were asked to limit their sampling of Phosphate levels to occasions where Nitrate levels were above 1mg L^{-1}. As a result, not all of the Phosphate measurements were repeated across all three sample periods, particularly the third sampling period, when some volunteers had run out. This makes any meaningful analysis of Phosphate levels across the catchment, and across the sample period impossible, but is worthy of further investigation.

Also with regard to Phosphate testing, the SWEPT project noted that the Phosphate PackTest requires a warmer water sample – sample temperature for the Phosphate test should be kept in the range 20-40°C – and that at cooler temperatures a longer response time was required. The instructions provided to volunteers made reference to this, with the recommendation that samples should be kept in a pocket for a time before the test was done. Despite this, given that the sampling period was done between late February and early April, water temperatures are likely to have been considerably lower than the product recommendations, and it may be that Phosphate results are an underestimate of actual Phosphate levels. On this subject, it should also be noted that PO4 levels tend to rise as the temperatures rise as a result of greater PO4 breakdown by increased bacterial activity in river sediment. So, again, the early season sampling period may have led to an underestimation of Phosphate levels.

It should be noted at this point that, at the beginning of the sampling period, and after particularly heavy rains, a pollution incident was reported to the project staff. Although not part of the survey, a sample of water was taken from the stream in question and tested using the PackTest kits.

While in no way representative of the catchment, or the survey, as a whole, this incident did bring some of the issues into sharp focus and highlighted a number of relevant considerations.

[46] http://afonyddcymru.org/combined-storm-overflows/ (Accessed 24/5/2021)
[47] Ibid.

Firstly, as well as smelling strongly of slurry, the water was very cloudy and brown, making judgement of the colour change difficult. However, it was clear that the Phosphate test sample turned a deep purple (range 1+ mg L^{-1}), indicating Very High Phosphate levels; the Nitrate test was less pronounced (in the range 1-2 mg L^{-1}). Secondly, lower Nitrate levels do not necessarily suggest low Phosphate levels – clearly the two are independent and the result of one should not dictate the merits of testing for the other.

Figure 26: Pollution incident on the Afon Nyfer involving slurry

Figure 27: Very high Phosphate levels in water tested following the pollution incident

As a postscript, the above-mentioned pollution incident was investigated by NRW and was found to be slurry, but no further action was taken.

Finally, adequate, safe and appropriate storage and use of slurry, and other agricultural inputs, is the subject of much debate and known to be a challenge for both farmers and environmental authorities. This would seem to be given credence by the results of the nutrient testing.

8.1.2 Nitrate levels

The Nitrate sample data appears more consistent across the sampling period (i.e. there appears less of a drop off of Nitrate levels from Sample Period 1 to Sample Period 3.) This may suggest a longer-term issue, with nitrate pollution resulting from groundwater sources. Evidence suggests that NO3 pollution of groundwater is significant and widespread – indeed NRW suggest that designations of Nitrate Vulnerable Zones is likely to increase due to evidence of nutrient enrichment of surface and groundwaters resulting from agricultural practices.[48]

Nitrate is more soluble than Phosphate, meaning it is easily transported in surface water flows and can travel long distances in both surface and groundwater. Therefore, diffuse Nitrate pollution is less

[48] Natural Resources Wales. 2016. *State of Natural Resources Report (SoNaRR): Assessment of the Sustainable Management of Natural Resources. Technical Report. Natural Resources Wales.*

likely than phosphate to be immediately related to, and dependent on, rainfall events, particularly in less free-draining soil types, such as is found in parts of the Nyfer catchment. Nitrate pollution is more likely to enter surface flows via groundwater, so may come from a wider catchment area and be more difficult to pinpoint. As such, reducing Nitrates in waterbodies is a more difficult proposition. Also, in terms of mitigation strategies, solutions such as riparian buffer strips that aim to reduce surface run-off getting into waterbodies will be less effective against groundwater flows.[49]

If measures to reduce pollution levels in the rivers of the Nyfer catchment are to be successful, the sources of the pollution need to be identified and acknowledged. In recent years there has been a significant advance in the conversations and action concerning land management and the challenges facing the farming community. Most stakeholders acknowledge that the majority of water quality problems come from diffuse pollution from agricultural land management and infrastructure. There is also a will to tackle the issue by many of those within the sector.

In 2017, a sub-group of the Wales Land Management Forum (WLMF) was asked to focus on tackling agricultural pollution. The group comprised NFU Cymru, Farmers' Union of Wales (FUW), Country Land and Business Association (CLA), Dŵr Cymru Welsh Water (DCWW), the Tenant Farmers Association Cymru (TFA), Hybu Cig Cymru (HCC), AHDB Dairy, the Carmarthenshire Fishermen's Federation (CFF), NRW and the Welsh Government.

On the back of evidence that, 'there is continued and damaging nutrient enrichment of surface and groundwater resulting from agricultural practices', their interim report focussed on slurry and nutrient management.[50] A number of opportunities and challenges were discussed by the parties and, encouragingly, significant consensus existed on many of the main issues. There was clear consensus that slurry application rates were sometimes excessive, and that even one pollution incident was one too many – slurry should not enter waterways. It was also recognised that the great majority of farmers and most areas were not a problem - although 50% of substantiated agricultural pollution incidents have been traced back to dairy farming, the incidents can be traced back to less than 1% of all farms in Wales.[51] That said, as has already been mentioned, the bigger issue with water quality is diffuse pollution which, by its very nature is more widespread, pervasive and systemic than specific, substantiated incidents.

The WLMF report suggests that solutions require a risk-based approach, including both regulatory and voluntary initiatives, and appropriate levels of investment. However, the sheer volume and disjointedness of regulation led to a lack of engagement and awareness, and there was a lack of resource for compliance checking and enforcement.

The WLMF report illustrates that much needs to be done to enable farmers to take effective action, but the level of consensus on many of the issues is a cause for optimism. The report points out that improvements have occurred since the 1990s, including a reduction in manufactured fertiliser use and more precise pesticide use, with 50% less active ingredient applied since 1990.

[49] Quantifying nutrient transfer pathways in agricultural catchments using high temporal resolution data, Mellander et al, 2012

[50] *Tackling Agricultural Pollution,* Progress report by the Wales Land Management Forum (WLMF) sub-group on agricultural pollution, April 2018

[51] Ibid, p11

Farming Connect[52] has provided significant information, training and support, including over 1000 nutrient management plans. Take up of agri-environmental schemes is positive, with over 2400 contracts agreed with Glastir, the 5-year, whole farm sustainable land management scheme.

There are also an increasing number of organisations, projects and reports raising awareness, offering best practice advice and advisory services. Examples include, Farming Connect, one of four schemes within the Welsh Government Rural Communities - Rural Development Programme, NRW's and Afonydd Cymru and Dŵr Cymru's 's West Wales Water Quality Improvement Project[53].

A number of solutions have been advocated by these and other organisations, including,

- The need to raise awareness and improve understanding regarding what slurry is and its impacts on water quality and the wider environment.
- Ensure improved management of rainfall and dirty water, including the good maintenance of gutters and stormwater drains, etc.
- Ensure adequate and secure slurry storage.
- Increase understanding of slurry and manure spreading risk and improve land management to reduce run-off.
- Avoiding risk of poaching of riverbanks and increase effective use of buffer strips.
- Reduce red tape and complexity of support grants such as Glastir; and simplify advice and regulation.
- Highlight win-win solutions, particularly financial incentives.
- Improving soil management to increase ability to hold water and improve grazing capacity[54] [55]

However, there is no denying the problem continues – 'a combination of farm visits and river walks by NRW have identified evidence of widespread diffuse pollution issues.'[56] And attempts to tackle the issues through changes in management and awareness may not be enough. It has been observed that, to achieve real reductions in Nitrate levels across the landscape, there needs to be 'substantial land use change and/or reduction in livestock numbers'.[57]

So, should we all just blame farmers?

There is one sizeable piece of the puzzle here that is often overlooked, and that is the role of the UK food system and historical consumption models.

The UK has, for the last half-century or more, pursued a policy of cheap food. Food expenditure in the UK, as a proportion of average income, is the lowest it has ever been, at around 8.3% compared to 34% in 1947, and lower than every other country in Europe.[58]

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[52] https://businesswales.gov.wales/farmingconnect/

[53] *West Wales Water Quality Improvement Project 2019,* Speke-Adams et al, 2019, http://afonyddcymru.org/wp-content/uploads/2019/12/ACDC-FINAL-REPORT-2019v3.5.pdf

[54] *West Wales Water Quality Improvement Project 2019,* Speke-Adams et al, 2019

[55] *Diffuse Water Pollution in Wales: Issues, solutions and engagement for action*, NRW

[56] *Tackling Agricultural Pollution,* Progress report by the Wales Land Management Forum (WLMF) sub-group on agricultural pollution, April 2018, Section 3.12, p12

[57] *Nitrates Directive Consultation Document Environmental Impact of the 2009-13 Nitrates Action Programme & of potential further measures,* Johnson et al, 2011 (ADAS)

[58] *The Hidden Cost of UK Food*, The Sustainable Food Trust, 2017

A House of Lords report, *Hungry for Change*[59], states that economic forces, including the demands of supermarkets, food manufacturers, the food services sector, and the large food commodity companies, require farmers to produce food as cheaply as possible. Pursuing such low food prices brings a host of negative impacts on farmers and farms and on rural communities. The Sustainable Food Trust[60] report that, between 1995 and 2014, the number of dairy farms in the UK declined from 35,741 to just 13,815, almost 22,000 farmers and their families.

It can also inhibit environmentally sustainable food production and increase the negative impacts of agriculture on the natural environment, threatening biodiversity and the quality of farmland. Professor Tim Lang, Professor of Food Policy, City University of London states that: 'We have very cheap food, relatively, but the costs are dumped elsewhere, on health and on the environment.'[61]

The situation confronting farmers has been summed up thus:

'Frustration was expressed at the difficult situation that producers find themselves in. The Sustainable Food Trust told us that farmers: "are trapped in an economic paradigm where they have little control of their method of production, since they understand that farming in an environmentally damaging way is the only way to make profit." A former dairy farmer who submitted written evidence had found it extremely difficult to balance the costs of environmental protections and livestock welfare with the price paid by a leading retailer for his produce, and had ultimately felt "compelled to call time on the business.'[62]

As stated above, there has been a slew of announcements from government regarding the need to address water pollution and the need to work with farmers to reduce diffuse pollution coming from unsustainable farming practices, and rightly so. But it is also worth considering the many other factors in a highly complex issue. There is a need to produce affordable food, but there is also a need for that food to be healthy and produced sustainably, with due regard for the livelihoods of food producers and the environment.

In this we all have a stake, and a role to play.

8.1.3 Survey of volunteers

Despite the inability to host the volunteers in person and for a more personal relationship to develop, all the participants showed great care and commitment to the task in hand, as demonstrated by the number of samples taken, observations made and time spent. The lack of contact also meant the volunteers had to be that much more committed, confident and resourceful to go it alone, to complete all three sample periods, and ultimately to collect sufficient data to fulfil the hope of a catchment-wide baseline.

The lack of a training day and more contact during the project probably did lead to a lack of standardisation in data collection and data entering, but that said, there was no indication in the

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[59] *Hungry for Change: Fixing the failures in food*, Select Committee on Food, Poverty, Health and the Environment, 2020
[60] Ibid. p44
[61] Ibid. p28
[62] *Hungry for Change: Fixing the failures in food*, Select Committee on Food, Poverty, Health and the Environment, 2020. p121

feedback and communications, either during or post sampling period, to suggest any significant difficulties in the survey tasks.

Following the end of the survey period, a brief volunteer survey was sent to all the volunteers, via Survey Monkey and to a printable survey form. Seven volunteers responded via the Survey Monkey, and one via the downloaded form. A summary of the results follows:

All the respondents enjoyed participating in the project and felt that they were doing something useful. A high proportion (71%) felt they had leant new skills and learnt more about their local area, which is gratifying given that COVID restrictions limited the scope of the project to get people to visit outside their immediate locale, or to deliver a more comprehensive training day.

This latter point is reinforced by the fact that fewer volunteers felt they had learnt more about nature, about the benefits of ecosystems, or felt part of a bigger group (57%, 28% and 57% respectively.) Assessment of the survey instructions pack and online resources was less positive, with 57% saying they liked the resources, and 43% saying they were OK. Some of these points could probably have been improved had more face-to-face contact been possible with the volunteers, more time spent designing and delivering materials and a training day provided.

A second part of the survey asked for some written answers concerning the volunteers' motives for participating, and thoughts on the survey and the issues raised.

Half the respondents commented that it was easy to get involved and the survey was simple to do – the testing was thought simple, and the local nature of the surveying was important, especially for one volunteer who had no car.

There is a clear interest in water quality, biodiversity, and the Afon Nyfer itself. This is reflected by the number of 'shares' of the initial call for volunteers, and anecdotal evidence from interest shown over social media. In addition, four of seven survey responses mention a level of concern for, or wanting to know more about, the health of the river.

When asked about things that drew volunteers' attention, or raised further questions, many of the responses mentioned the need to engage with landowners and land managers in the issues, raise awareness of the impacts and know about what levels of Nitrate were acceptable.

A strong theme throughout the responses to various questions was the need to educate, raise awareness, increase understanding, involve more of the community and different stakeholders, especially landowners.

The knowledge levels of the volunteers regarding the wider issues of ecosystem health and ecosystem services, particularly freshwater ecosystem and land use, is high. This is probably a reflection of the way the volunteers were recruited, being from local interest groups such as NAEG, Nevern Angling Association, Newport Boat Club, etc.

Overall, the importance of engaging volunteers seems to have been much appreciated. Responses reflecting this included:

Monitoring rivers through citizen science can be a key element in behaviour change as individuals gain understanding and polluters feel social pressure to take action.

Thank You for the opportunity to take part! I really enjoyed learning more about the river and the local area.

Thanks for making this happen - it was interesting and I look forward to more news about CLEAN in the future. Please share the results with us all and keep us updated!

9 Conclusions

Although stretches of the Afon Nyfer are reported as being in good health, large parts are ecologically degraded and under pressure, as established by the WFD assessments. More precise understanding of the reasons why parts of the Nyfer catchment failed to achieve Good status is crucial if the waters are to be improved.

Using the citizen science model, a group of volunteers conducted a survey assessment of the Nitrate and Phosphate levels across the whole catchment, as well as gathering a number of other observations of the ecological well-being of the Nyfer and its tributaries.

Observations found that litter was relatively rare, perhaps due to the season and the restrictions of COVID lock down; and occurrence of INNS was less than expected, perhaps due to the sampling period being early in the growing season – certainly other surveys undertaken over longer periods have discovered a considerable problem with INNS, particularly Himalayan Balsam. However, it is hoped that the CLEAN project can play a meaningful role in combatting the challenge of INNS in future.

Arguably of greatest significance is the amount of data collected from the Nitrate and Phosphate testing. In total 82 sample sites were surveyed, and 298 nutrient tests undertaken. Despite some reservations due to the relatively small sample of data across such a large area, and the short sampling period, it is clear that nutrient pollution in the Nyfer catchment is an issue.

The tests showed considerable levels of Nitrate pollution – 114 of 195 samples (58.5%) showed High or Very High levels of Nitrate pollution, with a further 27 (13.8%) showing some Nitrate pollution. Less than a third, 54 (27.7%) showed no evidence of Nitrate pollution.

Although Phosphate pollution was less of an issue, still 22.3% showed High or Very High levels of pollution, with a further 17.5% showing some level of pollution. Notably, the higher levels were found only in the first sampling period, soon after rainfall and when water levels were highest.

Tellingly, the sub-catchments that fail (or have been reported as failing) to achieve 'Good' status, according to WFD assessments are those that show the highest levels of Nitrate pollution – in the Headwaters to the Brynberian and the Nant Duad, 76.9% and 95.2% of samples taken indicate High or Very High Nitrate pollution respectively. In the 'Nyfer, from the Nant Duad to the Tidal Limit' sub-catchment, 88.2% of samples taken record a High or Very High level of Nitrate pollution.

One likely source of the water pollution is the sewage discharges from Dŵr Cymru and other private sewage discharge points throughout the catchment. Figures from Dŵr Cymru show that storm sewers and Combined Sewer Overflows and been activated and spilled untreated sewage into the waters of the Nyfer catchment on 283 occasions in 2020. It seems clear that work is required to reduce the impact of these spillages.

There also seems little doubt, given evidence of an increase in intensification of dairy farming, an increase in the dairy cattle numbers and a likely increase in slurry production and use, that agriculture and land use practices are a significant source of much of the pollution found. There are numerous reports and studies that highlight agriculture as a major source of diffuse pollution. It will be interesting to see whether the new Agricultural Pollution regulations can make an impact on this.

Given the numerous initiatives, advisory services and regulations recently enacted regarding agricultural pollution it must be hoped that action will be forthcoming to tackle this issue. However, any meaningful interventions will need the support, collaboration and goodwill of all stakeholders, not least land managers themselves.

As mentioned, the issue is complex and systemic – arguably more than just inadequate storage and inappropriate slurry spraying in the rain, important though they are. Longer term, the food system as a whole has to be challenged if food is to be produced sustainably, affordably and with due regard for both the livelihoods of food producers and the environment.

Raising awareness of, and engagement in, the issues of food production, ecosystem health and the importance of ecosystem resilience is increasingly urgent. At the same time, large scale monitoring and greater understanding of the impact of land management activities and interventions is critical if lessons are to be learnt and benefits shared. Both these needs are well addressed by engaging people in citizen science.

The efforts of the CLEAN volunteers have provided an invaluable insight into the Nyfer's furthest reaches, and most, if not all, are excited to be involved in what happens next.

10 Recommendations and Phase 2

Phase 1 of the CLEAN project should be viewed as a great success, but from the start it was conceived as only the first part of a more comprehensive and more ambitious project. It is strongly recommended that a second phase should be developed. Phase 2 should have two aims: a more extensive and comprehensive survey of the Nyfer catchment to build a fuller and more useful picture; secondly, and crucially, the development and implementation of solutions, many of which have already been developed and are widely accepted.

This report makes the following recommendations:

1. **Broaden survey parameters to include a more comprehensive survey of the Nyfer catchment, including assessment of biodiversity, particularly aquatic invertebrate populations, sediment load and turbidity, Invasive Non-Native Species (INNS) and pollution sources, among others.**
2. **Build on success of Phase 1 by reinvesting time in, and expanding, the existing CLEAN volunteer network.**
3. **Engage with, and facilitate greater involvement of, local Community Councils, landowners, and other interest groups, thus widening the stakeholder base and gaining greater support for initiatives and implementation.**
4. **Develop and implement a strategy for monitoring and eradication of INNS.**
5. **Ensure any Phase 2 activities and implementation makes use of the Fisheries Habitats Survey Report (soon to be published).**
6. **Engage with the farming community regarding challenges and opportunities affecting water quality and ecological health in the Nyfer catchment. Supporting implementation of best practice in land and nutrient management, to assist compliance with regulation whilst seeking business and efficiency opportunities.**
7. **Encourage, and source funding for, the establishment and improvement of livestock fencing, riparian buffer strips, and constructed wetlands.**
8. **Engage with Dŵr Cymru/Welsh Water to better understand and address challenges with Combined Sewer Overflows (CSO), including increasing capacity for intense rainfall events, and the more accurate and useful monitoring of spillage duration and volume.**
9. **Explore creatively the cross-sector benefits and economic opportunities inherent in improving the Afon Nyfer and its catchment; encourage collaboration and cross-fertilisation of ideas, including regarding funding, messaging, resources and synergies.**
10. **Repeat the CLEAN survey across the Nyfer catchment in the future to observe any potential changes in levels of nutrient pollution, and support transfer to other catchments.**
11. **Greater use of the Welsh language is required in all project materials and was commented on in the volunteer survey.**

In more detail:

1. **Broaden survey parameters to include a more comprehensive survey of the Nyfer and its tributaries, including assessment of biodiversity, particularly aquatic invertebrate populations, sediment load and turbidity, Invasive Non-Native Species (INNS) and pollution sources, among others.**
    - The Phase 1 survey was, by necessity and COVID restrictions, less comprehensive than it could been given the interest shown within the community. Phase 2 of the project should include the following to provide a richer and more valuable knowledge base/baseline.
    - Although not as accurate as laboratory testing, the use of the Kyoritsu Pack Tests has been proven to be a cost effective and valuable method of testing for Nitrate and Phosphate, particularly at a landscape scale, using a citizen science model. Their value for more extensive catchment surveys during Phase 2 of CLEAN, and in other catchments, should be noted.
    - Undertake a more in-depth study of the data. This was not possible given the resources of Phase 1 but would certainly provide greater insights, help land managers and environmental practitioners, and focus Phase 2 interventions.
    - There is little mention in the report of the importance of the Nyfer catchment for biodiversity, nor of the impact of water pollution on aquatic invertebrates and fish, etc. – this was not a key part of the Phase 1 survey. Healthy invertebrate populations are indicative of good water quality and a healthy ecosystem, and Phase 2 surveys should include kick-testing to survey for invertebrates.
    - Further surveys could also include more extensive monitoring of INNS, and better identification of pollution sources, including the presence of sewage fungus.
    - Given difficulty of assessing the possible source of Phosphate pollution (i.e. whether from CSO spillages or agricultural run-off) it would be useful to assess turbidity in any future water quality testing. Earthwatch's FreshWater Watch citizen science project used a simple Secchi tube to assess turbidity, associated with run-off as opposed to sewage spillages. An alternative would be to investigate the availability (and feasibility) of an electronic meter for this, and other measurements.
    - If more extensive testing is required in specific areas/sub-catchments perhaps, could loan SONS meter. Funding for such more extensive and accurate testing where merited should be investigated in collaboration with Dŵr Cymru.
    - Citizen science has a crucial role in mobilising citizens to take action to protect and enhance their local environment. It also contributes to mental health providing opportunities to join together in discussing, understanding and tackling big problems.
    - Citizen science can have a useful role in extending the scope of monitoring data available to policy makers and statutory bodies.
2. **Build on success of Phase 1 by reinvesting time in the existing CLEAN volunteer network.**
    - More time needs to go into planning the engagement of volunteers. Understanding their preferences and pressures as well as fears and aspirations; to develop a training and engagement program that feels supportive and encourages opportunities to develop knowledge and skills. Remaining realistic about varying engagement levels and effective for both organisations and volunteers.
    - In-depth training of volunteers will lead to greater engagement, more long-term commitment and more useful and accurate data. This could include training in Walk over Survey, as conducted by in the recent Afonydd Cymru and West Wales Rivers Trust, kick testing and identification of aquatic invertebrates identification and control of INNS, and better recognition of specific pollution sources, including, for example, identification of sewage fungus.

- Citizen science projects and the involvement of volunteers provide an important opportunity to educate, raise awareness of associated environmental issues, change behaviours and increase 'eco-sensitivity'.
- It could be worth developing training packages that could be transferred to other catchments, potentially linked to accreditation, increasing skills and employability.
- It should be recognised that this is a more interesting, extensive, but time-consuming involvement of volunteers. While likely to improve involvement and engagement for some it may be too much for others in terms of commitment and time. It is recommended a second 'level' of volunteer be considered, perhaps entitled River Watchers or River Wardens. Should funding be available, a small stipend could be offered for this more extensive role.
- Explore connections and collaboration with other volunteer networks, including those of the PCNPA, Wildlife Trust, Stitch in time, NAEG and others.
- The increased scope of the Phase 2 project will require a greater role of volunteers. This can be time consuming, and a dedicated co-ordinator should be considered to liaise with volunteers, particularly if the second level of volunteers is created (see above). Enough resource should be allocated to it.
- It is important to provide enough training and support, but also vital to ensure that the feedback process is not forgotten. Citizen scientists invariably volunteer because they are interested in the topic; their efforts need to be repaid with adequate follow-up and sharing of results to encourage continued involvement.
- Use of a mobile survey app such as Open Data Kit (ODK) could greatly aid data submission and subsequent collation, but this does rely on having volunteers with smart phones who are sufficiently confident with technology. Qfield also offers an open source platform for spatial data collection and representation.

3. Engage with, and facilitate greater involvement of, Community Councils, landowners and other interest groups, thus widening the stakeholder base and gaining greater support for initiatives and implementation.

- All members of Community Councils will have strong community links and connections, which should be explored in order to maximise the scope and impact of the project.
- Investigate more widely the existing community groups, both within and without the environment sector, in order to strengthen partnerships and create new connections to the project and the Nyfer catchment.
- An issue during Phase 1 was the inability to access private land to conduct nutrient testing on private land. Efforts should be made to build relations with landowners and get permissions for access to private land as part of a more extensive survey, particularly in areas of focus. This should include a more comprehensive assessment of adjacent land use within the catchment to better understand land use management issues and opportunities.

4. Develop and implement a strategy for monitoring and eradication of INNS.

- INNS, particularly Himalayan Balsam, are a significant challenge in the Nyfer catchment and must be monitored, controlled and if possible, eradicated. Where practical this could be contracted but, building on the success of the Stitch in Time project, it is recommended that workshop held for volunteers to disseminate identification and best practice training. This will generate interest and help establish volunteer groups across the catchment.
- Initiatives are already underway in several parts of the catchment, but a coordinated strategy and approach, starting at the source of the Nyfer (a 'source to sea' approach) should be taken (as recommended by PCNP and the Stitch in Time project)
- Work is already underway and further collaboration being discussed between GBC and PCNP to survey, map and start to tackle INNS at the top of the watershed.

5. Ensure any Phase 2 activities and implementation makes use of the Fisheries Habitats Survey Report (soon to be published).

- Publication of the results of walk-over surveys of the catchment, conducted by Afonydd Cymru and WWRT on behalf of NRW, is imminent. Any Phase 2 activities should be designed and implemented in concert with this work and report.
- The widespread nitrate pollution within the Nyfer catchment highlighted in this report needs to be reduced. Investigation and implementation of methods of reducing nutrient inputs to the waterway is urgently required.

6. Engage with the farming community regarding challenges and opportunities affecting water quality and ecological health in the Nyfer catchment. Supporting implementation of best practice in land and nutrient management, to assist compliance with regulation whilst seeking business and efficiency opportunities.

- Despite an initial attempt to engage with the agricultural sector/farming community this was not achieved within the short time of Phase 1 but is recognised as a critical step within Phase 2. Implementation of best practice and solutions associated with nutrient management and land management is fundamental to addressing agricultural run-off and nutrient pollution and will rely on the support and action of the whole farming sector. As well as local farmers and other landowners, key stakeholders include area representatives of the National Farmers Union, the local Young Farmers Club and the Pembrokeshire Coast National Park Authority's new Farming Liaison Officer. Initiatives and advisory groups are numerous, including work done by Afonydd Cymru, Farming Connect, the Wales Land Management Forum, and initiatives such as Blue Flag Farming should be noted and incorporated.
- Enabling and encouraging individual landowners and farmers to conduct their own testing, using the Kyoritsu Pack Tests, would enable immediate insights into local nutrient levels and the impact land management practices.
- Support farmers to find funding and practical interventions to assist them in meeting the requirements ot the Water Resources (Control Of Agricultural Pollution) Regulations 2021.
- Work with Coleg Sir Gar Prosiectslyri, and other partners to develop innovative and proven concept technology to reduce slurry volumes, including dewatering and methane production.
- Review findings of Building Resilience In Catchments and other projects to develop locally appropriate farmer led solutions.

7. Encourage and source funding for the establishment and improvement of livestock fencing and riparian buffer strips, and constructed wetlands.

- Effective fencing and creation and maintenance of riparian buffer strips help prevent poaching and, in the case of buffer strips, reduce the impact of slurry application and spray drift close to watercourses. Constructed wetlands can slow the flow of nutrient polluted water and produce biomass crops. The provision of other management tools and strategies to prevent poaching (e.g. pasture pumps) should be encouraged. The condition of fences could be part of any further survey activities.

8. Engage with Dŵr Cymru/Welsh Water to better understand and address challenges with Combined Sewer Overflows (CSO), including increasing capacity for intense rainfall events, and the more accurate and useful monitoring of spillage duration and volume.

- Given the findings of the report and information on spillages from CSOs, CSO monitoring should be a key part of future survey activities in Phase 2. However, the need to maintain the randomness of surveying is important so such testing (and any other event-specific testing, such as after intense rainfall events, should be done in addition to, and separate from, main surveys, and be noted as such.

9. Explore creatively the cross-sector benefits and economic opportunities inherent in improving the Afon Nyfer and its catchment; encourage collaboration and cross-fertilisation of ideas, including regarding funding, messaging, resources and synergies.

- Obvious interest groups include the Nevern Angling Association, Newport Boat Club and environmental organisations such as Newport Area Environment Group, and relationships with these organisations should be continued and enhanced. However, other sectors should, and probably do, have an interest in the ecological health of the Nyfer valley and associated economic opportunities, including the tourism sector, hospitality sector, rambling groups, and others (e.g., the Newport Walking Group have been heavily involved in monitoring and clearing INNS along footpaths in the area.)
- Potential opportunities for further funding from these sources (above) should be explored, for example, the Enhancing Pembrokeshire Grant, and development of a Visitor Giving Tax.
- Greater consideration of the impact of water quality on tourism, recreation and wellbeing is suggested, both the negative impact of poor water quality (e.g. diminishing the experience of the rich wildlife and fishing opportunities, reduction of bathing water quality), but also the economic and wellbeing benefits of good water quality and enhanced ecological status. There may be scope for social enterprises based on recreational activities to help fund interventions to improve water quality. Wild swimming and paddle sports offer two groups that would be likely to back any such initiatives.
- Encouraging more sustainable agriculture practices, highlighting their benefits in terms of catchment health, and publicising such successes, is likely to benefit the tourism sector. A successful joint approach of both the farming sector and the tourism sector should be explored.

10. Repeat the CLEAN survey across the Nyfer catchment in the future to observe any potential changes in levels of nutrient pollution, and support transfer to other catchments.

- This would be an invaluable way of assessing the impact of any Phase 2 activities designed to improve water quality and assess the efficacy of other interventions and relevant government regulations.
- CLEAN has demonstrated the success of transferring and extending SWEPT methodology to the Nyfer catchment.
- GBC have already been approached by individuals asking for information and support with similar initiatives on the Afon Taf and Afon Gwaun,. This has led to signposting, sharing resources and supplying the few spare kits that were returned. There could be future opportunities to develop a network of catchment based community projects to inform regional initiatives and contribute to national policy.
- Given sufficient funding the CLEAN project could be scaled up to tackle similar issues on major catchments such as the Afon Teifi, working across county and organisational boundaries.

11. Greater use of the Welsh language is required in all project materials and was commented on in the volunteer survey.

- With more time to prepare and a budget, translation services could be commissioned.
-

Appendix 1: Nitrate Results by Sub-catchments

	Sample Period 1			Sample Period 2			Sample Period 3		

Nyfer - headwaters to confluence with Brynberian

	n	%		n	%		n	%	
<0.2	1	5.6		1	5.9		3	17.6	
0.2-0.5	0	0.0	**5.6**	1	5.9	**11.8**	0	0.0	**17.6**
0.5-1	4	22.2	**22.2**	1	5.9	**5.9**	1	5.9	**5.9**
1.0-2.0	3	16.7		2	11.8		2	11.8	
2.0-5.0	4	22.2		6	35.3		6	35.3	
5.0-10.0	6	33.3		6	35.3		3	17.6	
10+	0	0.0	**72.2**	0	0.0	**82.4**	2	11.8	**76.5**
	18	**100**		**17**	**100**		**17**	**100**	

Brynberian - headwaters to confluence with Nyfer

	n	%		n	%		n	%	
<0.2	0	0.0		0	0.0		0	0.0	
0.2-0.5	2	16.7	**16.7**	0	0.0	**0**	4	57.1	**57.1**
0.5-1	4	33.3	**33.3**	1	100.0	**100.0**	2	28.6	**28.6**
1.0-2.0	2	16.7		0	0.0		1	14.3	
2.0-5.0	4	33.3		0	0.0		0	0.0	
5.0-10.0	0	0.0		0	0.0		0	0.0	
10+	0	0.0	**50.0**	0	0.0	**0.0**	0	0.0	**14.3**
	12	**100**		**1**	**100**		**7**	**100**	

Nant Duad - headwaters to confluence with Nyfer

	n	%		n	%		n	%	
<0.2	0	0.0		0	0.0		0	0.0	
0.2-0.5	0	0.0	**0**	0	0.0	**0**	0	0.0	**0**
0.5-1	1	14.3	**14.3**	0	0.0	**0.0**	0	0.0	**0.0**
1.0-2.0	0	0.0		2	28.6		3	42.9	
2.0-5.0	4	57.1		2	28.6		2	28.6	
5.0-10.0	2	28.6		2	28.6		1	14.3	
10+	0	0.0	**85.7**	1	14.3	**100.0**	1	14.3	**100.0**
	7	**100**		**7**	**100**		**7**	**100**	

Nyfer - Confluence with Nant Duad to tidal limit

	n	%		n	%		n	%	
<0.2	0	0.0		0	0.0		0	0.0	
0.2-0.5	0	0.0	**0**	0	0.0		0	0.0	**0**
0.5-1	0	0.0	**0.0**	2	20.0	**20.0**	2	14.3	**14.3**
1.0-2.0	3	30.0		0	0.0		3	21.4	
2.0-5.0	3	30.0		2	20.0		4	28.6	
5.0-10.0	2	20.0		4	40.0		3	21.4	
10+	2	20.0	**100.0**	2	20.0	**80.0**	2	14.3	**85.7**
	10	**100**		**10**	**100**		**14**	**100**	

Clydach - headwaters to confluence with Nyfer

	n	%		n	%		n	%	
<0.2	1	12.5		0	0.0		2	18.2	
0.2-0.5	2	25.0	**37.5**	4	44.4	**44.4**	4	36.4	**54.5**
0.5-1	2	25.0	**25.0**	3	33.3	**33.3**	2	18.2	**18.2**
1.0-2.0	1	12.5		1	11.1		1	9.1	
2.0-5.0	2	25.0		1	11.1		0	0.0	
5.0-10.0	0	0.0		0	0.0		2	18.2	
10+	0	0.0	**37.5**	0	0.0	**22.2**	0	0.0	**27.3**
	8	**100**		**9**	**100**		**11**	**100**	

Nyfer Estuary and Coast

	n	%		n	%		n	%	
<0.2	7	46.7		5	45.5		7	50.0	
0.2-0.5	3	20.0	**66.7**	4	36.4	**81.8**	3	21.4	**71.4**
0.5-1	1	6.7	**6.7**	0	0.0	**0.0**	1	7.1	**7.1**
1.0-2.0	1	6.7		0	0.0		1	7.1	
2.0-5.0	0	0.0		0	0.0		1	7.1	
5.0-10.0	3	20.0		2	18.2		1	7.1	
10+	0	0.0	**26.7**	0	0.0	**18.2**	0	0.0	**21.4**
	15	**100**		**11**	**100**		**14**	**100**	

Nitrate results by sub-catchment, where 'n' is the number of samples recorded of each range in each sample period, followed by the percentage of the total. For each sample period, the third column is the combined percentage, namely No Pollution, Some Pollution, and High or Very High Pollution levels.

Catchment Level Environmental Action Network

AFON NYFER RIVER NEVERN

Instructions

Government agencies monitor pollution in our larger rivers, some streams and lakes, but we know nothing about nutrient pollution in most of our steams, headwaters, ditches and other freshwater habitats, where so much of our fantastic freshwater wildlife lives.

The CLEAN project aims to collect information on nutrient pollution from as many freshwater habitats as possible; particularly places which have never been monitored before.

You have been supplied with test kits for Nitrate and Phosphate and have been allocated an area close to your home or work. There are limited test kits available, but I do have a few spares if you want any more. Also, there are fewer phosphate tests so only do a Phosphate test if you get a positive nitrate test (value greater than 1).

Any spare kits can be used to test other water bodies that you are interested in or returned for us to reallocate.

Summary of the steps involved:

- Identify the body of water you want to test from the maps provided.
- Record the Grid Reference (e.g. SN 05794 38965) or Digital Degrees (e.g. 52.015037 , -4.8314604) (in the field using an app, or when you get home using Grid Reference Finder)
- Take a water sample (see Health and Safety Information Pack).
- Measure the amount of two nutrients in the water, nitrate and phosphate, using the kits. Record the colour found (see p2 of survey sheet)
- Fill out a survey sheet for each site – (land-use and bank vegetation, presence of any litter and invasive species, any pollution, any human activity, etc. See p1 of survey sheet)
- Take and log photos as appropriate (see p2 of survey sheet)
- Tell us what you've found - enter the data online or email us your results.

Sample sites

Around your area, please identify locations where it is safe to access the water from publicly accessible points, then use the same locations for sampling on subsequent visits (once in February and twice in March)

Where you see a stream, ditch, drain or overland flow joining the main watercourse, please test that. At confluences test both inputs upstream of where they join.

Please also test the water on the main channel close to where it leaves your sample area.

If possible, try to take subsequent samples at different flow rates at the same locations.

How to do your water test

On arrival at your site assess the water levels and flow, and the accessibility to the water.

If safe, take a small water sample using a cup or small container. Attach your container securely to a long stick or cane if access is dangerous or awkward. Remember to rinse your container and sample bottle in the water first to remove any residue from any previous sample.

Transfer some of the water into the sample bottle provided. Test for Nitrate.

How to test for Nitrate:

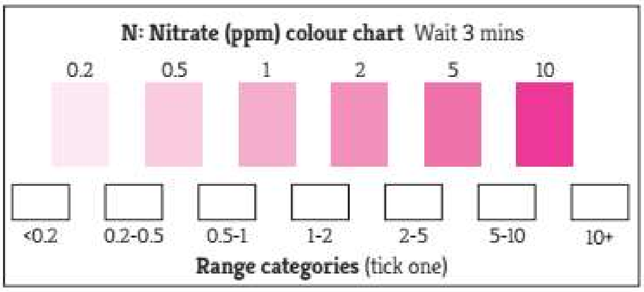
1. Take a Nitrate testing tube (marked NO3 on the tab at the bottom of the tube) and pull out the yellow plastic pin leaving a small air hole. Keep pin and dispose of in your recycling.
2. With the air hole pointing upwards, use your finger and thumb to squeeze out half the air
3. Keeping the air squeezed out, turn the tube upside down and insert into the water
4. Gently release the pressure and suck up enough water to fill the tube just over half way (If you need to, turn the tube upright again, squeeze out a bit more air to suck up a little more water)
5. Gently shake the tube to mix the water and powder inside
6. Make a note of the time and wait 3 MINUTES
7. Put the sample bottle into a pocket to warm up in case you need to do the Phosphate test
8. After 3 minutes compare the tube with the colour chart immediately as the colour will continue to develop

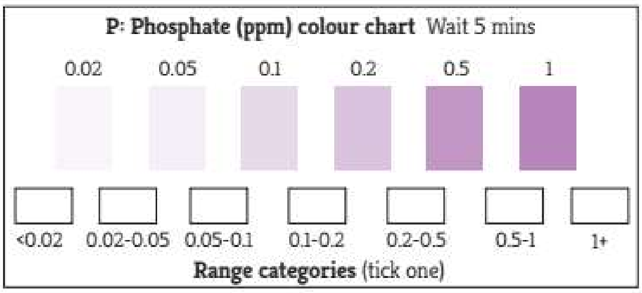
If the N test is positive (i.e. a value greater than 1) please do a Phosphate test:

1. Retrieve sample bottle from your pocket – the water should now be warm enough to do the Phosphate test (marked PO4)
2. Repeat steps 1-6 above, but wait for 5 MINUTES

Record the range that matches your colour. If your tube matches one colour exactly record the higher range (e.g. if recording 5, tick the range 5-10)

When you get home empty the reagent down the sink. The tubes can be recycled so dispose of them with your plastic recyclables.





N = 3 Minutes

P = 5 Minutes

CLEAN

Site Survey Sheet

Afon Nyfer Volunteer Project

Report ID:

Survey section name		Completed by (Name)	
Date dd/mm/yy		Others present	
Section start grid ref		Section start access point name:	
Section finish grid ref		Section finish access point name:	
Walking u/s or d/s		Access issues	
Weather now		Weather last 24hrs	
Time at start of survey		Time at end of survey	

ENSURE YOU ARE ACTING AS PER RISK ASSESSMENT & GUIDANCE. IN PARTICULAR, AVOID SWOLLEN STREAMS, DO NOT GET CUT OFF BY THE TIDE & DO NOT TAKE SHORT CUTS OVER CREEKS.

DO NOT HANDLE OR MOVE ANY WASTE MATERIAL OR DEAD ANIMALS

Observations - use codes (in orange) to describe your survey section. Include ; in lists.

Water Input Number (e.g. if first input put 1, if second, 2, etc.)		**Grid Reference**	
Adjacent land use			
(agri crops agric; grazing agrig; urban urb; semi-urban urbs; wooded woo; natural nat)			
Livestock bank access?		Structures/building on the bank?	
Description of bank/foreshore:			
Trees; Grass/pasture; Marsh; Rock; Gravel/sand; Mud; Aquatic plants; Algal mats; Drift algae;			
If algal mats are present indicate quantity (%)			
Flytipped waste * (Describe)		Photo Y/N	
		Include in photo log	
Litter (Indicate none/rare, occasional or lots. Plastics? Sanitary items?)		Photo Y/N	
		Include in photo log	
Non-native species (e.g. Japanese knotweed, Himalayan balsam)		Photo Y/N	
		Include in photo log	
Human activity (e.g. angling/fishing/gathering of any kind/shooting...)		Photo Y/N	
		Include in photo log	
Possible pollution* (e.g. slurry, sewage, chemical/oil)		Photo Y/N	
		Include in photo log	
Any other observations (e.g. signs of otters, dead animals, unusual sightings)		Photo Y/N	

* FOR ALL OBSERVATIONS MARKED WITH ASTERIX TAKE A PHOTO & IMMEDIATELY RING NRW ON 03000 653000. Say you are a CLEAN survey volunteer when you make your report.

If required you can record observations for additional Water Inputs overleaf. Record all water quality data in the Water Inputs Description section on page 7

Water Input Number (e.g. if first input put 1, if second, 2, etc.)		Grid Reference	
Adjacent land use			
(agri crops agric; grazing agrig; urban urb; semi-urban urbs; wooded woo; natural nat)			
Livestock bank access?		Structures/building on the bank?	
Description of bank/foreshore:			
Trees; Grass/pasture; Marsh; Rock; Gravel/sand; Mud; Aquatic plants; Algal mats; Drift algae;			
If algal mats are present indicate quantity (%)			
Flytipped waste * (Describe)		Photo Y/N	
		Include in photo log	
Litter (Indicate none/rare, occasional or lots. Plastics? Sanitary items?)		Photo Y/N	
		Include in photo log	
Non-native species (e.g. Japanese knotweed, Himalayan balsam)		Photo Y/N	
		Include in photo log	
Human activity (e.g. angling/fishing/gathering of any kind/shooting...)		Photo Y/N	
		Include in photo log	
Possible pollution* (e.g. slurry, sewage, chemical/oil)		Photo Y/N	
		Include in photo log	
Any other observations (e.g. signs of otters, dead animals, unusual sightings)		Photo Y/N	

Water Input Number (e.g. if first input put 1, if second, 2, etc.)		Grid Reference	
Adjacent land use			
(agri crops agric; grazing agrig; urban urb; semi-urban urbs; wooded woo; natural nat)			
Livestock bank access?		Structures/building on the bank?	
Description of bank/foreshore:			
Trees; Grass/pasture; Marsh; Rock; Gravel/sand; Mud; Aquatic plants; Algal mats; Drift algae;			
If algal mats are present indicate quantity (%)			
Flytipped waste * (Describe)		Photo Y/N	
		Include in photo log	
Litter (Indicate none/rare, occasional or lots. Plastics? Sanitary items?)		Photo Y/N	
		Include in photo log	
Non-native species (e.g. Japanese knotweed, Himalayan balsam)		Photo Y/N	
		Include in photo log	
Human activity (e.g. angling/fishing/gathering of any kind/shooting...)		Photo Y/N	
		Include in photo log	
Possible pollution* (e.g. slurry, sewage, chemical/oil)		Photo Y/N	
		Include in photo log	
Any other observations (e.g. signs of otters, dead animals, unusual sightings)		Photo Y/N	

DATE OF SURVEY (DD/MM/YY):	
SURVEYOR NAME:	

No.	**Photo log. (Send all photos along with your survey sheet. Extract location info only if you can. Make sure your photo location can be** **Description (What were you taking the photo of? Water source (number it)? General view? Wildlife? Algal mat or pollution?**	Photo location Grid Ref
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Water inputs description - note you have limited sample kits so may not be able to test all inputs. Test N first, if >1 then test P. All water inputs must be photographed and logged.

Note drop-down box choices to make life easier and to improve data consistency. Once on the correct cell, click on the arrow and make your choice. If N/A leave blank.

No.	Description (e.g. pipe, stream, ditch)	Water clarity/ colour	Any smell?	Flow (High/Med/ Low)	Depth (cm) Estimate	Width (cm) Estimate	Samples taken Y/N	Nitrates Result range	Phosphates Result range	Photo location Grid Ref
1										
2										
3										
4										
5										
6										
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Water sample testing - refer to separate sheet for instructions on how to take a water sample and record your corresponding results in the table above.

Drop - down box options (do not change!):

Nitrates	*Phosphates*	*sample*	*flow estimate*	**Guideline to flow estimate**
<0.2	<0.02	Y	none	None
0.2-0.5	0.02-0.05	N	very slow	Barely perceptible
0.5-1	0.05-0.1		slow	Slower than walking pace
1-2	0.1-0.2		medium	Walking pace
2-5	0.2-0.5		fast	Faster than walking pace
5-10	0.5-1		very fast	Wow, keep away from there!
10 +	1 +			