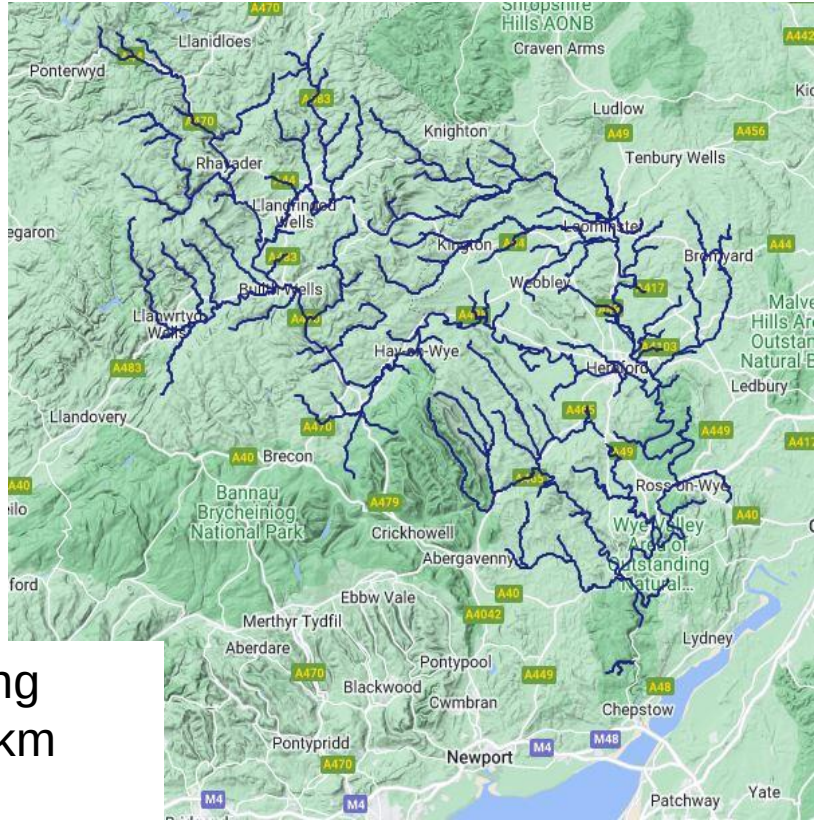
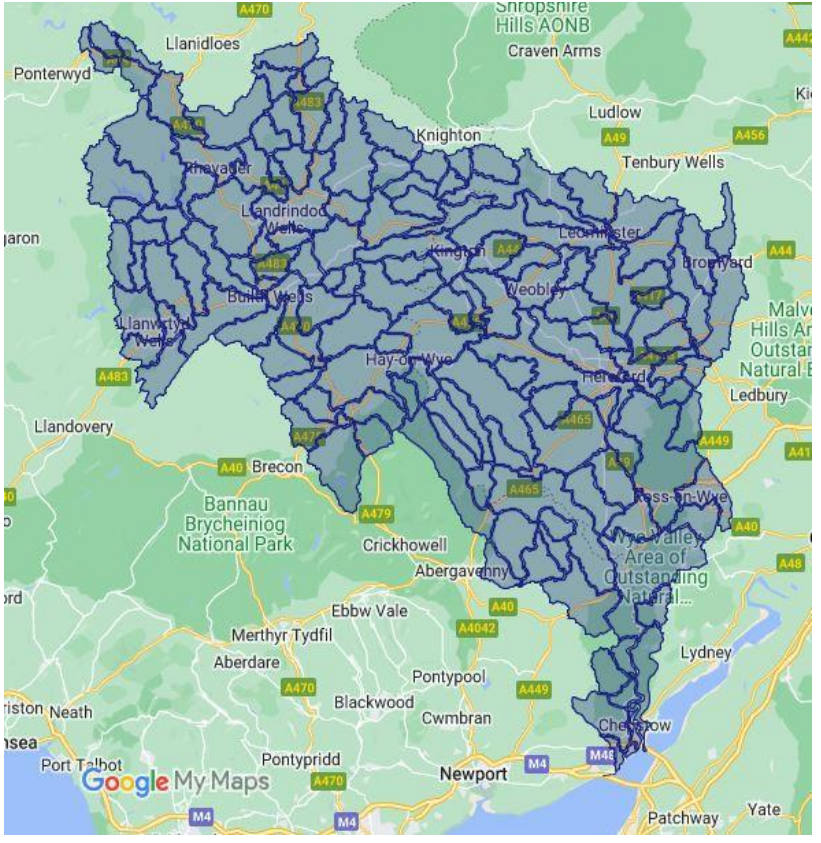
The Wye catchment

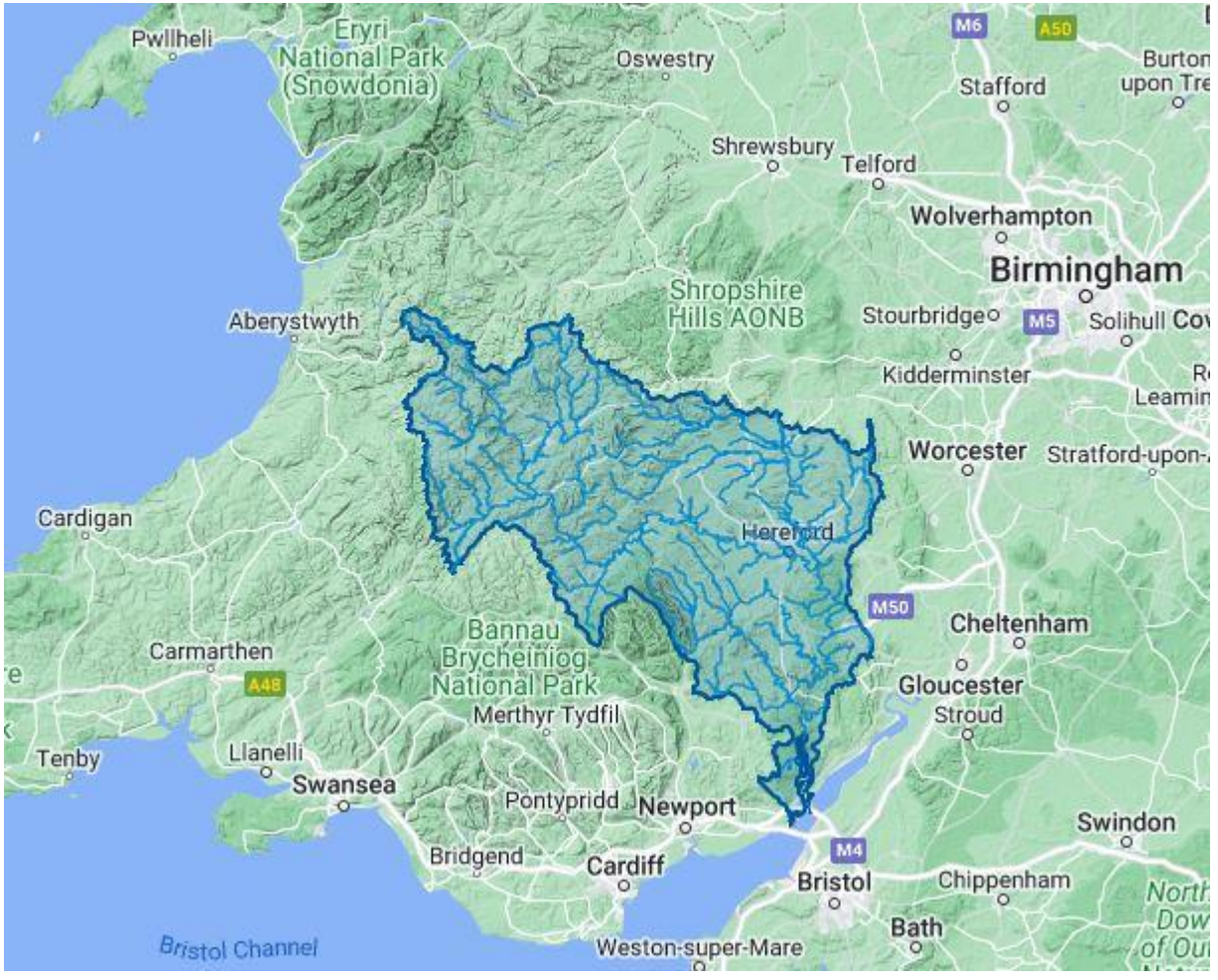
- The Wye catchment is large (for the UK) and complex in its history, geology, hydrology, and ecology.
- And: Sociology and politics -at local, regional and national levels





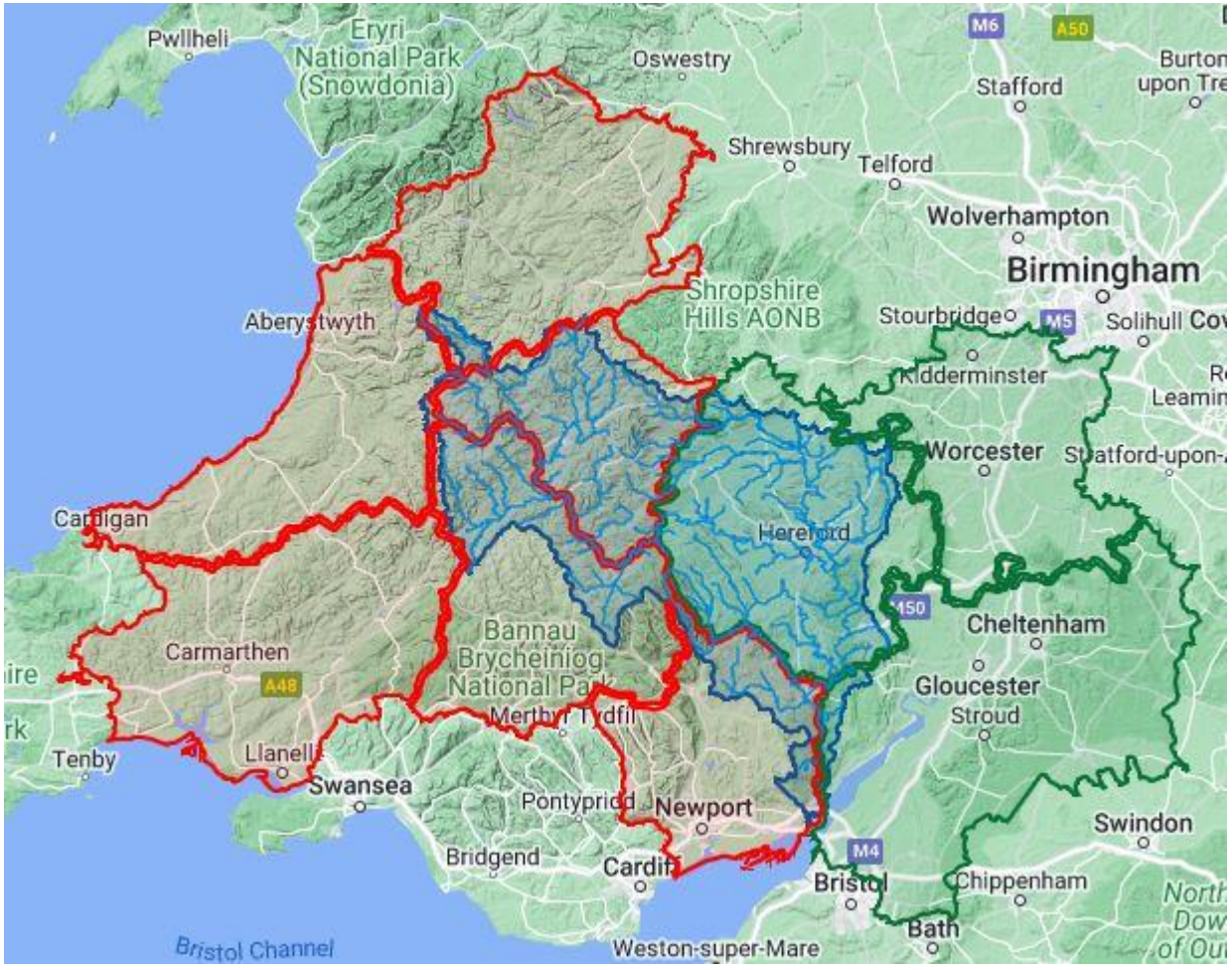
250km long
~4,000sqkm
~40 waterbodies

The catchment in outline, with its Rivers



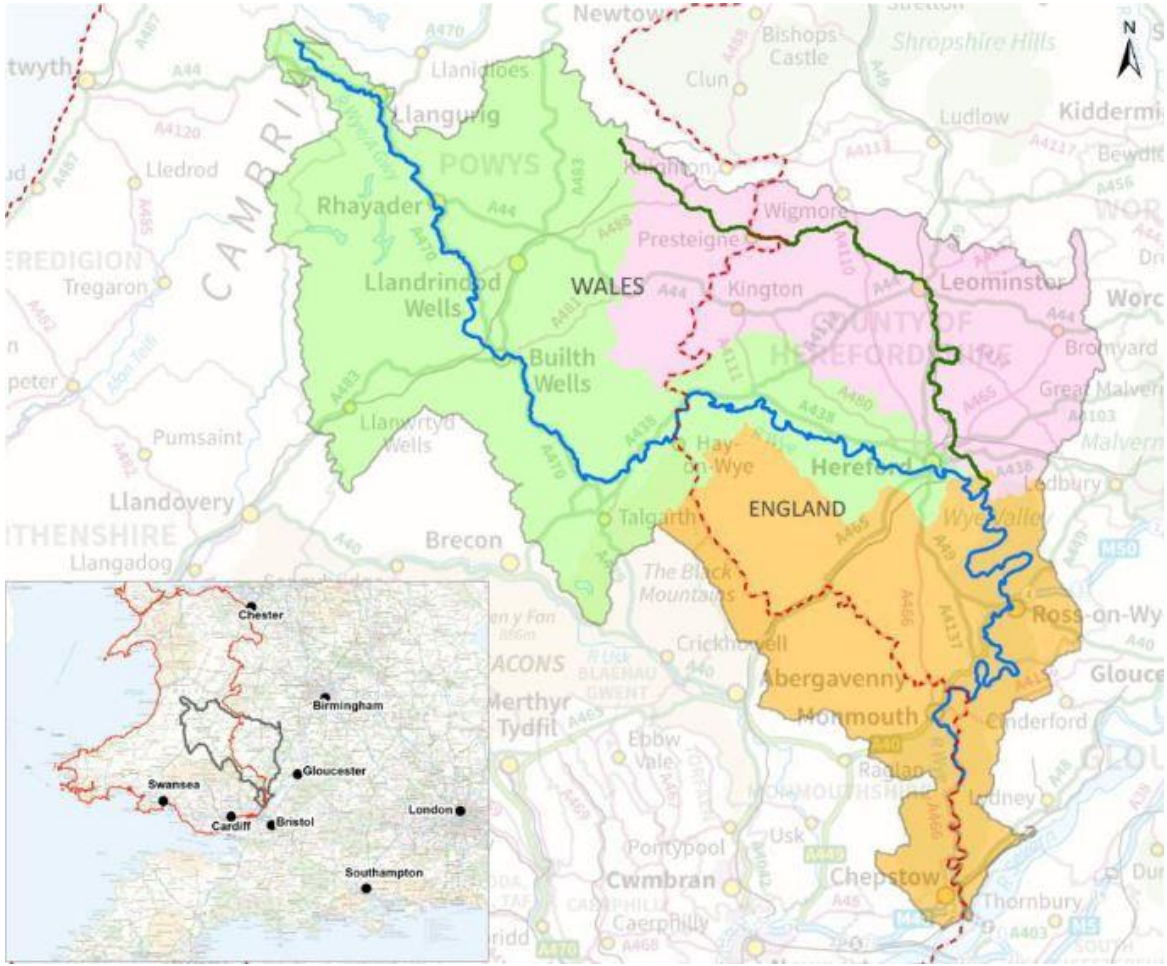
The catchment in outline, with its Rivers

And showing Administrative Areas
-some 9 in total,
3 in England,
6 in Wales



The catchment, with principal subdivisions

-Upper Wye,
-Lugg,
-Lower Wye



Pollution

It takes a bit of effort to see what state the water is in- peering down (somewhere where there aren't strong reflections) to see into the bulk of the water, checking the (sometimes naturally muddy) banks for whether there are discoloured deposits, checking the surface for whether there are unnaturally persistent bubbles, and checking spots where foam sometimes (now all too frequently) collects, noticing unusual smells, and monitoring whether all our native species are thriving.

And beyond the visible, we often need to check for substances not apparent to the naked eye.

Pollution

As with all the UK's rivers, the Wye has been suffering increasingly from pollution of varied nature originating from a wide variety of sources. Various tipping points have been identified- degradation has been increasingly apparent to its ecology and hence its perceived amenity for all users, notably the fishing community, wild swimmers, canoeists, - and also including walkers, cyclists, artists, naturalists, other boating communities, etc. Interestingly, some of these have competing/ clashing demands on the environment, but what unites us all is the desire to see the river restored to a healthy state

Traditionally what we associate with the term 'pollution' are substances which are poisons- biocides: herbicides, pesticides, fungicides, heavy metals, mine tailings, heavy industrial waste, plastics, fire retardants etc. - and We'll be hearing about Emerging Threats to Water after this from Adriana Kiss-Davies- but Ironically, Pollution in the Wye that we're aware of and have been testing for to date is largely of the nature of excess levels of substances we consider to be nutrients.

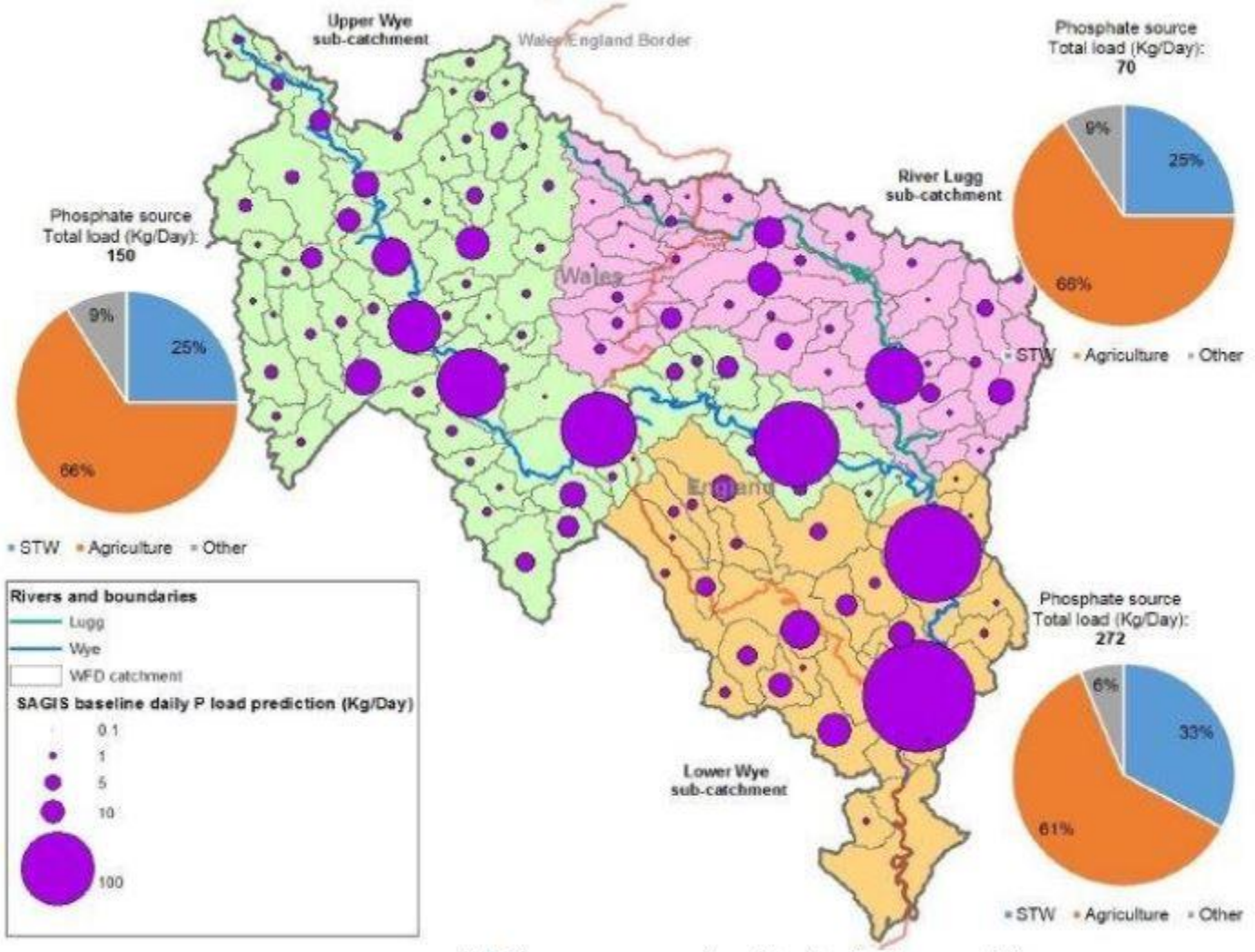
Fertilisers are often described as N,P,K and all these three are bulk nutrient elements (micronutrients are also needed for most growth). The imposition of a Nitrate Vulnerable Zone (NVZ) follows the understanding that our soils and waters are more than saturated with Nitrogen and Nitrates; it is further understood that phosphates are often the critical factor in triggering adverse growth events and especially Algal Blooms.

The RePhoKUs Project Report calculated an annual surplus of over 3,000T of phosphorus being brought into the catchment. (https://wp.lancs.ac.uk/rephokus/)

Phosphates

Source Apportionment GIS Modelling (quoted from the RePhoKUs study*) suggested that 60-70% of the total phosphate load comes from agriculture- in more recent updates to the modelling the ‘agri’ source proportion has risen above 70%

* https://wp.lancs.ac.uk/rephokus



This image was produced by the Environment Agency

Nutrients and Algal Blooms

Excess nutrients are highly favourable to algae, which blanket the water, hindering sunlight from penetrating, also taking up excessive amounts of oxygen at night, contributing to stress on other life-forms. The Algae thrive at the expense of everything else in the river.

Algal blooms from ca. 2016 on have resulted in accumulation of slime on the riverbed

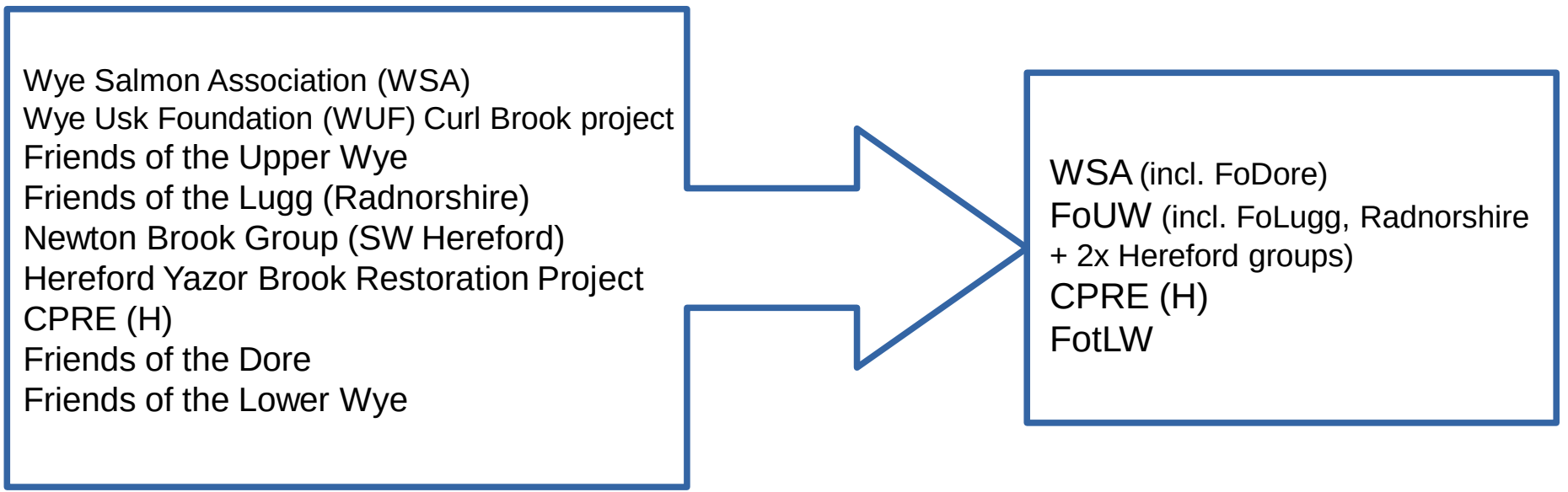
Algae* identified recently on the Wye include:

- Cladophora
- Ulva intestinalis
- Ulva (Enteromorpha) intestinalis
- fine filamentous green alga (probably Spirogyra)
- Spirogyra-like filamentous weed and duckweed
- Ulva lactuca (Enteromorpha)
- Stephanodiscaceae(+)

- Sources: * EpiCollect5 dataset, Friends of the Lower Wye; + Environment Agency

Citizen Science Water Quality Sampling and Testing

ca. 2020 the Wye Salmon Association (WSA) began Citizen Science Testing; this was followed by Friends of the Upper Wye and other groups large and small, coordinated by Elle vonBenzon at Cardiff University.
At one stage some 9 separate groups were identified, which has now coalesced into 4 larger groups.



Citizen Science Outline

At an early stage, CitSci volunteers were sampling and testing at several hundred locations (in 2021, 265; in 2022, 339) across the catchment, generally aiming for twice weekly, though accepting that realistically once weekly was often the best achievable.

This compares with EA and NRW testing (often for a very wide range of substances) at ca. 40 locations each, typically monthly, and gives a clear indication of the extra detail regarding specific measurements potentially available through use of CitSci volunteer efforts. (4 or more x temporal resolution, much more spatial resolution).

From an early stage we have been interested in the catchment-wide pattern of our measurements, and we have been keen to understand how we can refine our approach to better support the regulatory authorities in terms of what and where we measure. The wider picture is of immense value to see how any given measurement fits in and whether it is indicative of a need for further investigation, and also to feed back to individual volunteers.

What the Groups initially measured:

	A	B	C	D	E	F	G	H	I
1		Water Temp	Nitrates	Phosphates (mostly using Hanna digital, some using Lamotte strips)	Turbidity	Electrical Conductivity	Nitrites	pH	Ammoniacal Nitrogen
2	FotLW	y	y	y	y	y	y		
3	FoUW	y	y	y	y	y			
4	FoLugg	y	y	y	y	y			
5	CPRE(H)	y	y	y	y	y			
6	WSA	y	y	y				y	y
7									

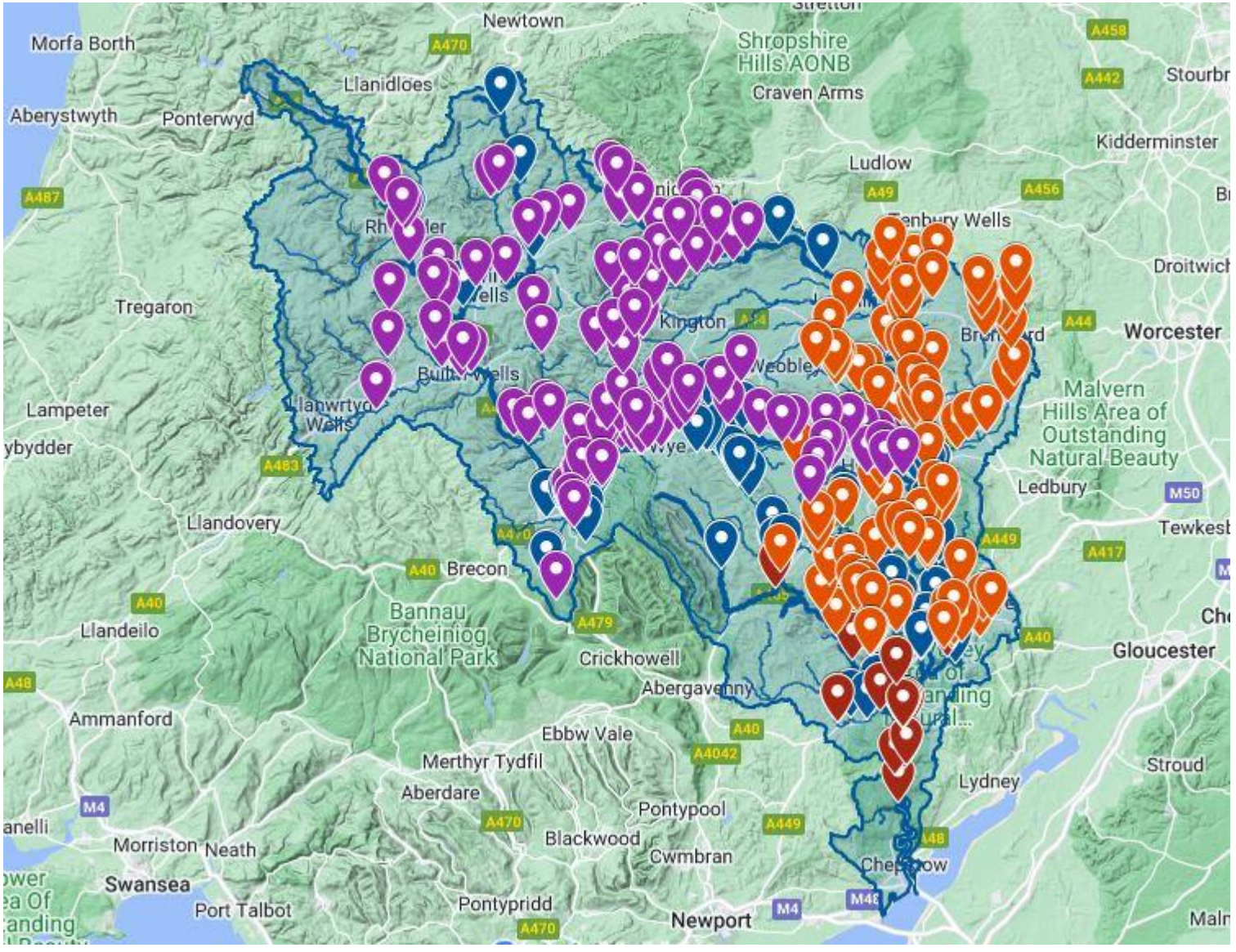
(NB WSA sometimes measure TDS; others also interested in pH and NH3)

January 2022:

Citizen Science water quality testing sites

By group:

- FOUW & FOL (137)
- CPRE (94)
- WSA (92)
- FotLW (15)



Collaborating Groups

The groups have met to collaborate in various ways on frequent occasions and there is now an increasing sense of community among the river groups across the entire area of the catchment.

'Umbrella' organisations include:

- Wye Catchment Collaborative Monitoring Network (Cardiff project),
- WUF/Wye Catchment Partnership (WCP)
- Save the Wye, (mainly publicity and campaigning)
- The Wye Alliance, (initially to collaborate on CitSci)

Events have been hosted by various of the groups, including

- CPREH emerging threats afternoon
- FotLW Symposia -'Seeking Solutions' (Nov 22) (Politicians, EA & Avara)
  -'Working Together' (May 23) (EA, NRW & RA)
- FoUW/CPRW/STW/FotLW Sustainable Farming etc.
- FoUW/Mott MacDonald* collaboration and invitations to others
- Related Campaigns for publicity and 'hustings' political action
- WUF/WCP sessions on flooding, ecology, nutrients etc. in the Wye

Pooled experience has helped with

- Lessons learnt re planning, consistency of approach and kit,
- Consistency of contacting/ alerting the agencies
- Approaches to catchment-wide merging and mapping of data

- *Mott MacDonald through their Corporate social responsibility outreach programme have helped with various aspects

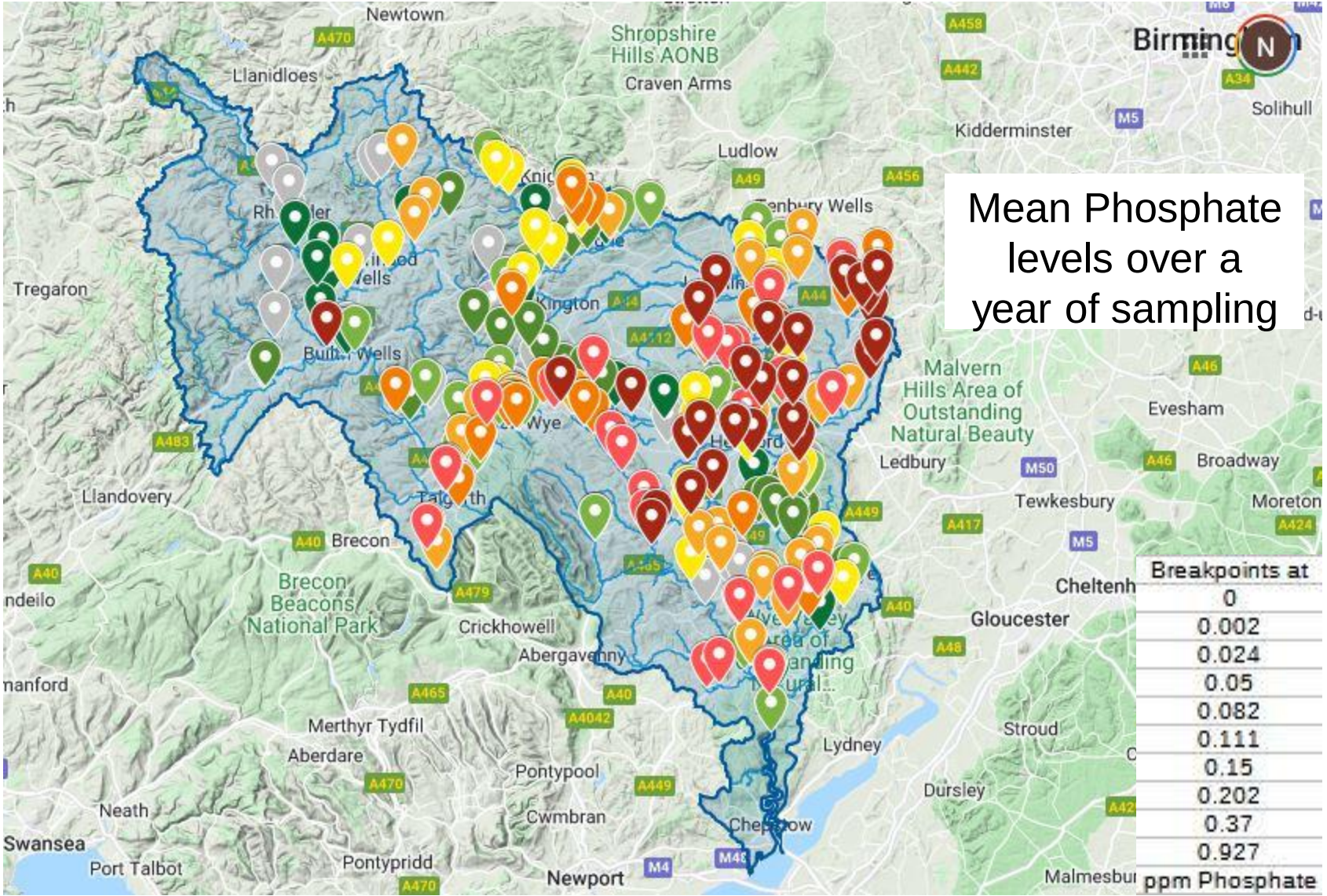
- There has also been extensive liaison with Wildlife Trusts

- Events have allowed extensive interaction with staff from the EA, NRW, and DCWW

Catchment picture From 2021

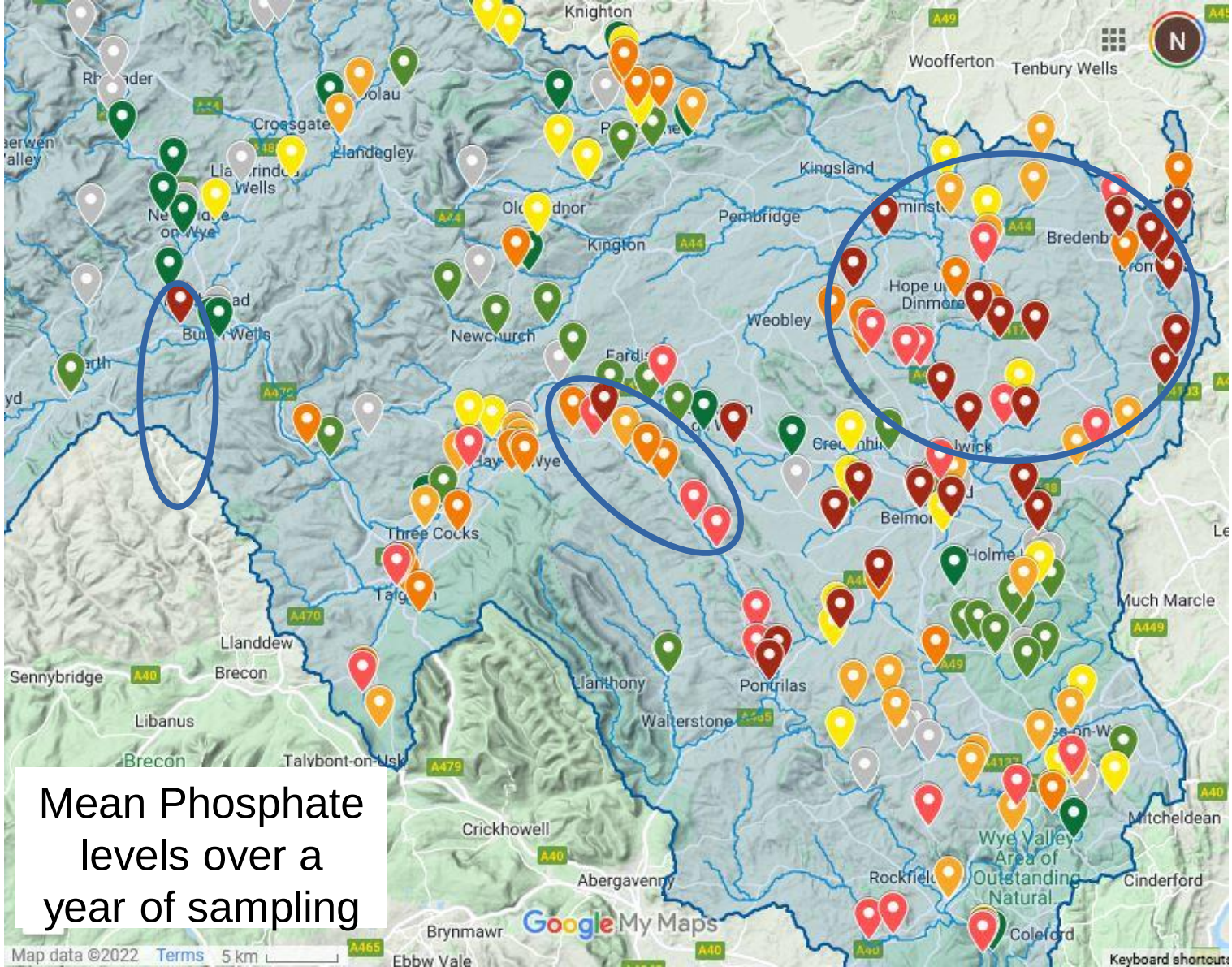
Testing coordinated by Elle vonBenzon of Cardiff University

Data from WSA, FoUW, CPRE(H), & FotLW merged by Nick Day, Friends of the Lower Wye



Catchment picture From 2021 (zoomed)

Showing the first few FotLW results: Through the coordination of Cardiff University, we can fit our results into a wider picture



Appears ‘noisy’ but backs up general expectation

3 features:
* Lugg
* Dore
* STW on Chwefru near Cilmeri, Builth Wells

More details available by clicking on each pin

Caveats:

These maps were produced largely to 'show what it's possible to show',
They're at an interim standard and gathered by 'ordinary citizens', not 'professionals'
The maps would not stand up in a court of law, but...
nevertheless indicative of what's going on;

Green doesn't mean perfect but is a lot less bad than **red**,
Red IS indicative of **very high phosphate levels**;
Broadly speaking the top 3 categories are very likely to be fails against WFD targets

*treat with some degree of caution (but we can have growing levels of faith);
-'mass testing events' and 'back-to-back' assays have indicated value of approach
*compared with maps for other time periods (April, June 2022 figures were also mapped),
-the data continues to show similar overall patterns and
-the data shows similar scattered local peaks…

Lessons:

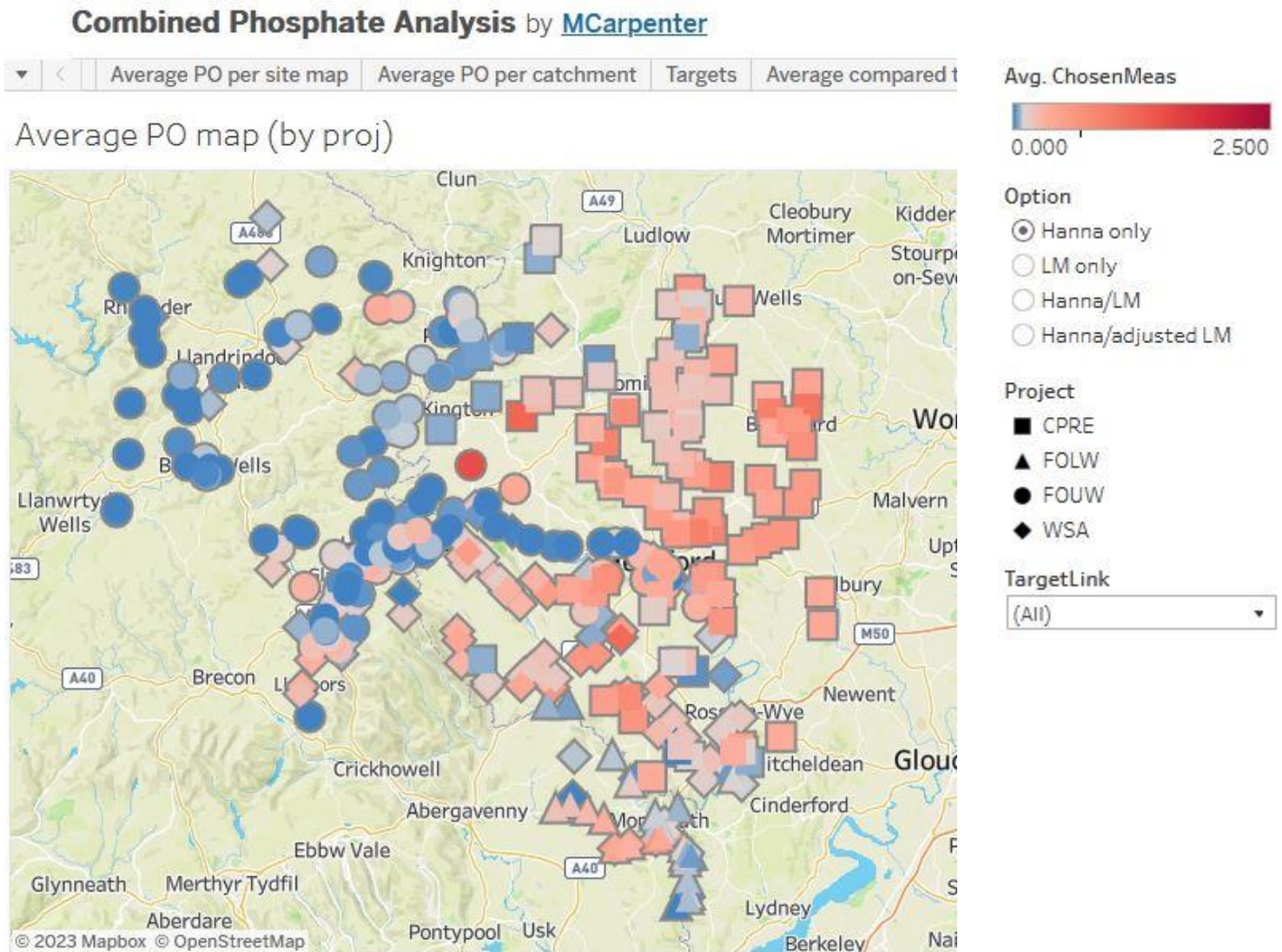
These colourful maps provoked some discussion and informed a more considered approach to presenting the data

The **value** of the pre-processed display approach is that it provides an immediate view, suitable for the less technical and numerate viewer

Limitations on the pre-processed display using Google MyMaps were evident as various questions emerged-

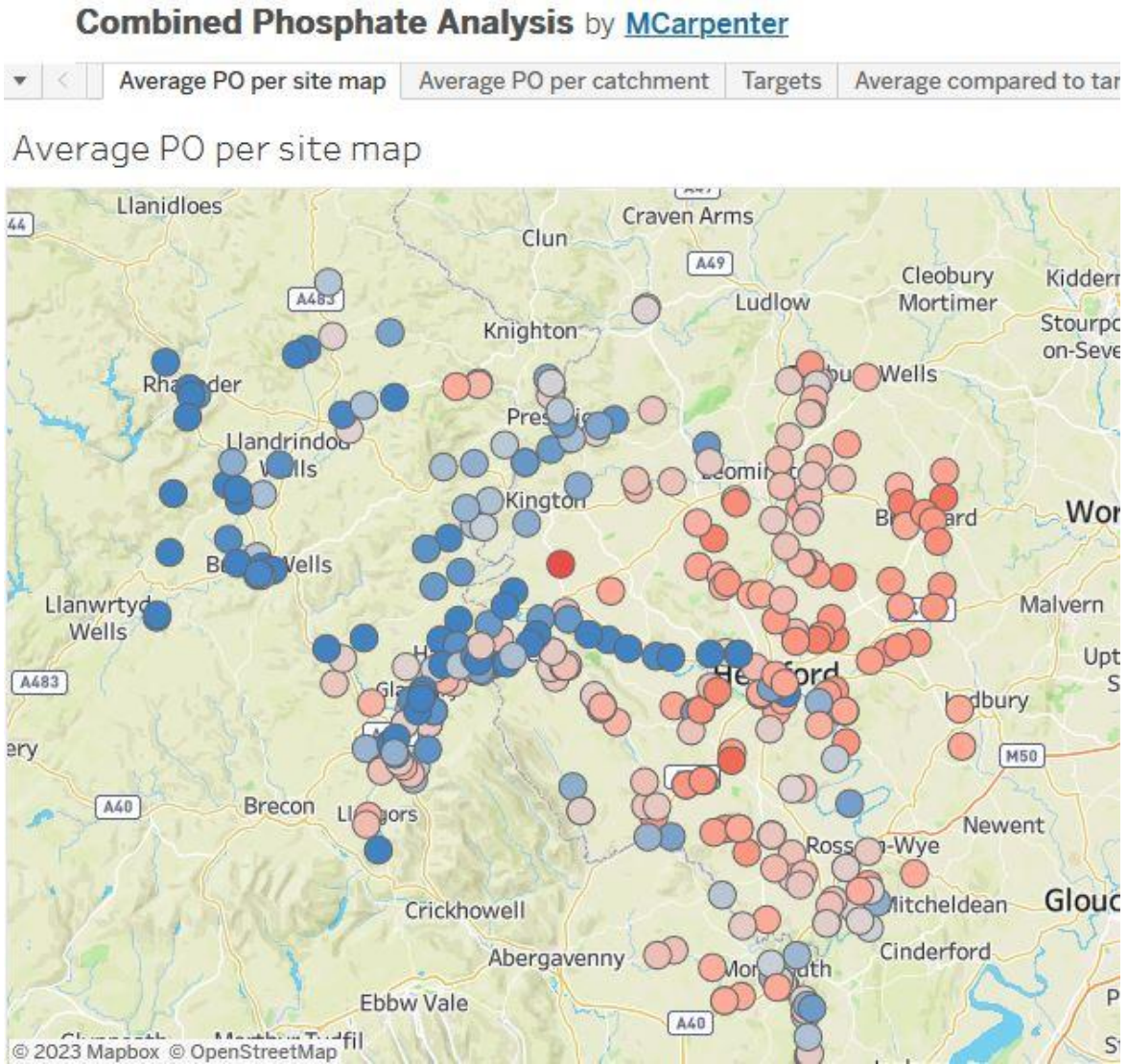
what-ifs included:
* - exclude locations with low numbers of observations
* - incl/ excl LaMotte phosphate stick measurements
* - compare annual or growing season means
* - compare directly with WFD target levels

The ability to query the data fully interactively is highly desirable for more ‘advanced users’, and has been provided by Michael Carpenter of FoUW using the ‘Tableau’ data visualisation tool; a cut-down version will be available as an ‘entry level’ option



Individual groups' datasets

Group shown by different icons



Avg. ChosenMeas

0.000 2.500

Option

- (•) Hanna only
- ( ) LM only
- ( ) Hanna/LM
- ( ) Hanna/adjusted LM

Growing season

- [x] No
- [x] Yes

Count of ChosenMeas

5 188

Project

- [x] (All)
- [x] CPRE
- [x] FOLW
- [x] FOUW
- [x] WSA

Full Combined Data Set

Can:

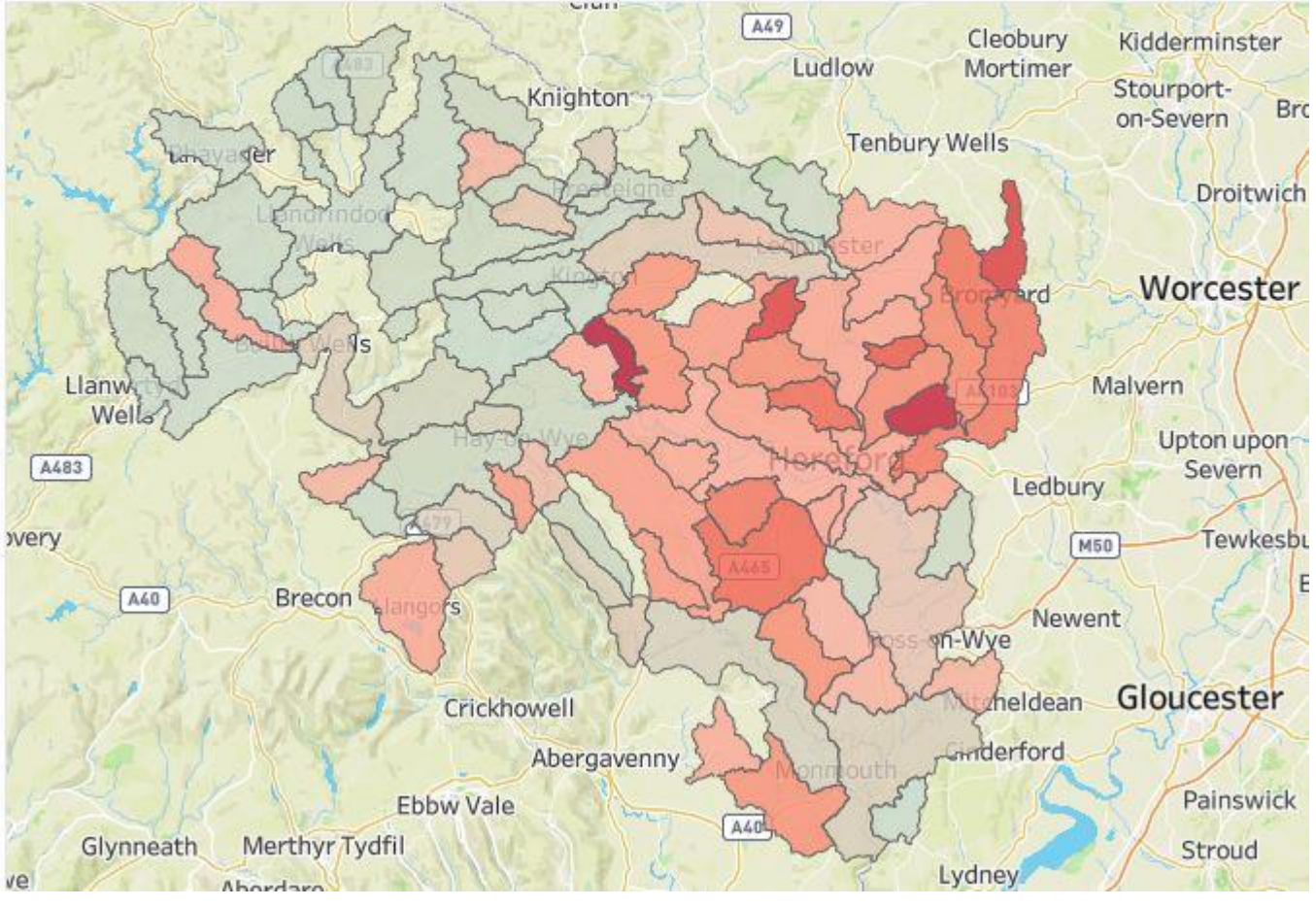
* - exclude low numbers of observations
* - incl/ excl LaMotte phosphate stick measurements
* - show annual or growing season means

Combined Phosphate Analysis by MCarpenter

Average PO per site map | Average PO per catchment | Targets | Average compared to targets

Average PO per catchment

Note different colour scale (as averages over wide areas)



Option
- (•) Hanna only
- ( ) LM only
- ( ) Hanna/LM
- ( ) Hanna/adjusted LM

Growing season
- [x] (All)
- [x] No
- [x] Yes

Avg. ChosenMeas

0.000 — 1.000

Count of ChosenMeas

5 — 1,244

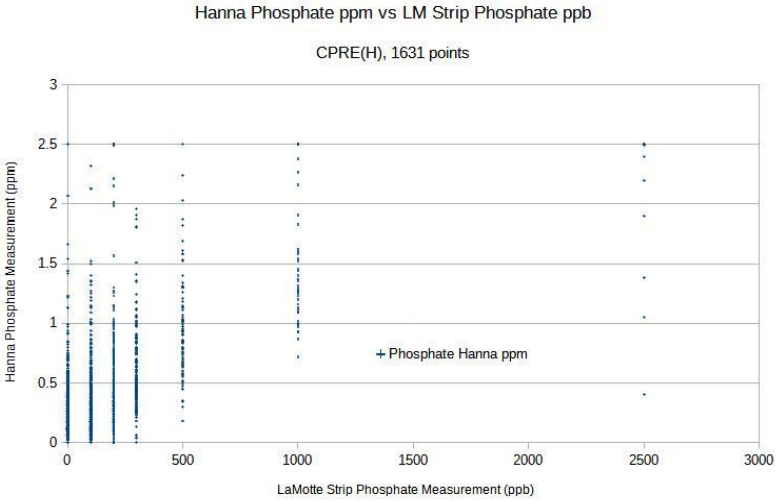
Project
- [x] (All)
- [x] CPRE
- [x] FOLW
- [x] FOUW
- [x] WSA

Further lessons:

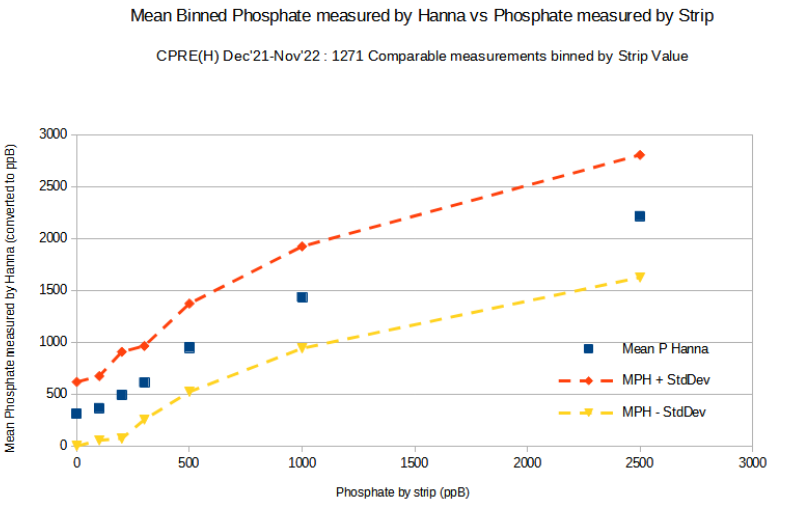
1). LaMotte strips vs Hanna digital:
Some 4,000 datapoints from CPRE(H) and FoUW had duplicated Phosphate measurements, samples tested by both Hanna and LaMotte. Full data set below:

Strip → / Hanna ↓	0	0.1	0.2	0.3	0.5	1	2.5
0-0.1	1261	569	158	50	61	32	3
0.1-0.2	223	198	90	7	2	3	
0.2-0.3	178	119	102	22	4	2	
0.3-0.4	112	81	63	29	4	2	
0.4-0.5	69	54	43	50	7	1	1
0.5-0.6	37	33	20	25	10		
0.6-0.7	21	23	19	18	13		
0.7-0.8	15	13	20	14	10	1	
0.8-0.9	7	9	11	13	12	1	
0.9-1	7	5	10	7	12	4	
1-1.1	3	7	3	7	7	5	1
1.1-1.2	2	4	3	5	5	5	
1.2-1.3	4	3	3	1	2	6	2
1.3-1.4		5	1	2	4	3	1
1.4-1.5	2	1		2	1	4	
1.5-1.6	1	2	1	2	3	3	
1.6-1.7	1				2	2	
1.8-1.9				3	2	1	
1.9-2			1	2		1	1
2-2.1	1		1		1		
2.1-2.2		2	1			1	
2.2-2.3			1		1	1	2
2.3-2.4	1	1				1	
2.4-2.5			1				2
2.5-2.6	3		4		1	3	13
3.4-3.5		1					

CPRE(H) data set on right



Means of CPRE(H) data set for each LM Strip value with SD bounds

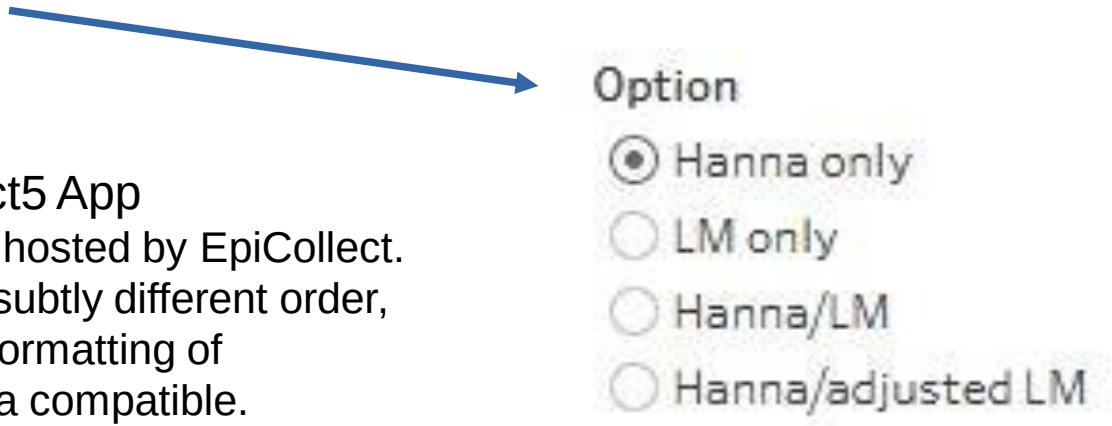


Further lessons: 1). LaMotte strips vs Hanna digital (contd.)

Groups (CPRE & FOUW) which use some LaMotte strips are phasing in their changeovers to use Hanna handheld digital meters instead.

Until that process is complete, a considerable amount of data remains being collected by LM Strips. At the moment, the total number of measurements made using only LM Strips is a significant proportion of the whole and so it is desirable to be able to make some use of this.

Hence the option in Tableau:



2). Joint common EpiCollect5 App

The groups use different Apps hosted by EpiCollect. These have their questions in subtly different order, which necessitates a lot of re-formatting of spreadsheets to get all the data compatible.

'context' observations also varied between Apps.

The simple solution is to ask all groups to change to using a Common Unified App. After considerable discussion, the C.U.A. is in the final stages of pre-launch testing.

Catchment-wide patterns of observations

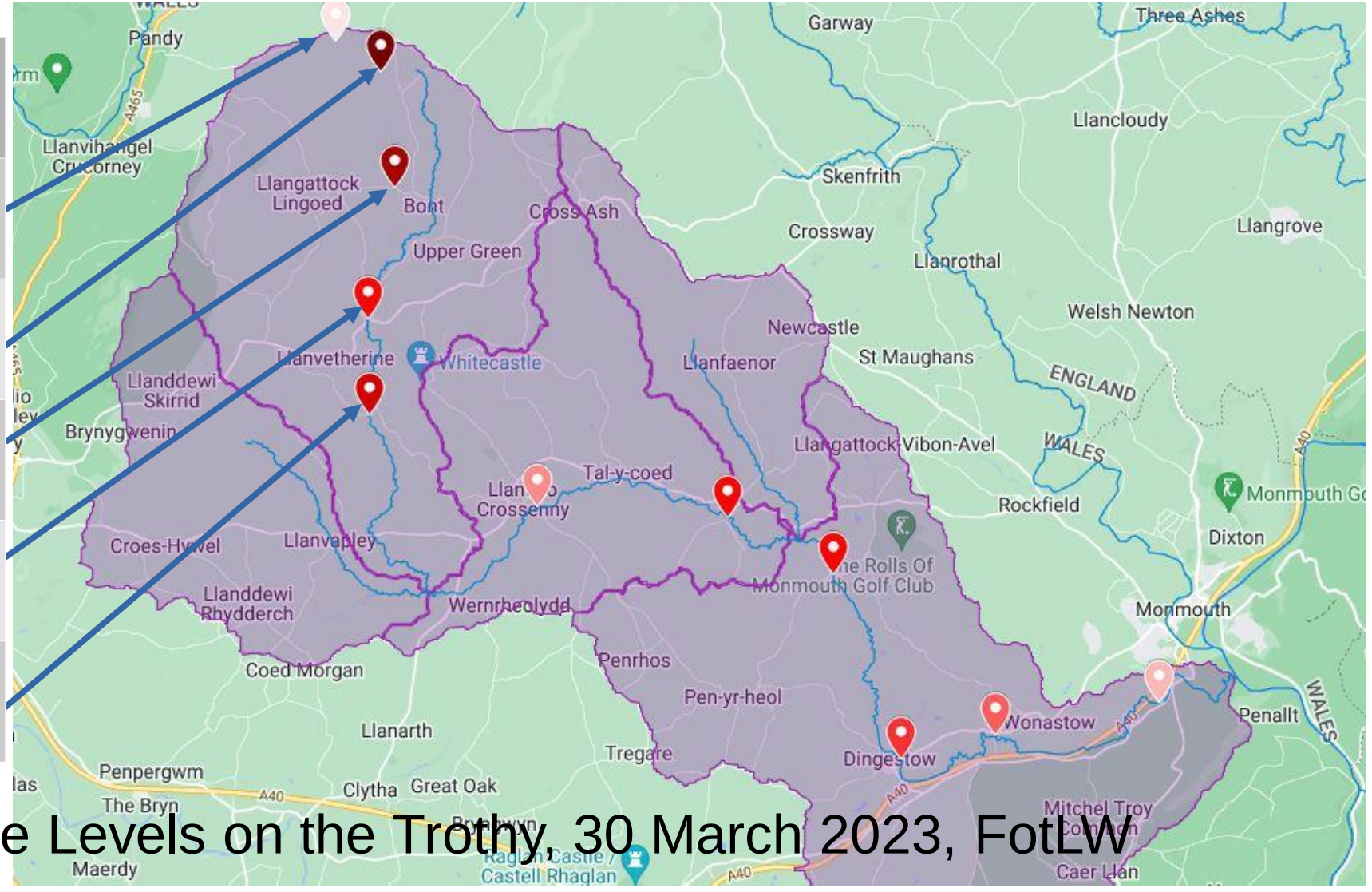
We have been working on these means to provide Volunteers with timely feedback as to the state of the river. It is the Citizen Scientist Volunteers' hope that the catchment-wide patterns of observations will also be of use to the EA and to NRW in identifying parts of the catchment which are in particularly critical need of regulatory attention. The data is made available to them, and the EA have been merging the groups' data and forwarding the results to NRW.

Specific local investigations

Meanwhile, on a more local level, some of the volunteers have been eager to track down specific sources of very high nutrient loading, and the results of one such exercise are presented below. The selection of testing points was driven almost entirely by considerations of public accessibility and safety, and the selection of the particular tributaries to be checked was made in conjunction with NRW.

FotLW are in ongoing discussion with NRW as to what appropriate next steps might be made.

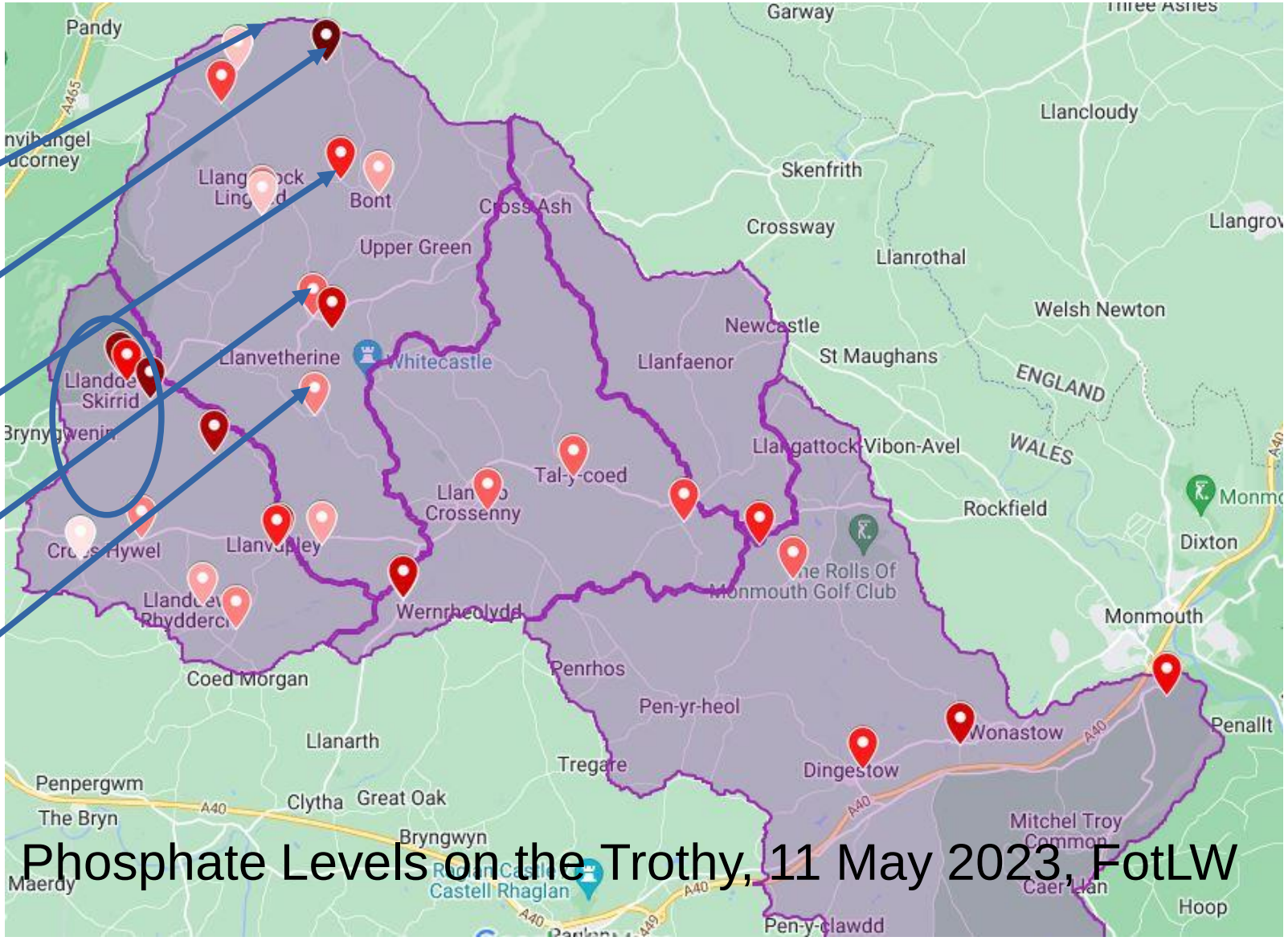
Phosphate Levels ppm
0.0 at source
2.31
0.57
0.31
0.34



Phosphate Levels on the Trothy, 30 March 2023, FotLW

Phosphate Levels ppm
Source n/a
4.15
0.25
0.21
0.18

Same worst case site, more concerns emerge



Phosphate Levels on the Trothy, 11 May 2023, FotLW

Results across the Trothy Catchment 11.05.23

- 33 locations tested – the same previous 11 places plus 22 more
- Lower stretches – Phosphate in the range 0.19 to 0.28 ppm (low for the Trothy but still ~double the target level)
- Near the source, the **same** location as before (near the source of contamination) was tested- Phosphate **4.15 ppm**
- In the adjacent valley, a tributary of the Full Brook measured
- at 1.07 ppm- fed from a farm pond
- A branch of the Llanymynach Brook is quite bad as high up as was tested (0.4 to 0.6 ppm) -source not tested- for a distance of over two kilometers

NB Phosphate ppm figures given as measured using the Hanna handheld meter

Friends of the Lower Wye
Protecting the river's health & wellbeing

Conclusions

2 years into the River Wye Citizen Science project,

- Harmonisation between the 4 main groups is progressing
- Combining all the data has become the norm
- Sampling locations are becoming better distributed
- ‘Best practice’ ideas are being shared
- Selection of equipment is maturing
- ‘Buddy working’ is becoming better established
- Data visualisation is maturing
- Understanding of the catchment-wide and more local patterns is growing

Opportunities

- Integrate other data sources
  - Weather
  - Level and Flow data
  - Sonde data?
- Identify CitSci-friendly tests for other substances
- Incorporate more hydrological understanding
- Opportunities to work with NRW and the EA are becoming apparent