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How Can Citizen Science Data Improve Eutrophication Assessments?

Ribble Case Study

Bill Brierley, Will Wright, Paul Hulme, Ellie Brown and Luke Sherwood

Document Information

Title: Using Citizen Science data to improve Eutrophication Assessments – a case study of a Weight of Evidence approach in the Ribble Catchment

Authors: Bill Brierley (Independent), Will Wright and Paul Hulme (Rivers Trust), Ellie Brown and Luke Sherwood (Ribble Rivers Trust)

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Acknowledgments:

We are indebted to the volunteers, volunteer coordinator and staff from the Ribble catchment and RRT who spent many hours collecting data about their rivers. Without their dedication and skill this interpretation would not have been possible. We are grateful to staff at the Environment Agency for giving us access to the WoE (2021) eutrophication assessment table and for providing advice and guidance on the use of the current spreadsheet and discussions on potential future developments.

1. **Link to hosting website:** Home - CastCo

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1. Introduction

Introduction

- These slides describe and illustrate how we can better improve Eutrophication Assessments using examples from the Ribble Catchment. We illustrate this by including citizen science data and observations and combining them together with Environment Agency data and Eutrophication Assessments using a Weight of Evidence (WoE) approach. This shared and collaborative understanding helps target future monitoring, catchment management actions, future water company investments and agricultural best practice and advice.
- After this introduction, Section 2 gives a background to eutrophication including costs, Section 3 covers eutrophication assessments in the Ribble catchment with examples of improving assessment by inputting citizen science data at a catchment and waterbody level, we also include recommendations for future development of the WoE tool, guidance and publication of Eutrophication maps, Section 4 introduces the Weight of Evidence approach and also introduces the Environment Agency's Eutrophication Assessment tool. Annex 1 proposes suggested citizen science evidence and data that could be included in future versions of the assessment tool.
- The citizen science data and Ribble Rivers Trust staff data used in this interpretation was collected between 2023 and 2025. Currently we can illustrate the value of including this data in the Eutrophication assessments. It is hoped that in future revisions to the WoE tool (2026 onwards) it could be modified to allow more citizen science and observations to be included.

References to the sources of data are shown in these blue boxes

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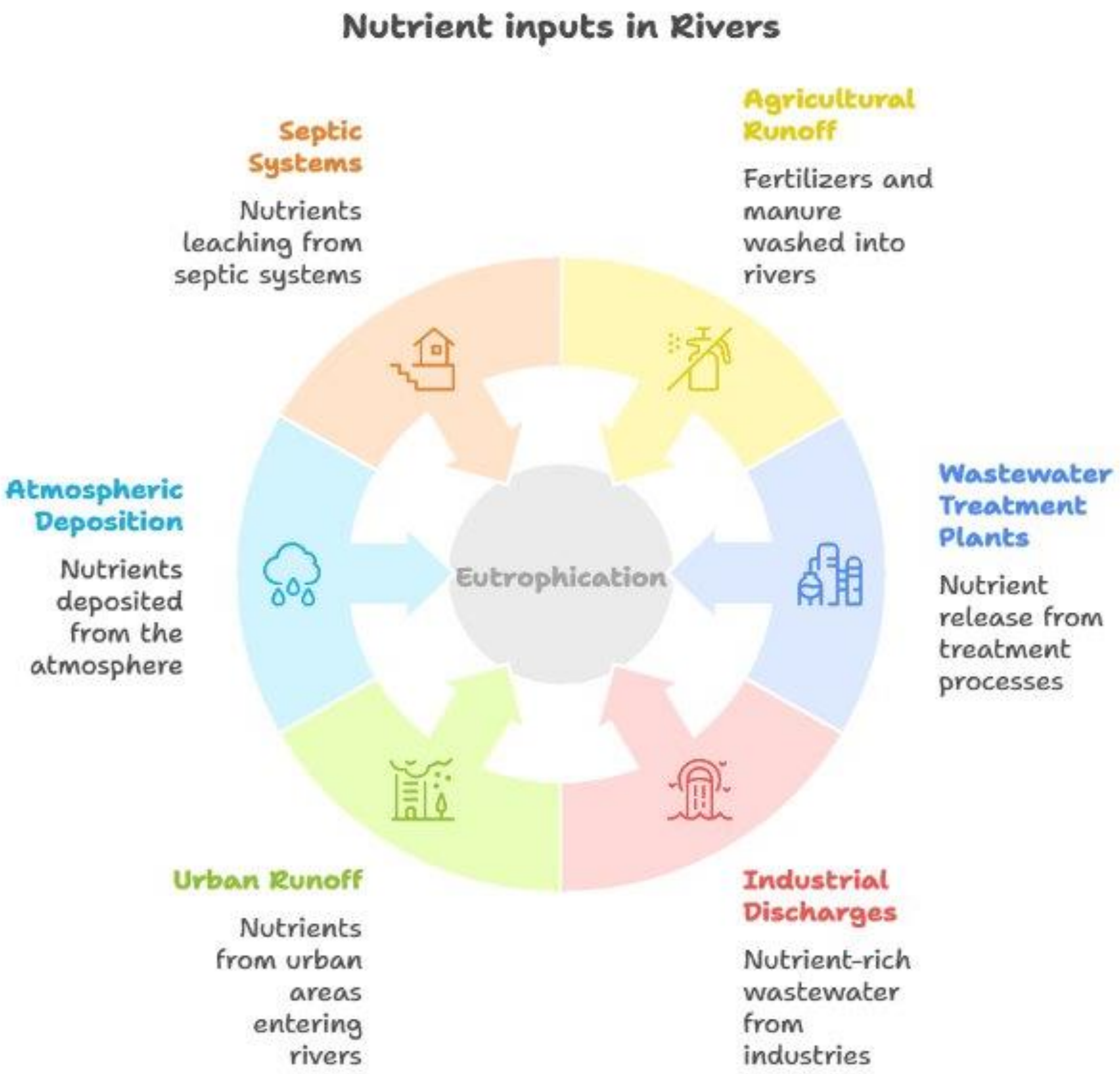
2. What is eutrophication and why is it important?

What is eutrophication?

Eutrophication is the enrichment of a water body with nutrients, primarily phosphorus and nitrogen, leading to excessive plant and algal growth. While nutrient enrichment can occur naturally, human activities have significantly accelerated the process, leading to widespread ecological problems in rivers worldwide. This accelerated, human-induced eutrophication is a major concern for river health and water resource management.

The primary causes of eutrophication in rivers are anthropogenic nutrient inputs and come from a number of different sources.



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Eutrophication – a legal definition

Eutrophication is a significant global problem with substantial environmental and financial costs.

International and national legislation and actions have been taken to reduce or minimise the impacts of eutrophication. The legal definition of Eutrophication is defined in European and UK legislation (Urban WasteWater Treatment Directive and Nitrates Directive) as:

"…the **enrichment of water by nutrients**, especially compounds of nitrogen and/or phosphorus, causing an **accelerated growth of algae and higher forms of plant life** to produce an **undesirable disturbance to the balance of organisms** present in the water **and to the quality of the water concerned**…"

UWWTD (Art. 2(11), 91/271/EEC)

Cost of eutrophication

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Eutrophication results in significant environmental degradation, such as the loss of biodiversity and water quality, which can impact industries like tourism and fishing.

The cost of eutrophication in England & Wales was estimated in 2003 to be:

- **£75-115 million per year due to**:
  - reduced value of waterfront dwellings
  - reduced recreational and amenity value of water bodies
  - drinking water treatment costs for removal of algal toxins and nitrates
  - negative ecological effects on biota
  - net economic losses from the tourist industry
- Plus **£55 million per year** in policy response costs

*"By 2020 the P load from sewage treatment works was estimated to have been cut by 66% (to 7.2kt/year), at a cost to Water Companies of **£2.1bn"*** (mainly a result of the implementation of the UWWTD and WFD)

"Agriculture and rural land management has now overtaken water industry STWs as the most common cause of water bodies not achieving good status for P. This is a significant change from second cycle of the river basin management plans when water industry sewage works were the most common cause"

Environmental Costs of Freshwater Eutrophication in England and Wales **(2003)**
Jules N. Pretty, Christopher F. Mason , David B. Nedwell , Rachel E. Hine , Simon Leaf and Rachael Dils

Phosphorus: challenges for the water environment EA (2022) https://www.gov.uk/government/publications/phosphorus-challenges-for-the-water-environment

Assessment of Eutrophication

In assessing eutrophication, we normally collect 3 strands of evidence :

1) **Pressure** evidence - increased concentrations of nutrients (phosphorus and nitrogen) or nutrient loading.

2) **Primary impact** evidence – direct impact and response of algal or macrophyte growth in response to the nutrient pressure such as increases in filamentous algae or macrophytes and /or changes in species to more nutrient tolerant taxa

3) **Secondary impact** evidence - indirect impact and other possible effects of nutrient enrichment such as excessive diurnal variations in dissolved oxygen (DO) or pH, impacts of DO and pH on fish or invertebrates or impacts on recreational activities, such as cancellation of regattas, swimming events and fishing matches

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3. Eutrophication assessment for the Ribble catchment

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Conclusions

- **We demonstrate that including citizen science data can change the eutrophication assessments in the Ribble at both the catchment scale – see here and waterbody scale – see here**
- The changes can **increase or decrease the levels of certainty of there being a eutrophication problem or not**.
- These improved assessments will help:
    - target future monitoring efforts (both spatially and different methods) for citizen scientists and RRT staff, EA/NRW and Water Companies
    - inform and target further investigations and advisory visits
    - inform water industry WINEP and AMP investments
    - inform where other actions such as Nature-based Solutions or agricultural advice may be appropriate
    - inform further catchment and management actions
- Eutrophication assessments are carried out by the Environment Agency on a regular cycle (approximately 5 yearly) and can include data evidence from third parties - we hope that more citizen science data will be included in future versions of the tool and assessment cycles.

Recommendations

- **Add new Citizen Science evidence columns into tool – see here - so that data is included and valued in revised eutrophication tool - examples of evidence to include are:**
  - Phosphate data – time series or spot samples
  - Evidence of sewage spills and CSOs
  - Algal or plant surveys eg filamentous algae (RAPPER) or photos
  - Impacts on recreation or aesthetics – photos or reports
- **Work with EA national team to develop guidance for EA Area staff and Rivers Trusts:**
  - the value of including CS data and what types of data are useful
  - how to include CS data into WoE tool and assessments
  - develop trusted monitoring and evidence sources with quality assurance protocols in place
- **Promote use of CS data and evidence in tool with RTs, WTs and Catchment partnerships and inclusion with Collaborative Monitoring Plans (CMPs)**
- **Publish Eutrophication maps for the whole country so that CaBA partnerships and citizen science groups can see where to focus collaborative monitoring and what to monitor.**

4. Summary of Eutrophication Assessment Cycle that includes Citizen Science evidence

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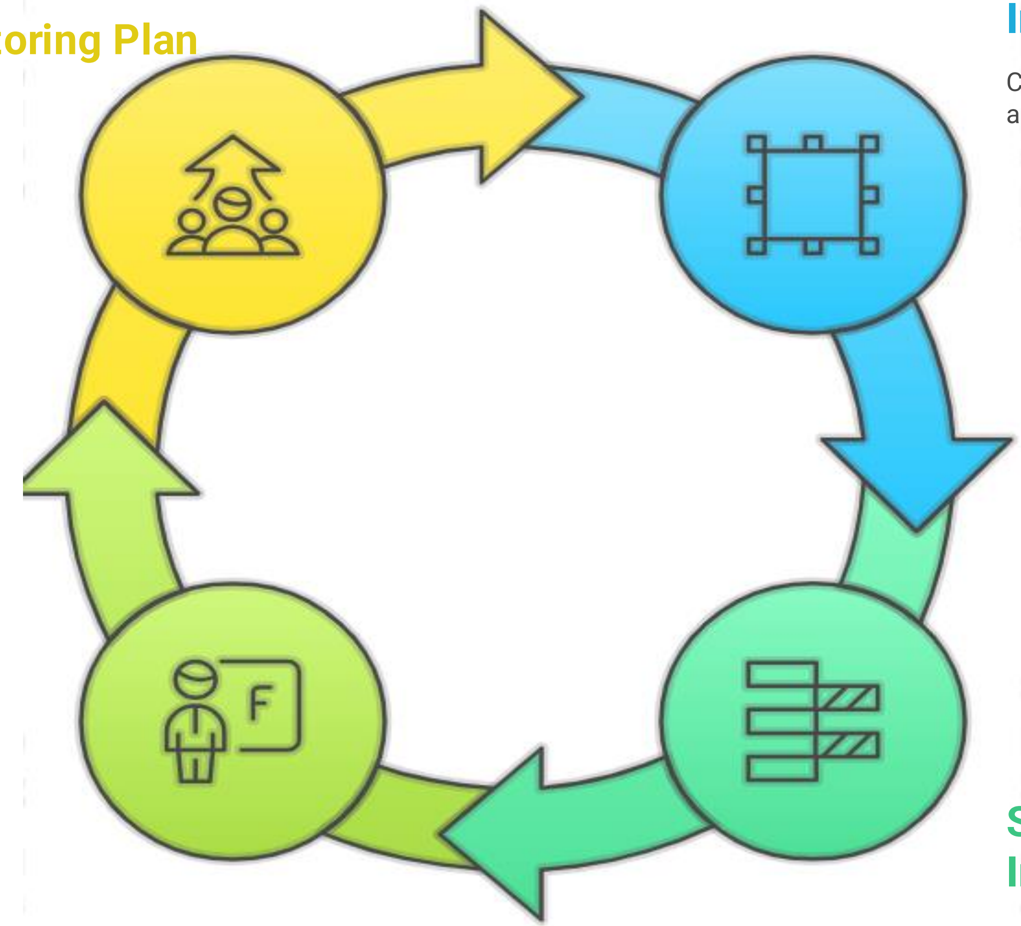


Step 1.
Initial Assessment

Conduct initial assessment using EA tool

Step 2
Integrate Citizen Science

Incorporate citizen science data

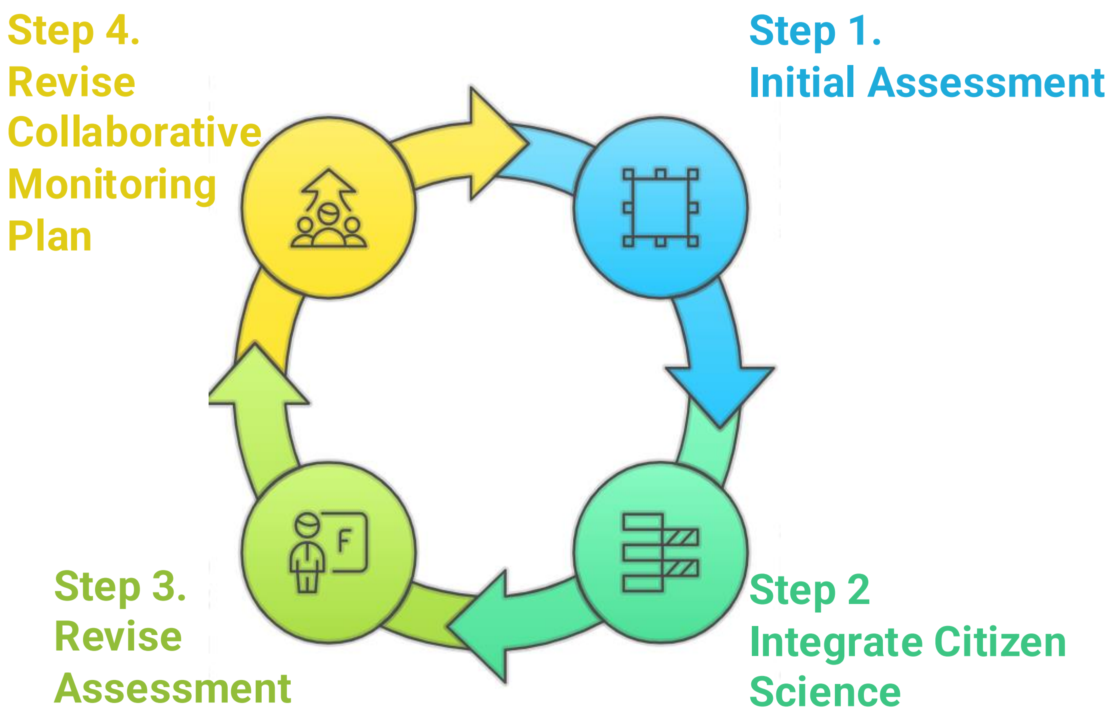
Step 3.
Revise Assessment

Revise assessment based on new data

Step 4.
Revise Collaborative Monitoring Plan

Add to-collaborative monitoring plan

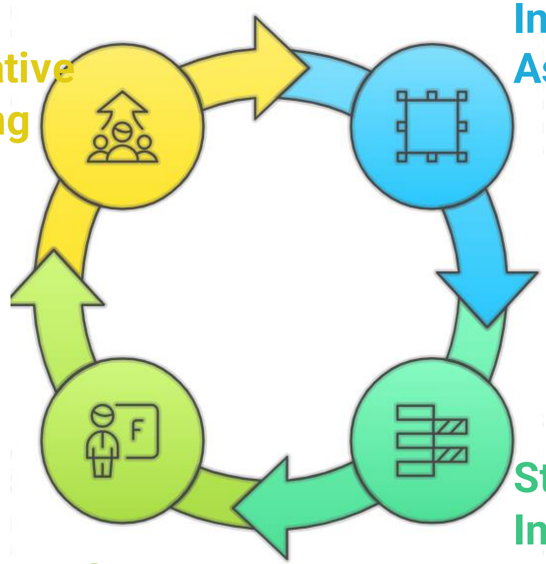
Step 1:
Initial Assessment



- Conduct initial assessment using EA tool.
- This tool provides a structured framework for evaluating various lines of evidence related to eutrophication,
- It combines these different lines of evidence to provide an overall assessment.
- Crucially, **the tool also identifies areas of uncertainty in the assessment and suggests what type of further evidence** (pressure or impact) would be most beneficial to collect to reduce this uncertainty and improve the assessment.

Step 2:

Integrate Citizen Science



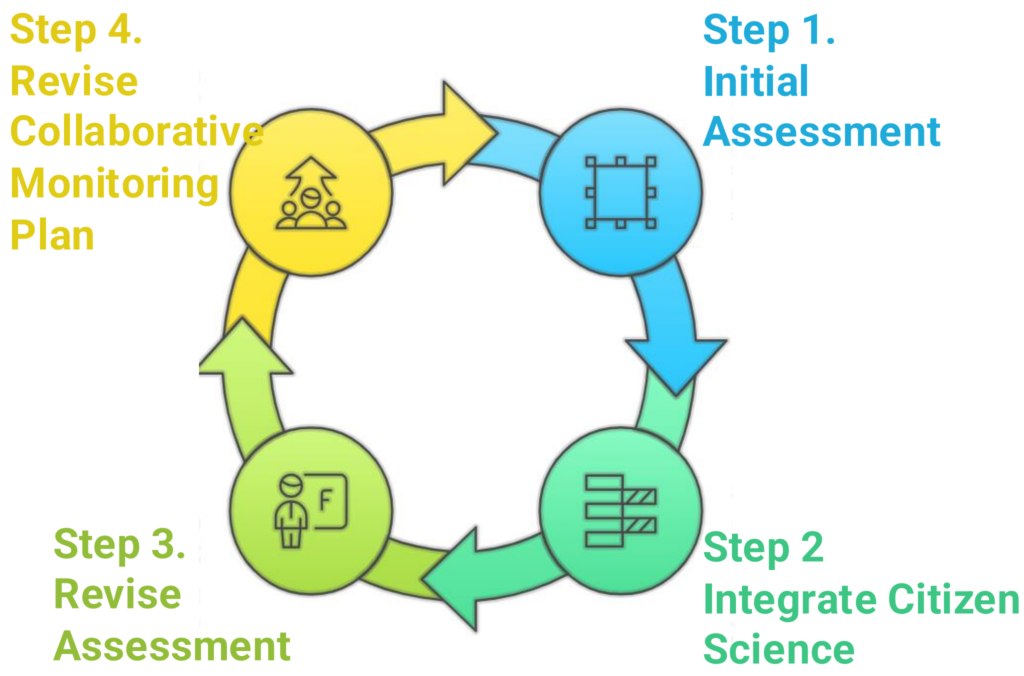
This focuses on identifying citizen science data to supplement the existing evidence and improve the assessment. Particularly important for water bodies where the initial assessment is uncertain and CS evidence can help reduce the uncertainty.

Local evidence or knowledge indicates the initial assessment may not be correct. Citizen scientists often have valuable local knowledge that can challenge or refine the initial assessment.

The process involves:

1. **Identifying available citizen science data.**
2. **Reviewing the data.** The quality and relevance of the citizen science data must be carefully reviewed before it is included in the assessment.
3. **Deciding whether to include the data.** Based on the review, a decision is made whether to include the citizen science data into the tool. Factors to consider include the reliability of the data, its relevance to the eutrophication assessment, and its potential to reduce uncertainty or improve the accuracy of the assessment.
4. **Adding the evidence into the tool as an additional line of evidence.**

Step 3:
Revise Assessment



Once the citizen science data has been incorporated into the WoE tool, the tool then produces a new revised assessment.

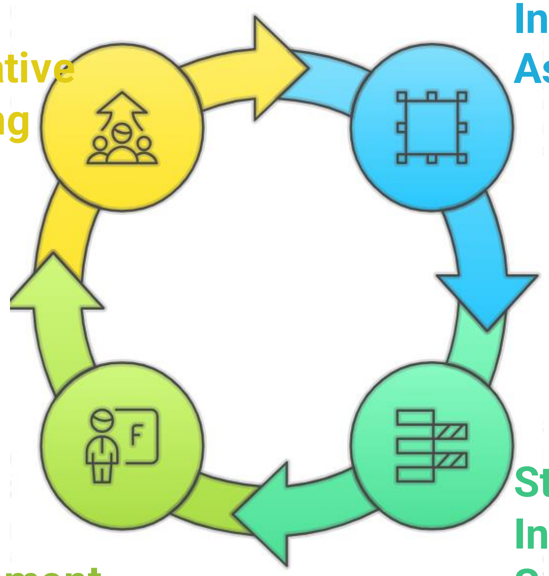
The revision may result in:

1. **A change in the eutrophication status of the water body.**

2. **Identification of data gaps.** The citizen science data may highlight areas where further data collection is needed to improve the assessment.

Step 4:

Revise Collaborative Monitoring Plan



The revised assessment from Step 3 is reviewed by the relevant partners (e.g.EA, Water Utilities, Rivers Trusts, CaBA partnership) and next steps agreed, which may include:

- Further data collection aiming to reduce the uncertainty of the eutrophication assessment.
- Further data collection to identify the sources of the high nutrients that are causing eutrophication in areas where the assessment indicates high risk.
- Action to reduce eutrophication.

If further data collection is agreed, it is important to identify which partners (including citizen scientists) will collect which data and incorporate this into the collaborative monitoring plan.

Steps 2-4 may then be repeated using the new data in an iterative cycle to produce a revised eutrophication assessment. This ensures that the eutrophication assessment is regularly updated, which then informs effective and appropriate management strategies.

The involvement of citizen scientists is crucial to this process, providing valuable evidence and local knowledge that can significantly enhance the assessment.

5. Eutrophication assessment at the Catchment scale in the Ribble

Step 1. Initial assessment (WoE assessment spreadsheet 2021) across the catchment - see here

Step 2. Further evidence, including CS evidence identified and input into the WoE tool. This included:

i) updating the EA Phosphate classifications to 2022 for all waterbodies in the Ribble catchment

ii) inputting citizen science and staff data (Ribble Rivers Trust) into WoE tool.

Step 3. Revised assessments - see here

The changes this makes at a catchment level are illustrated here

Eutrophication assessment change

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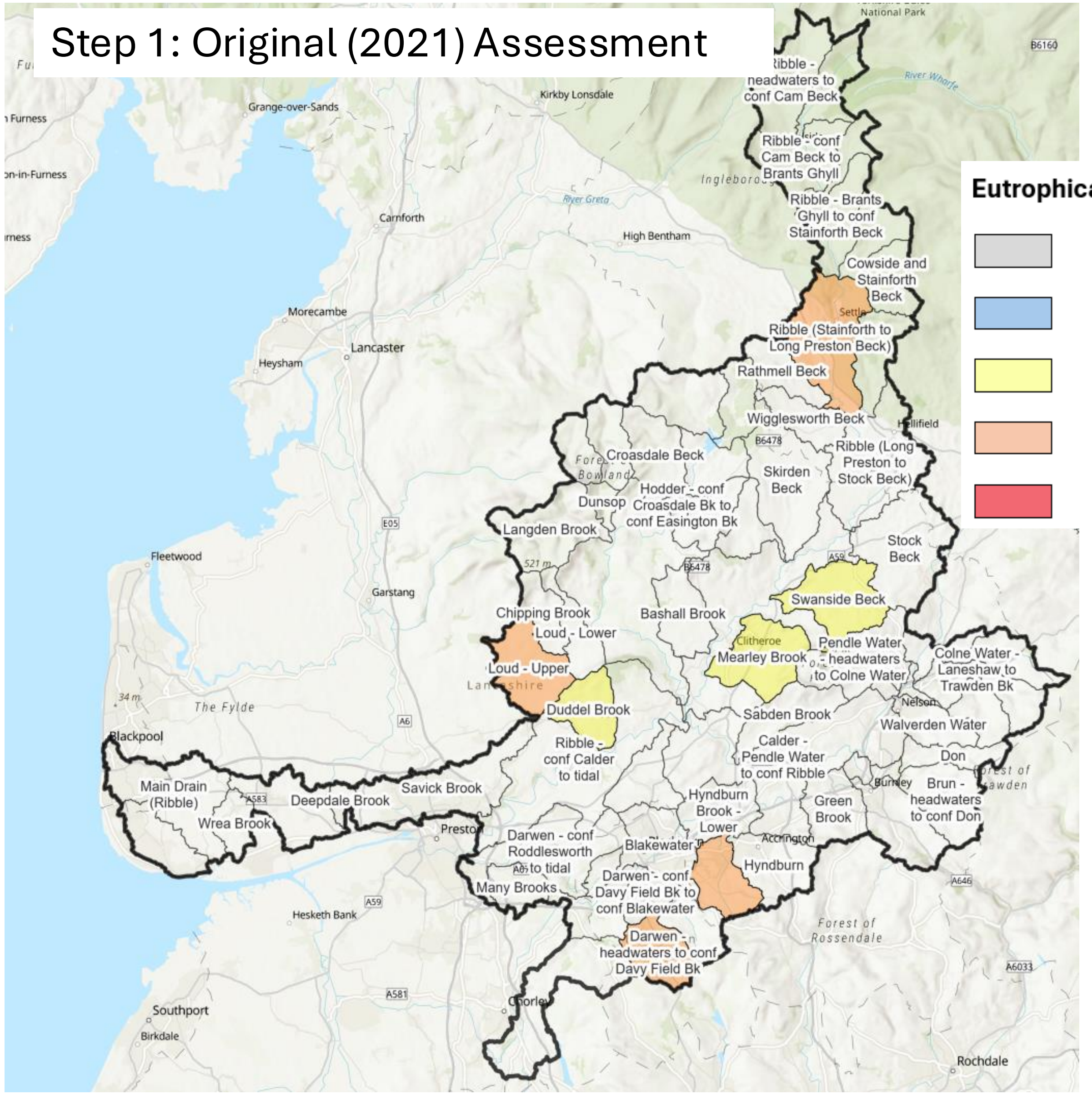
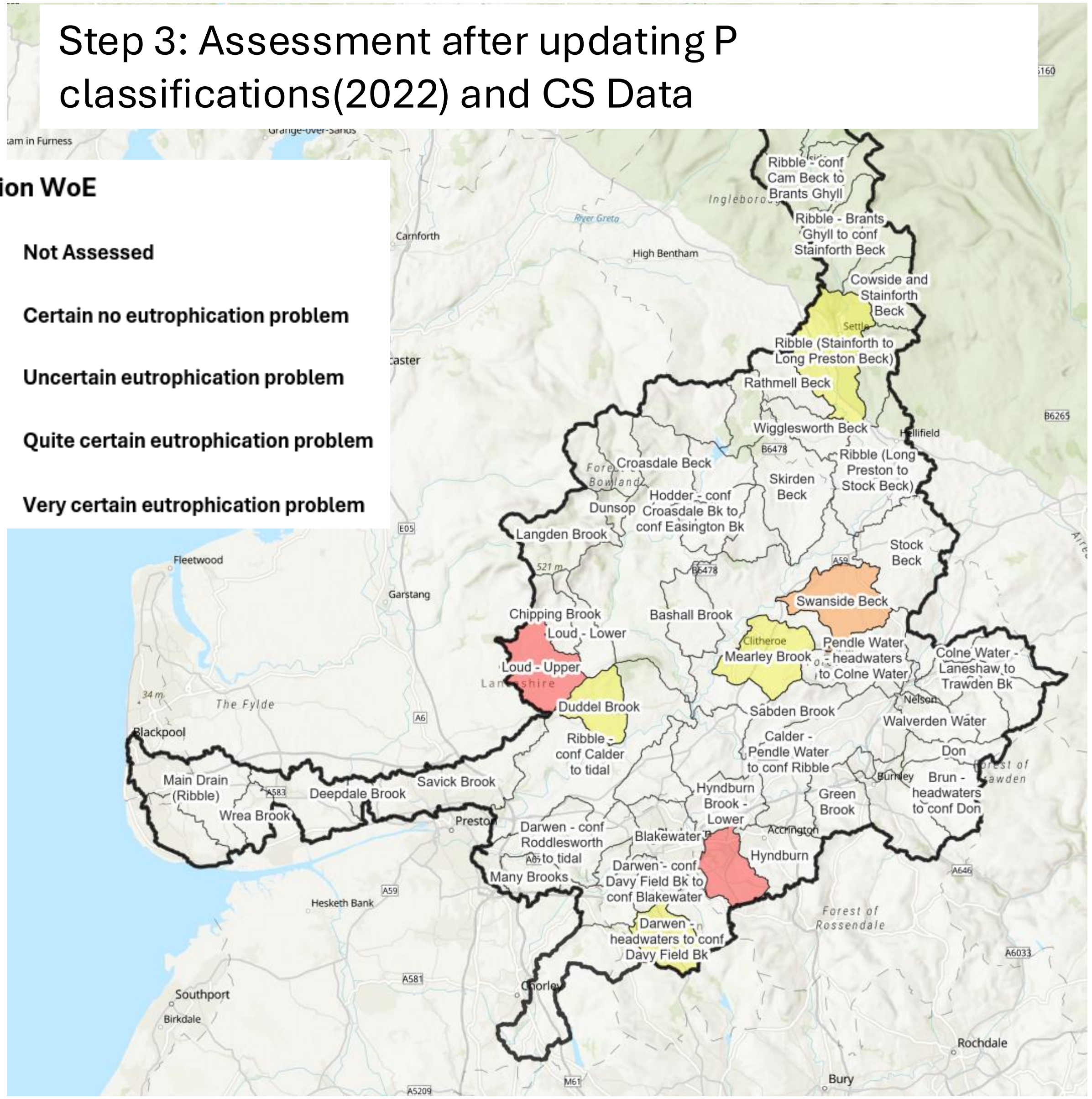


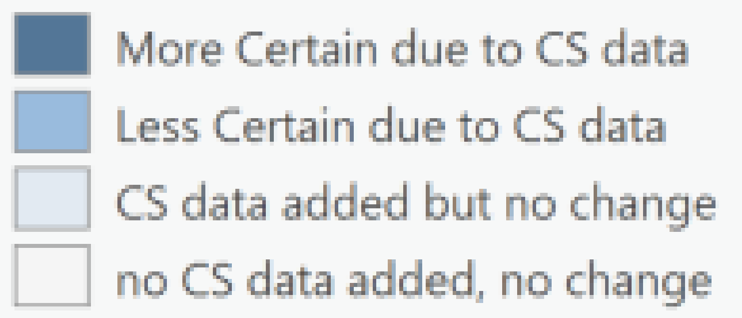
Eutrophication WoE

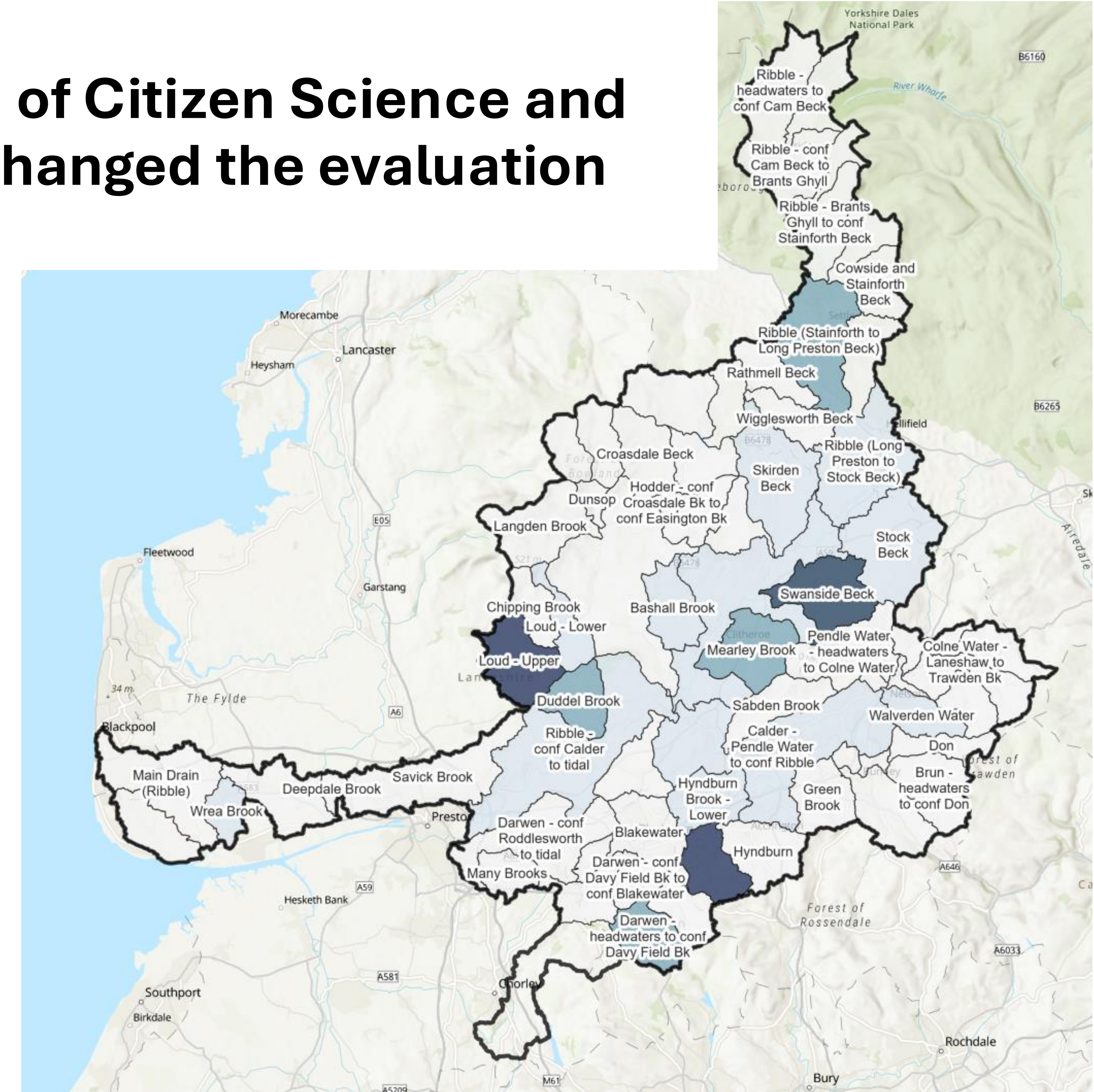
- Not Assessed
- Certain no eutrophication problem
- Uncertain eutrophication problem
- Quite certain eutrophication problem
- Very certain eutrophication problem



Waterbodies in which the use of Citizen Science and Ribble Rivers Trust data has changed the evaluation

- Out of the 71 water bodies in the Ribble, 53 water bodies had CS/RRT data, and of these the eutrophication assessments for 6 waterbodies changed:
  - 3 were **more certain** of a eutrophication problem
  - 3 were **less certain** of a eutrophication problem
- **This is an 11% change in the risk assessments for the waterbodies that have CS evidence**
- There was no change in 10 waterbodies with the input of CS/RRT data





6. Case studies illustrating the value of CS data in assessments at a waterbody level

In the following slides we illustrate the value of including CS evidence in 2 waterbodies **– Swanside Beck** and the **Upper Loud**

Again the steps are :

- **Step 1. Initial assessment** (WoE assessments spreadsheet 2021) for the waterbody
- **Step 2. Further evidence**, identifying and including CS and RRT staff evidence to input into the WoE tool.
- **Step 3. Revised assessments**

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Swanside Beck – Step 1
Original EA assessment (2021)

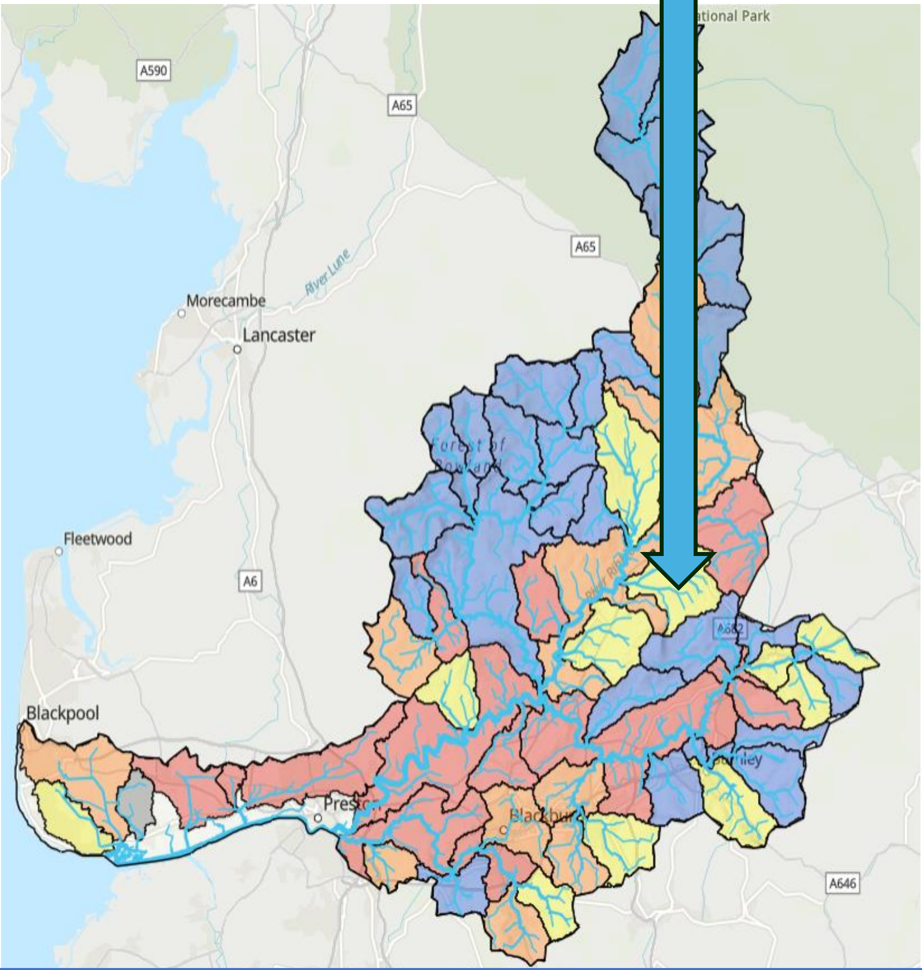
Original EA assessment (2021) is that Swanside Beck is "**Uncertain eutrophication problem**"

Core Quality elements Face value classification (High=6, good=4, moderate=3, poor=2, bad=1)							Core Quality elements Confidence of Moderate or Worse						Combine Diatoms with Macrophytes		Combine biology (Diatom/ Macrophyte) with Phosphorus	
P 2019 classification	Rolled fwd from year	Diatom 2016 classification	Rolled fwd from year	Macrophyte 2019 classification	Rolled fwd from year	Combined Macrophyte-phytobenthos element (worst of either)	Phosphorus 2019 classification	Diatom 2016 classification	Macrophyte 2019 classification	Phosphorus 2019 classification	Diatom 2016 classification	Macrophyte 2019 classification	Code Diat/Mac	Combined macrophyte & phytobenthos WoE	Code (Diat/macro)/P	Weight of Evidence Core Tools (Phosphorus & Biology)
4	2019			3	2016	3	0		0.78	GorB	ND	Q	ND/Q	Q	Q/GorB	Uncertain

2019 P classification is **GOOD**

2019 Macrophyte classification is **MODERATE**

Spreadsheet advises: '**Evidence of ecological impact but no pressure, is this a different pressure, how strong is the evidence of impact**?



Open Rivers Network – Ordnance Survey, The RiverRestoration Centre, GeoData (University of Southampton)
Mapped Eutrophication Assessments from EA WoE tool (2021) and available via CaSTCo Open data hub: https://data.castco.org/

Swanside Beck – Step 2

Adding CS and RRT staff data and evidence

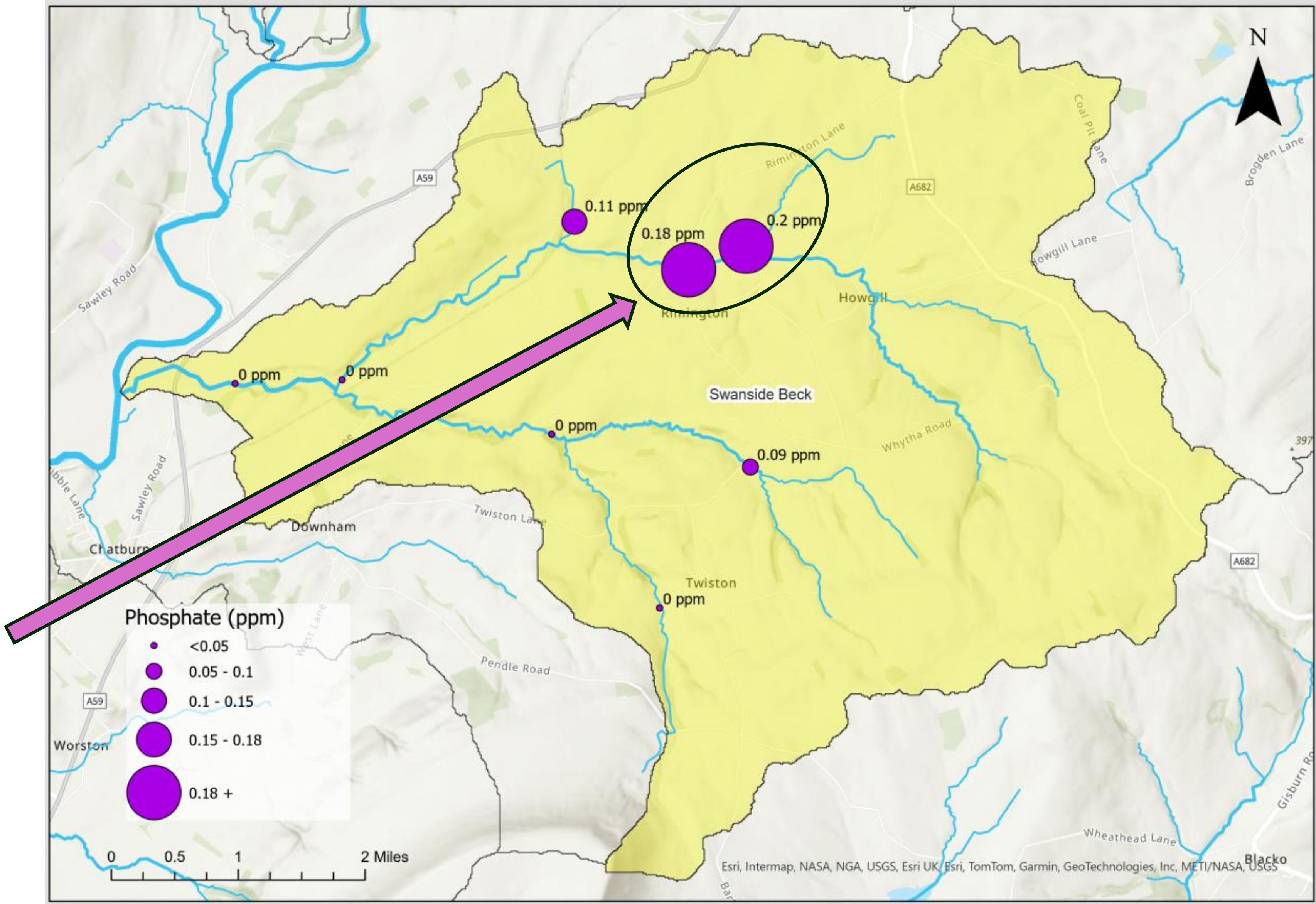
WoE tool recommends need to look for further evidence - "*if there is a different pressure*" or

"further evidence of the pressure" – - so looking for ***high levels of phosphorus or phosphate .***

Citizen science and Ribble RT staff monitoring from River Blitzes between 2023 and 2025 show low levels of phosphate across much of catchment measured using the Hanna method.

2 sites have elevated levels of phosphate (0.2 and 0.18 mg/l as Phosphate) in the upper catchment.

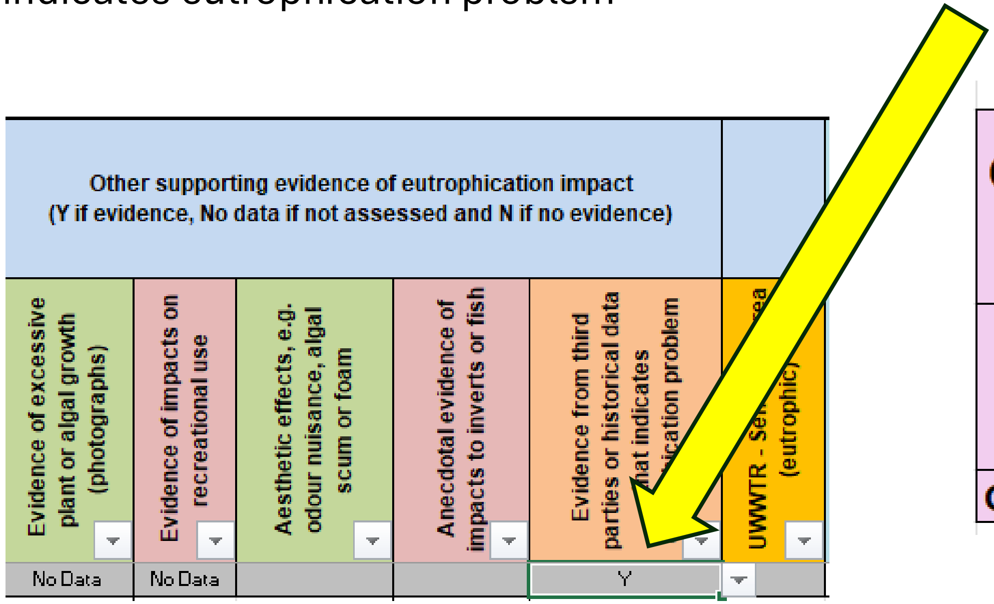
Data from Ribble Rivers Trust Citizen Science monitoring - https://ribbletrust.org.uk/volunteer/citizen-scientists/



Step 3 - Swanside Beck

Updated assessment using Citizen Science data and other evidence

As we have evidence of elevated levels of P in the waterbody, we can add a "Y" into the “Evidence from third parties or historical data that indicates eutrophication problem”



Confidence of Eutrophication Impact considering Wider Weight of Evidence	
Change (no change or consider increase/decrease to)	Final confidence
Consider increase to	Quite certain eutrophication problem

The addition of the Citizen Science P data leads to a change in the assessment and suggests **“consider increase to quite certain eutrophication problem"**

Upper Loud – Step 1

Original EA assessment (2021)

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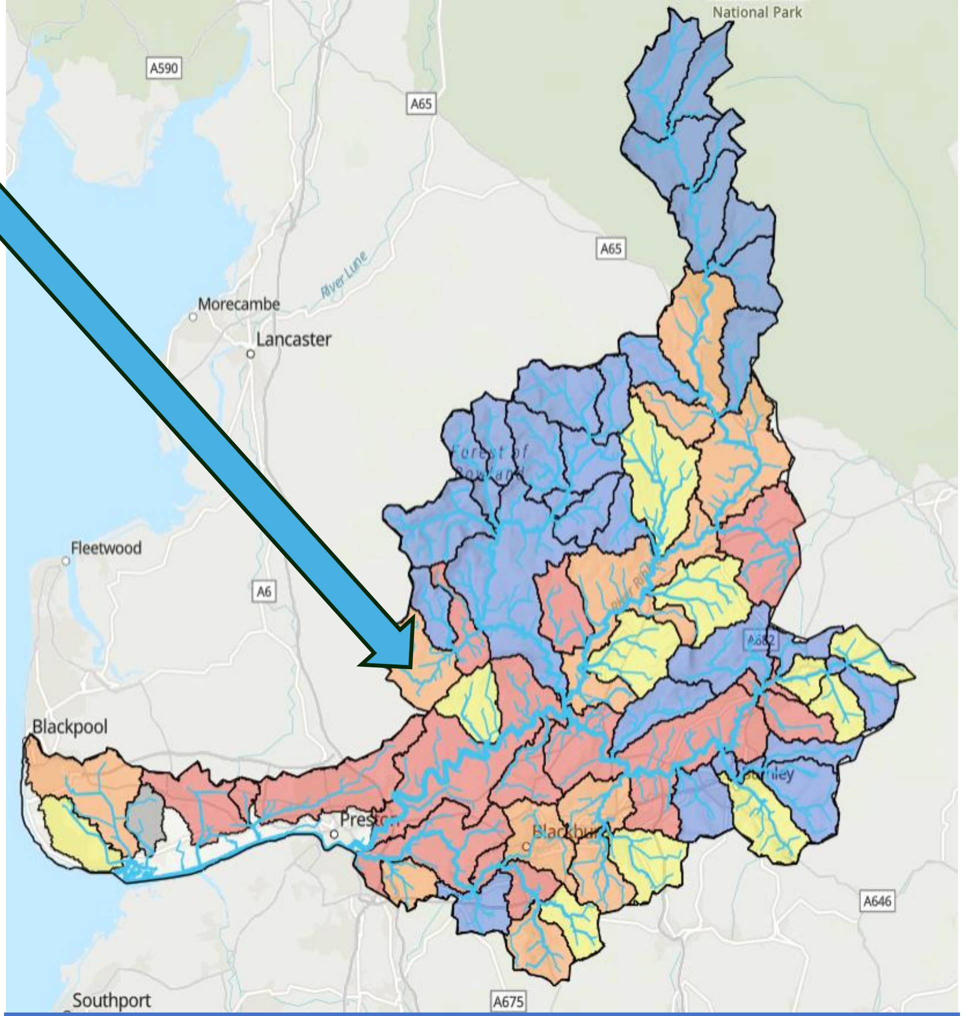
Original EA assessment (2021) is that Upper Loud is "**Quite certain eutrophication problem**"

NATIONAL CLASSIFICATION DATA (last updated July 2020)																
Core Quality elements Face value classification (High=6, good=4, moderate=3, poor=2, bad=1)							Core Quality elements Confidence of Moderate or Worse						Combine Diatoms with Macrophytes		Combine biology (Diatom/ Macrophyte) with Phosphorus	
P 2019 classification	Rolled fwd from year	Diatom 2016 classificcation	Rolled fwd from year	Macrophyte 2019 classification	Rolled fwd from year	Combined Macrophyte-phytobenthos element (worst of either)	Phosphorus 2019 classification	Diatom 2016 classification	Macrophyte 2019 classification	Phosphorus 2019 classification	Diatom 2016 classification	Macrophyte 2019 classification	Code Diat/Mac	Combined macrophyte & phytobenthos WoE	Code (Diat/macro)/P	Weight of Evidence Core Tools (Phosphorus & Biology)
2	2019			4	2016	4	0.9915		0.05	V	ND	GorB	ND/GorB	UGorB	UGorB/V	Quite certain

2019 P classification is **POOR**

2019 Macrophyte classification is **GOOD**

Spreadsheet suggests : 'Evidence of pressure but ecological impact does not occur, is there any wider evidence of impact ? '



Open Rivers Network – Ordnance Survey, The RiverRestoration Centre, GeoData (University of Southampton)
Mapped Eutrophication Assessments from EA WoE tool (2021) and available via CaSTCo Open data hub: https://data.castco.org/

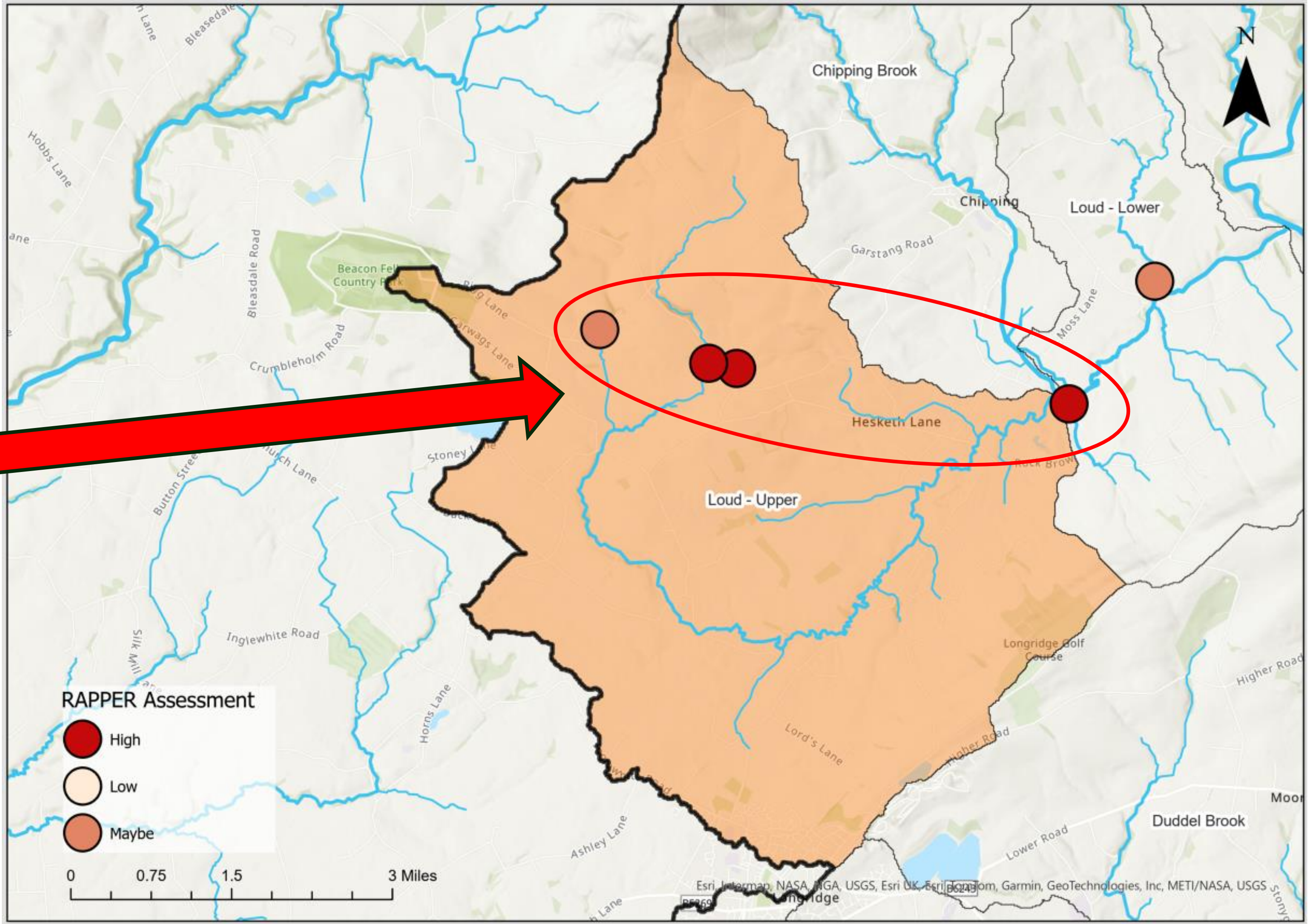
Upper Loud – Step 2

Adding CS and RRT staff data and evidence

EA tool recommends need to look for *"further evidence of impact on algae, macrophytes or other biology and …….."*

Algal surveys (RAPPER) carried out by CS and RRT staff in the Upper Loud during 2025 at 4 sites within the waterbody indicate 3 sites at HIGH risk and the other site MAYBE at risk – this provides ***"evidence of an impact on algae"***

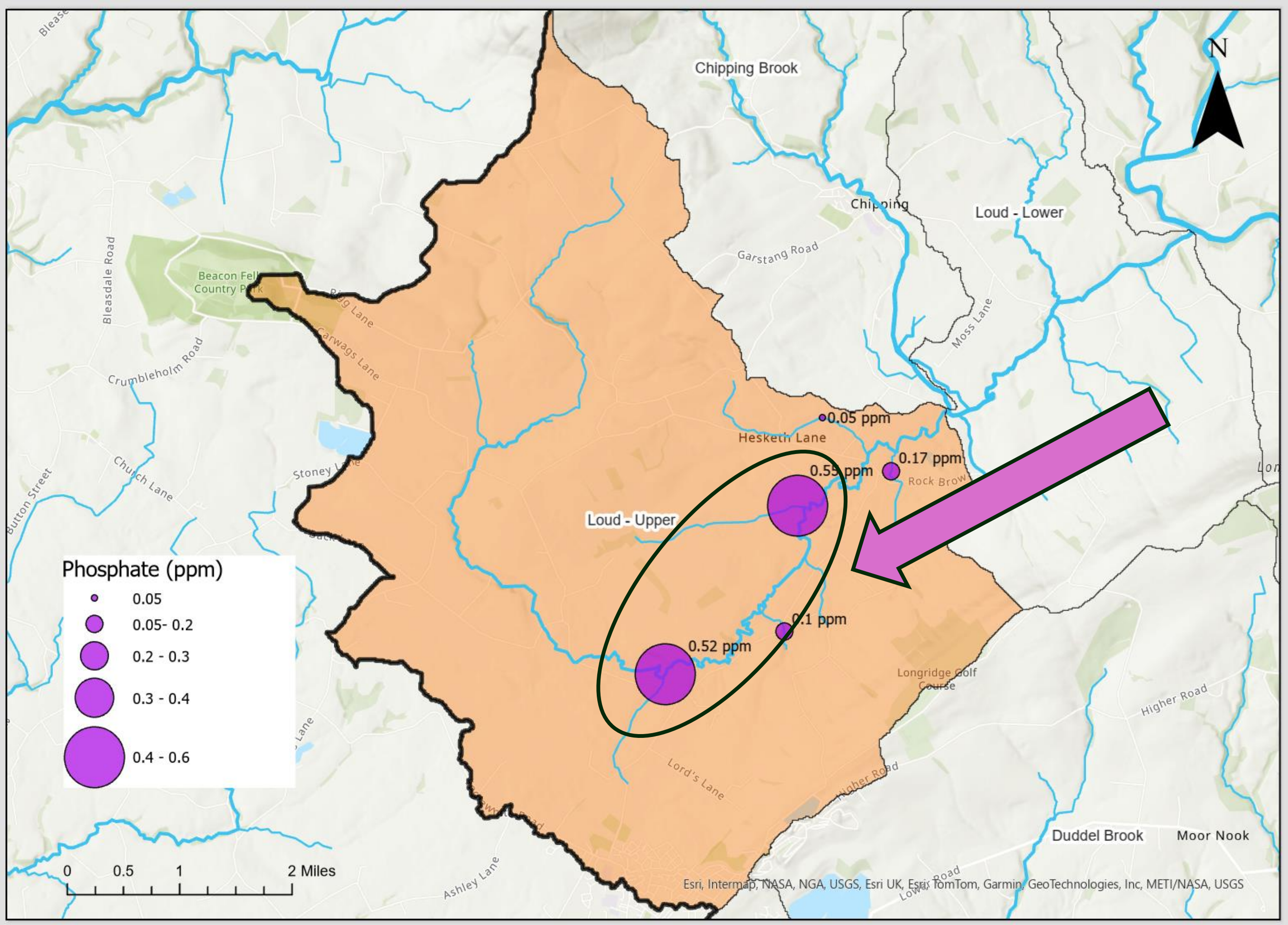
Data from Ribble Rivers Trust RAPPER Results - https://ribbletrust.org.uk/volunteer/citizen-scientists/



Upper Loud – Step 2

Adding CS and RRT other data and evidence

EA tool also suggests that we might look for
*"further evidence of .... **and other information"***



Citizen science and Ribble RT staff monitoring from River Blitzes between 2023 and 2025 show low levels of phosphate across much of catchment

2 sites have elevated levels of phosphate (0.52 and 0.55 mg/l as P) in the middle/lower catchment when monitored as part of a River Blitz

These levels are well above the EA Moderate to Poor thresholds (0.149, 0.154 and 0.156 mg/l as P) for this waterbody. These values are derived from long term averages

This indicates recent localised problems.

Data from Ribble Rivers Trust Citizen Science monitoring - https://ribbletrust.org.uk/volunteer/citizen-scientists/

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Step 3 – Upper Loud

Updated assessment using Citizen Science data and other evidence

As we have evidence of an **impact on algae** (high risk category) and 2 high P results in the waterbody we can add a "Y" into the “Evidence from third parties or historical data that indicates eutrophication problem” column.

Other supporting evidence of eutrophication impact (Y if evidence, No data if not assessed and N if no evidence)					
Evidence of excessive plant or algal growth (photographs)	Evidence of impacts on recreational use	Aesthetic effects, e.g. odour nuisance, algal scum or foam	Anecdotal evidence of impacts to inverts or fish	Evidence from third parties or historical data that indicates eutrophication problem	UWW... sensitive Area (eutr...
No Data	No Data			Y	

Confidence of Eutrophication Impact considering Wider Weight of Evidence	
Change (no change or consider increase/decrease to)	Final confidence
Consider increase to	Very certain eutrophication problem (if adequate impact data ?)

The addition of the Citizen Science data leads to a change in the assessment and suggests **“consider increase to Very certain eutrophication problem"**

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7. Background to the Weight of Evidence (WoE) approach and introduction to the EA Eutrophication Assessment tool

Weight of Evidence

- The Weight of Evidence approach (also referred to as Evidence Based Decision Making) is used in many areas of daily life - UK legal system, health care, catchment and conservation management and eutrophication.....
- Evidence can both support or refute an assumption
- Evidence is 'relevant information used to assess one or more assumptions related to a question of interest' (modified from Salafsky et al., 2019)

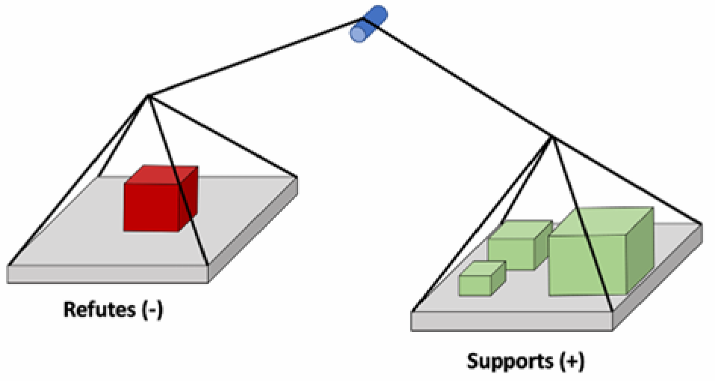
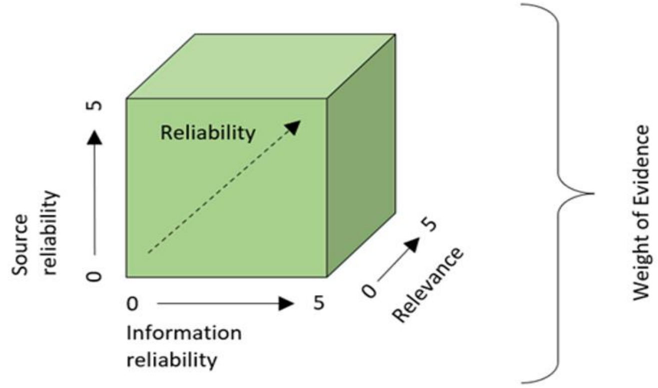


Figure 2.3 A means of visualising the evidence behind an assumption. The pieces of evidence are placed on either side of the scale, with evidence supporting the assumption falling on the right-hand side (green cuboids), and evidence refuting the assumption and the improbability (red cuboid) falling on the left-hand side. The volume of each cuboid represents its weight. The greater the tilt the higher the confidence in accepting (or rejecting) an assumption. (*Source:* adapted from Christie et al., 2022, following an idea of Salafsky et al., 2019, CC-BY-4.0)



Bill Sutherland's cube William J. Sutherland, Transforming Conservation: A Practical Guide to Evidence and Decision Making. Cambridge, UK: Open Book Publishers, 2022, https://doi.org/10.11647/OBP.0321 **@Bill_Sutherland 14/10/2022**

Defining and using evidence in conservation practice. Conservation Science and Practice 2019. Salafsky, N., Boshoven, J., Burivalova, Z., et al.
Transforming Conservation A Practical Guide to Evidence and Decision Making 2022 Edited by William J. Sutherland, Open Book Publishers

Why do we need "Weight of Evidence"?

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Many environmental processes are highly complex with multiple impacts and pressures interacting with each other via a wide range of inter-related feedback loops and pathways that often make the observed results difficult to predict. Any particular piece of evidence usually shows only part of the overall picture. This is why we need multiple stands of evidence (the Weight of Evidence approach) to build an adequate understanding.

A Weight of Evidence approach is therefore often used for the assessment, management and conservation of rivers because:

- river are **complex ecosystems**

and

- rivers normally exhibit **natural inherent variability**

so

- they respond and behave in different and varied ways to pressures
  (and not always in the way we may predict or understand)

EA Eutrophication Assessment Weight of Evidence Tool

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The Environment Agency developed a decision support tool for assessing eutrophication across all rivers (and lakes) in England. This was released and first used in 2013

- Developed using expert judgement.
- Provides a **consistent** and **nationally standardised approach** to eutrophication assessment with a consistent approach for collecting evidence.
- Is based on the following data: 1) Phosphorus concentrations (pressures), 2) Response of macrophytes or algae to these pressures (primary impact), 3) Subsequent effects on water quality (dissolved oxygen, pH), ecology (fish, invertebrates) or human recreation (fishing, water sports).
- Tool gives clarity for stakeholders such as water companies, local government and agriculture
- Determines the **certainty** or **uncertainty** of there being a eutrophication problem, or not, within a waterbody in 4 categories (see below).

- Allows prioritisation of actions and measures nationally and locally.
- Helps decide where further monitoring and evidence is needed.
- Helps identify third party data and involve partners in understanding complex catchment issues.

Very Certain of a eutrophication problem	Combined weight-of-evidence from nutrients, relevant plant/algal indicators and wider evidence indicates eutrophication impacts.
Quite certain of a eutrophication problem	Combined weight-of-evidence from nutrients, relevant plant/algal indicators and wider evidence indicates possible eutrophication impacts.
Uncertain of a eutrophication problem	Combined evidence from nutrient, relevant plant/algal indicators and wider evidence indicates that eutrophication impacts are unlikely, or there are insufficient data to assess the position with confidence.
Certain no eutrophication problem	Combined evidence from nutrients, relevant plant/algal indicators and wider evidence indicates no eutrophication impacts or imminent likelihood of them.
Not assessed	There are no or very limited recent classification data and it is not possible to assess water body scale eutrophication and categorise the impacts.

Eutrophication Weight of Evidence tool

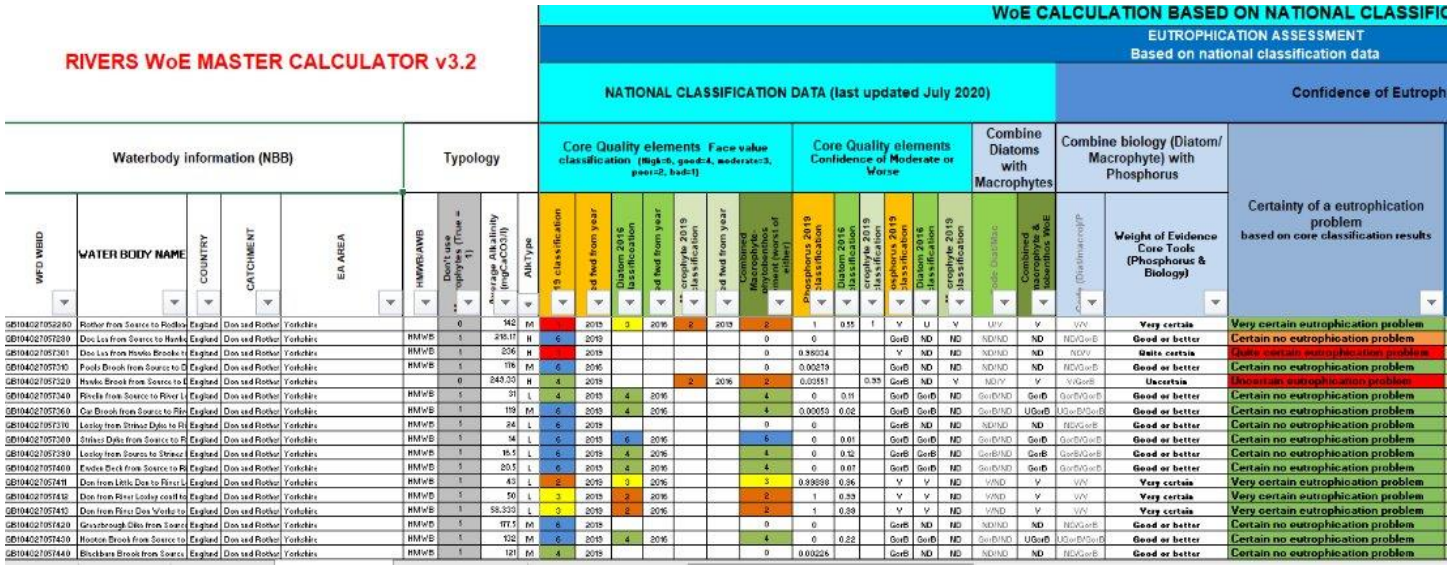
The tool is updated every 5 years (approximately) when new national classification data becomes available.

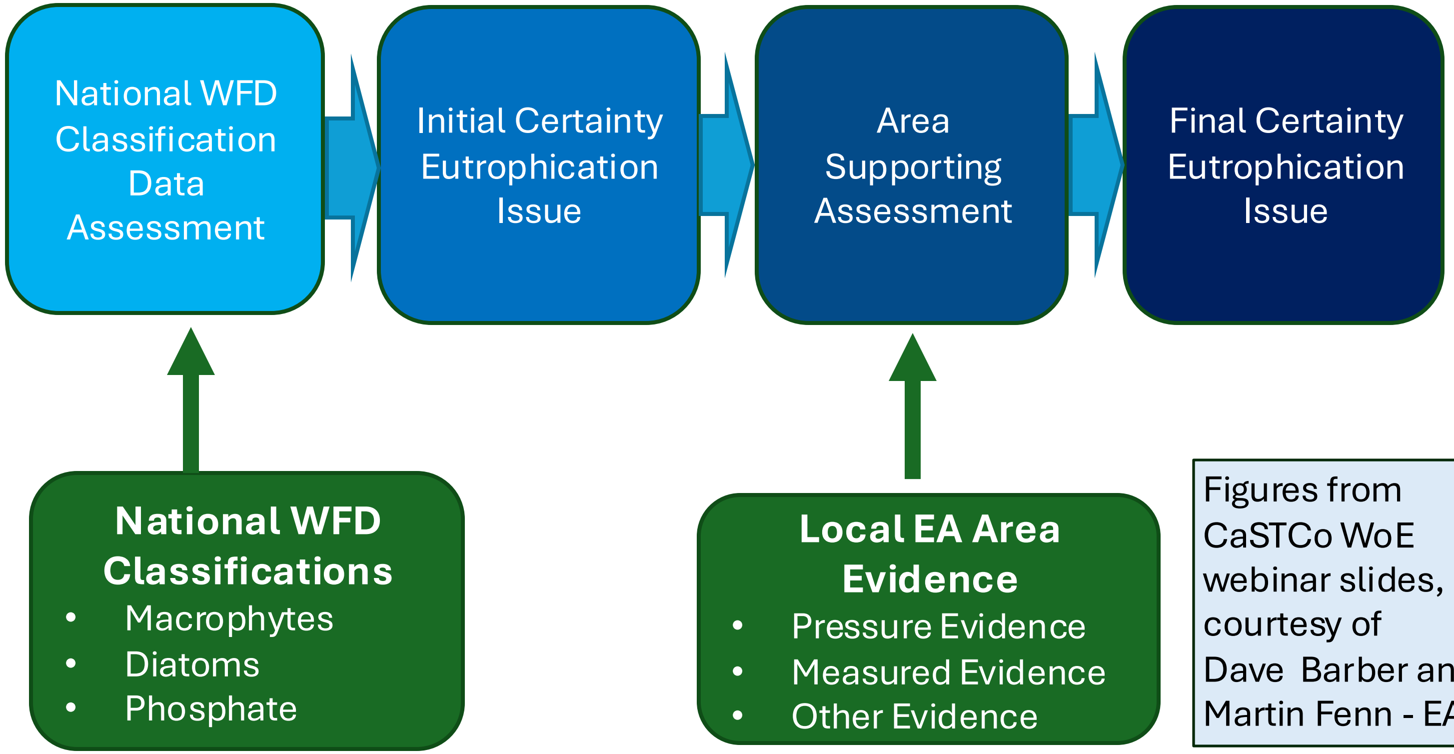
Pre-populated with national data from WFD classification monitoring results

EA area teams input local knowledge and data – the wider WoE

Now used by EA Areas to provide evidence for i) agricultural advice and improvements and ii) to Water Companies for investment via WINEP/AMP

The tool enables the inclusion of 3rd party data as supporting evidence which could include citizen science information. However, citizen science and/or 3rd party data is not consistently applied across all EA areas or weighted to reflect level and scale of data. The final decision on the Eutrophication risk is made by EA experts





Figures from CaSTCo WoE webinar slides, courtesy of Dave Barber and Martin Fenn - EA

Annex 1.

Suggestions for Citizen Science data input to WoE tool

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Citizen science data		
Pressure Evidence (Y if evidence, No data if not assessed and N if no evidence)	Measured supporting evidence eutrophication impact (Y if evidence, No data if not assessed and N if no evidence)	Other supporting evidence of eutrophication impact (Y if evidence, No data if not assessed and N if no evidence)
Long term and averaged CS P data using standardised P method	Simplified RAPPER score "at risk"	Anecdotal evidence of impacts to inverts or fish - verified photos or reports
Samples or blitz data from CS P (using standardised Hanna protocols - showing consitently high levels of P (variable by catchment)	Dissolved Oxygen or pH problem linked to eutrophication (extreme diurnal fluctuations) - from sonde data or diurnal sampling	Evidence from third parties or historical data that indicates eutrophication problem eg letters from fishing clubs, local councils
Storm overflow data (from RT or Water Co)	Excessive plant or filamentous algal growth - plant or algae surveys	Aesthetic effects, e.g. odour nuisance, algal scum or foam - verified photos or reports
Package plants or septic tanks in WBs	Impacts on invertebrates - Riverfly RMI or Extended scores, SmartRivers scores	Evidence of impacts on recreational use - verified sources of information or photos
Private or other STWs (not included in EA data)		
Scoring/Weightings?		

END

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