

# Partnership Meeting

# Agenda

## Wye Catchment Nutrient Management Board

Date: **Wednesday 29 April 2026**

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Time: **2.00 pm**

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Place: **Conference Room 1 - Herefordshire Council, Plough Lane Offices, Hereford, HR4 0LE**

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Notes: For any further information please contact:  
[nutrientmanagementboard@herefordshire.gov.uk](mailto:nutrientmanagementboard@herefordshire.gov.uk)

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# Agenda for the meeting of the Wye Catchment Nutrient Management Board

## Voting membership

Chairperson	Councillor Elissa Swinglehurst	Herefordshire Council
	Merry Albright	Herefordshire Construction Industry Representative
	Liz Bickerton	Bannau Brycheiniog National Park Authority
	Louise Bodnar	Voice of the River
	Councillor Jackie Charlton (Vice-Chairperson)	Powys County Council
	Helen Dale	Country Land and Business Association
	Nick Day	The Friends of the Lower Wye
	Simon Evans	The Wye and Usk Foundation
	David Gillam	Save the Wye
	Gordon Green	Wye Salmon Association
	Saul Herbert	Herefordshire Wildlife Trust
	Christine Hugh-Jones	Council for Protection of Rural Wales
	Georgie Hyde	National Farmers Union
	Sarah James	Farm Cymru
	Councillor Catrin Maby	Monmouthshire County Council
	Councillor Andrew McDermid (apologies received; Councillor Chris McFarling substitute)	Forest of Dean District Council
	Andrew McRobb	Council for Protection of Rural England
	Silvia Sivers	Radnorshire Wildlife Trust
	Pat Stirling	Friends of the Upper Wye

## Agenda

		Pages
<p>Note: In addition to this meeting being recorded by Herefordshire Council, parts of the meeting will be filmed by Eighty Sita Productions. If there are any members of the public present who do not wish to be filmed, please identify this before the start of the meeting.</p>		
1.	<p><b>APOLOGIES FOR ABSENCE</b></p> <p>To receive apologies for absence and to note any substitutes.</p>	
2.	<p><b>NOTES OF THE PREVIOUS MEETING</b></p> <p>To receive the notes of the meeting held on 21 January 2026.</p>	7 - 12
3.	<p><b>QUESTIONS FROM MEMBERS OF THE PUBLIC</b></p> <p>To receive any written questions; including a question received from Nick Day, Friends of the River Wye, to Natural Resources Wales (attached).</p>	13 - 14
4.	<p><b>NUTRIENT MANAGEMENT PLAN (NMP) - INTRODUCTION OF APPROACH</b></p> <p>Update on the Wye Catchment Management Plan and intention to extract nutrient elements to form a new Nutrient Management Plan.</p> <p style="text-align: right;">[Oliver Bowers, Haskoning UK Ltd; 15 minutes]</p>	
5.	<p><b>THE UNIVERSITY OF THE WEST OF ENGLAND (UWE BRISTOL) HAS BEEN AWARDED £1 MILLION TO LEAD RESEARCH INTO AGRICULTURAL POLLUTION IN THE RIVER WYE</b></p> <p>Outline of approach and how the Nutrient Management Board might have a role in the development of the work.</p> <p style="text-align: right;">[Dr Rounaq Nayak, UWE Bristol; 15 minutes]</p>	
6.	<p><b>NUTRIENT BALANCE PROJECT</b></p> <p>Outcomes of Farmgate nutrient balance analyses.</p> <p style="text-align: right;">[Dan Smith, Herefordshire Rural Hub; 10 minutes]</p>	
7.	<p><b>UNLOCKING SOIL LEGACY PHOSPHORUS: IMPROVING NUTRIENT MANAGEMENT THROUGH TOTAL PHOSPHATE SOIL TESTING IN THE WYE CATCHMENT</b></p> <p>To receive an overview and to take questions; the 'Total Phosphorus Soil Testing Pilot - Project Report' is attached.</p> <p style="text-align: right;">[Dan Smith, Herefordshire Rural Hub; 10 minutes]</p>	15 - 30
8.	<p><b>GYPSUM FOR PHOSPHATE RETENTION IN SOIL</b></p> <p>Results from the rapid analysis of affect of gypsum on phosphate in Herefordshire soils; paper attached.</p> <p style="text-align: right;">[Rosie Willmott, Herefordshire Council; 15 minutes]</p>	31 - 36

**9. UPDATES FROM THE RIVER WYE STATUTORY OFFICERS' GROUP (SOG)**

To receive the updates report from the Statutory Officers' Group (SOG).

[Statutory bodies; 15 minutes]

**10. WIDER UPDATES FROM MEMBERS OF THE BOARD**

To receive updates on activity from members of the Wye Catchment Nutrient Management Board.

[Board members and other participants; 5 minutes]

**11. DATES OF FUTURE MEETINGS**

To note the schedule for future meetings, as follows:

[Wednesday 24 June 2026, 2.00 pm](#)

[Wednesday 7 October 2026, 2.00 pm](#)

[Wednesday 20 January 2027, 2.00 pm](#)

[Wednesday 3 March 2027, 2.00 pm](#)

[Wednesday 7 July 2027, 2.00 pm](#)

[Wednesday 6 October 2027, 2.00 pm](#)

To Follow

## **The Seven Principles of Public Life**

### **(Nolan Principles)**

#### **1. Selflessness**

Holders of public office should act solely in terms of the public interest.

#### **2. Integrity**

Holders of public office must avoid placing themselves under any obligation to people or organisations that might try inappropriately to influence them in their work. They should not act or take decisions in order to gain financial or other material benefits for themselves, their family, or their friends. They must declare and resolve any interests and relationships.

#### **3. Objectivity**

Holders of public office must act and take decisions impartially, fairly and on merit, using the best evidence and without discrimination or bias.

#### **4. Accountability**

Holders of public office are accountable to the public for their decisions and actions and must submit themselves to the scrutiny necessary to ensure this.

#### **5. Openness**

Holders of public office should act and take decisions in an open and transparent manner. Information should not be withheld from the public unless there are clear and lawful reasons for so doing.

#### **6. Honesty**

Holders of public office should be truthful.

#### **7. Leadership**

Holders of public office should exhibit these principles in their own behaviour and treat others with respect. They should actively promote and robustly support the principles and challenge poor behaviour wherever it occurs.



**Notes of the meeting of Wye Catchment Nutrient Management Board held in Conference Room 1 - Herefordshire Council, Plough Lane Offices, Hereford, HR4 0LE on Wednesday 21 January 2026 at 2.00 pm**

**Chairperson:**

Councillor Elissa Swinglehurst      Herefordshire Council

**Voting members present in person:**

Merry Albright	Herefordshire Construction Industry Representative
Louise Bodnar	Voice of the River
Simon Evans	The Wye and Usk Foundation
David Gillam	Save the Wye
Christine Hugh-Jones	Council for Protection of Rural Wales
Andrew McRobb	Council for Protection of Rural England
Stuart Smith	Wye Salmon Association
Pat Stirling	Friends of the Upper Wye

**Voting members in attendance remotely:**

Liz Bickerton	Bannau Brycheiniog National Park Authority
Councillor Jackie Charlton	Powys County Council
Helen Dale	Country Land and Business Association
Nick Day	The Friends of the Lower Wye
Sarenta King	Radnorshire Wildlife Trust
Councillor Catrin Maby	Monmouthshire County Council
Councillor Andrew McDermid	Forest of Dean District Council

**Other participants present in person:**

Claire Minett	Natural England
Martin Quine	Environment Agency

**Other participants in attendance remotely:**

Emma Guy	Bannau Brycheiniog National Park Authority
Daniel Humphreys	Dwr Cymru/Welsh Water
Craig O'Connor	Monmouthshire County Council
Ann Weedy	Natural Resources Wales

**Support officers:**

Ben Baugh	Herefordshire Council
Gemma Dando	Herefordshire Council
Donna Thornton	Herefordshire Council
Judith Whateley	Herefordshire Council
Bradley Willson	Herefordshire Council

**28. APOLOGIES FOR ABSENCE**

Apologies for absence were recorded from Gordon Green, with Stuart Smith present as the representative for the Wye Salmon Association.

**29. NOTES OF THE PREVIOUS MEETING**

The notes of the previous meeting held on 22 October 2025 were agreed.

### 30. QUESTIONS FROM MEMBERS OF THE PUBLIC

The full details of the context and question from James Marsden was published in advance of the meeting, [Questions from members of the public \(link\)](#). The question being:

'Whether, and if not why not, the Board will adopt and promote a nutrient and sediment target for the River Wye/Lugg SSSIs and SAC aligned with EIP25 Commitment 26, such as: *Reduction in total N, P and sediment pollution (tonnes) from agriculture by at least 18% by December 2030 from 2018 baseline.*

The new Wye Catchment Management Plan (CMP) should at least align with EIP25, and arguably should be more ambitious, so a nutrient and sediment target (eg as proposed above) could be adopted now without pre-empting what the CMP may say about the 'what, where, how and who by when' trajectories to achieve the target?'

The Chairperson commented on the need to explore alignment between the Nutrient Management Plan and the Catchment Management Plan. James Marsden emphasised that the Environment Improvement Plan (EIP) included legal binding targets but there was the option to go further.

It was moved that the new Nutrient Management Plan, as and when it was scoped and designed, needed to at the least accord with the legally binding targets.

### 31. DIFFUSE WATER POLLUTION PLAN (DWPP) UPDATE

The main points of the discussion on the ['Diffuse Water Pollution Plan - River Wye Special Area of Conservation, November 2025'](#) (DWPP) included:

- a. Pat Stirling made observations about the identified issues with diffuse agricultural pollution, particularly run-off, and the suite of mitigation measures, noting that a focus on regulatory compliance would not deliver the reductions needed. Martin Quine said that the mitigation measures would contribute towards reductions but acknowledged that there would still be a gap, highlighting the need for further research to identify additional measures and mechanisms. In response to a question about the level of commitment to deliver the range of options presented, Martin Quine explained that: the DWPP was an updated evidence base which identified the actions needed to reduce nutrients, albeit it did not come with funding; there was delivery against some actions already and others required more investment or work with the supply chain; significant resources were already being deployed in this area; and the DWPP provided the evidence for the direction of travel.
- b. Pat Stirling requested that best efforts be made to produce a forecast of what would be achieved, based on the actions identified in the document, with specified timeframes. Andrew McRobb supported this request, stating that the board needed to understand what was going to happen and by when, along with measurable impacts such as reductions in kilograms. Councillor Maby endorsed this suggestion; comments were also made about the need to combine the English and Welsh evidence, and the need to identify and highlight resource issues. At the discretion of the Chairperson, James Marsden reminded the board of the Environment Improvement Plan targets and said that it should be feasible to plot a trajectory to identify the extent of the gap; a comment was also made about the reductions to the budgets of environmental regulators over the past decade.
- c. Councillor Charlton said that it was clear from the DWPP and the Evidence Base for Wales that no single agency or authority could achieve the priorities on its own

but there was currently a lack of a clear strategy for collaboration, to assign responsibilities, or to monitor progress; adding that, despite ongoing uncertainties, action was necessary and on a cross-border basis.

- d. Louise Bodnar questioned the extent to which the board was able to input into the strategic priorities and said that existing research pulled together by WWF into the effectiveness of different mechanisms to reduce diffuse pollution should be utilised. Claire Minett noted that there was an item on the Nutrient Management Plan later in the agenda and outlined how Natural England used research and evidence to target advice on farming practices.
- e. Louise Bodnar commented on the effectiveness of buffers in reducing diffuse pollution into rivers, streams, and ditches but noted that this was not identified as a strategic priority. Claire Minett commented on voluntary initiatives and need for collaboration across sectors.
- f. Merry Albright considered that: the DWPP did not say what actions were required and by when to bring the river into favourable condition; further assessment of a Water Protection Zone was needed, as uptake and delivery of voluntary measures could not be relied upon; the work of Welsh Water had been acknowledged appropriately; developers had made significant contributions to offset nutrient loads from new housing but this could not remedy diffuse pollution from other sources; the '85% reduction of loads' for the Lugg should be quantified in terms of kilograms; and targeted action may provide better value for money.
- g. Martin Quine clarified that the judicial review concerning the Water Framework Directive was distinct from the judicial review related to the Habitats Regulations, with each involving different legal frameworks and obligations. Clarifications were also provided about the designations and targets in different parts of the catchment.
- h. In response to a question from David Gillam, Martin Quine commented on the potential for a feasibility study for a Water Protection Zone but a timeframe or indicative process for this could not be provided.
- i. The Chairperson noted that, in addition to Herefordshire Council's motion in favour of a Water Protection Zone for the whole of the River Wye system ([Full Council minute 31 of 28 January 2022 refers](#)), the Wye Catchment Nutrient Management Board had voted to submit its own request in January 2022.
- j. The Chairperson commented on the need to explore the cost benefit analysis of potential actions, including broader opportunities such as flood prevention, flood alleviation, and biodiversity net gain.
- k. A request was re-iterated for an indication for the reduction that would be achieved and over what timeframe. The Chairperson questioned whether it would be possible to expand the DWPP to include such a trajectory. Martin Quine said that the DWPP had been developed jointly by the Environment Agency and Natural England, and that feedback would be provided to the agencies.
- l. Simon Evans commented on: the significance of other actions to meet water quality conservation objectives; the difference between phosphate and phosphorus; and the implications of soil loss in the vicinity of the Black Mountains.
- m. Councillor McDermid commented on the need to raise issues at a higher political level, including the constraints of voluntary approaches and concerns about strategic issues such as water supply into the future, housebuilding commitments, and wastewater management.

- n. The Chairperson questioned whether the number of Ground Water Source Protection Zones within the English portion of the catchment, as referenced at page 67 of the DWPP, had resulted in guidance being issued. A response could not be provided in the meeting.

## 32. WELSH EVIDENCE BASE UPDATE

The main points of the discussion on the ['Phosphorus in the River Wye - Evidence Base for Wales, Issue 4, 8 December 2025'](#) (Evidence Base for Wales) included:

1. The Chairperson noted the need for an overarching document to reconcile differences of approach taken to the Evidence Base for Wales and the Diffuse Water Pollution Plan (DWPP).
2. Simon Evans commented that: references to phosphorus should be reviewed; the document was well structured; modelling using Farmscoper V5 was endorsed; and the findings of UKTAG and the Wye Algae Project in relation to phosphate should be noted.
3. Jed Knight said that there was a lack of ownership in the document in terms of some of the recommendations and actions currently but acknowledged that this may be addressed through the Nutrient Management Plan.
4. Councillor Maby queried the percentage figures for 'attributed sources of phosphorus in the failing waterbodies', as mentioned in the Executive Summary; it was noted that Figure 11 showed total sector contributions.
5. Merry Albright commented on the need for universal information and noted potential challenges in aligning the Evidence Base for Wales and the DWPP.
6. Councillor Charlton commented on: differences in the presentation in the two documents; the need to assist laypersons in understanding the situation and the proposed actions; the limitations of voluntary agriculture mitigation measures; and the positive actions being undertaken by water companies.
7. Merry Albright re-iterated the need for quantification, especially as this would help to demonstrate the outcomes being delivered.
8. The Chairperson urged delivery partners and board members cited on actions applying to the production or control of nutrients to report such matters to the board.
9. In response to questions from the Chairperson, Ann Weedy commented on the phasing of the Control of Agriculture Pollution Regulations and said that it would take time to increase compliance and for associated improvements to become evident; hence the sentence 'It is recommended that compliance with existing regulation is improved before NRW introduce increased controls as part of a WPZ.'
10. The Chairperson acknowledged the concerns expressed by other board members regarding the uptake and implementation of voluntary measures and the necessity for a more assertive stance, noting 'Do not apply P fertilisers to high P index soils' as an example.
11. Andrew McRobb said that it would have been preferable if both documents had been commissioned in identical formats but noted the different drivers for each.

### 33. NUTRIENT MANAGEMENT PLAN (NMP)

The Chairperson outlined options for the development of the Nutrient Management Plan (NMP) and invited comments from board members and other meeting participants. The principal points included:

- i. Gemma Dando reported that: the Statutory Officers' Group had identified a preference for single plan, with a single set of objectives, given the need to pull in the same direction and work to the same goals; and Herefordshire Council would be prepared to undertake a coordinating role.
- ii. Pat Stirling said that: the proposal was welcomed, particularly given the overlap between the Nutrient Management Plan and the Catchment Management Plan; the process would need to be communicated to the respective members; the Evidence Base for Wales identified measures per sub catchment area and this level of specificity would be needed in the plan; and the need to improve the ecological status of the catchment on both sides of the border should be recognised.
- iii. The Chairperson suggested that interim targets and trajectories should be included, and consideration should be given to lifting the evidence base further, particularly to assist regulators on matters such as voluntary agriculture mitigation measures and Water Protection Zones.
- iv. Andrew McRobb noted that there was general consensus for a single plan, but consideration should be given to discrete elements for the Nutrient Management Board given its specific responsibilities and accountabilities.
- v. In response to a question from the Chairperson, Pat Stirling advised that the membership of the task and finish group for the Catchment Management Plan had not yet been announced but he supported the inclusion of a representative from the Nutrient Management Board.

Later in the discussion, the following additional points were made: Helen Dale requested agricultural sector representation; and the Chairperson said that the Nutrient Management Board nominee would need to represent the diverse viewpoints of board members.

- vi. In response to a question from Pat Stirling, Claire Minett reported that Natural England had undertaken condition assessments for the Lugg and the Wye, and subsequent analysis may inform whether a nitrogen target was applicable or necessary; data would be shared at the earliest opportunity. Ann Weedy reported that SAC and WFD compliance had been undertaken in 2024, with the next assessment due in 2027.
- vii. Helen Dale supported a single plan, subject to it being produced collaboratively, with any proposals informed by risk and cost assessments.
- viii. Liz Bickerton made observations about the need for an actions focused approach and for measurable indicators to ensure that progress was being made.
- ix. Councillor Charlton said that it was important to have clarity around the ownership of the plan, with a preference expressed for ownership by the Nutrient Management Board.
- x. Gemma Dando clarified that the Herefordshire Council resource offer was around the initial development of the plan. It was noted various issues would need to be explored, including ownership and the roles of each organisation, mindful of the separate decision-making arrangements.

- xi. Louise Bodnar invited the Environment Agency to consider whether any effective and actionable measures identified through the Nutrient Management Plan would help to progress the case for a Water Protection Zone. It was suggested that funding should be used on applied research to test the effectiveness of the actions in the Nutrient Management Plan.

Martin Quine confirmed that the Environment Agency considered data and evidence from various sources.

It was moved that the Nutrient Management Plan forms in some way part of the Catchment Management Plan, as a detachable document and which will be overseen in terms of the delivery of actions by the Nutrient Management Board.

#### **34. UPDATES FROM THE RIVER WYE STATUTORY OFFICERS' GROUP (SOG)**

The Chairperson welcomed the updates and invited comments from board members and other meeting participants. The principal points included:

- Gemma Danda reported that, following comments made by the board at the last meeting ([note 17 of 22 October 2025 refers \(link\)](#)), the SOG had considered its purpose and ways of working, and that there was an appetite to refresh the terms of reference. The board was invited to provide further feedback about the information being shared.

Councillor Charlton said that the board should review the arrangements regularly and provided an update on officer representation from Powys County Council.

- Merry Albright made a number of points, including: the 'River Wye Special Area of Conservation 2025 growing season monitoring summary report' was interesting but it was considered unfortunate that monitoring had been paused at two sites during part of 2023 and all of 2024, and that more testing points would be helpful; attention was drawn to the RePhoKUs document 'Soil Phosphorus Status and Water Quality in the River Wye, Phase 3: Surplus P and Subsoil P Enrichment of Wye Soils', particularly the ongoing issues with legacy P; and, with reference made to national funding opportunities identified in the Natural England slide, it was suggested that there should be clarity about the allocations for initiatives in the catchment and the nutrient reductions that were anticipated.
- Pat Stirling considered that there was a need to articulate targets and measurable outcomes to provide insight into progress over time.

#### **35. WIDER UPDATES FROM MEMBERS OF THE BOARD**

It was noted that that The Wye and Usk Foundation would endeavour to provide written updates to the board more often.

#### **36. DATE OF THE NEXT MEETING**

The date of the next scheduled meeting was noted.

[Note: This was moved subsequently to [Wednesday 29 April 2026, 2.00 pm](#)]

The meeting ended at 4.09 pm

**Chairperson**

Questions received for the 29 April 2026 meeting

<b>Questioner: Nick Day, Trustee, Friends of the River Wye</b>	[copied to NRW, 21 January 2026]
"Looking at the FORW Citizen Science data we see little/no impact from the "Central Monmouthshire Opportunity Catchment project 2022-2025" on the Trothy water quality. Does NRW have data on water quality and habitat of the Trothy showing a positive impact from the Central Monmouthshire Opportunity Catchment project 2022-2025? What are the expectations of the successor to this plan?"	
<b>Response from Natural Resources Wales (NRW)</b> [to be provided]	



## Total Phosphorus Soil Testing Pilot –Project Report

March 2026

### 1. Project Background and Partnership

This report summarises the findings from a pilot project exploring total phosphorus within agricultural soils in the Wye catchment. The work was undertaken to improve understanding of legacy phosphorus, that is, phosphorus accumulated in soils over time through historic nutrient inputs but not fully captured through standard agronomic testing. The report should be read as an exploratory assessment designed to support further investigation, on-farm learning and development of future research, rather than as a definitive scientific analysis or as prescriptive agronomic advice.

The Total Phosphorus soil testing pilot was developed in response to increasing recognition that conventional approaches to nutrient management do not fully capture the complexity of phosphorus behaviour within agricultural soils. In the Wye catchment in particular, there is a growing understanding that historic nutrient accumulation continues to influence present-day water quality outcomes. While standard soil testing provides a measure of plant-available phosphorus, it does not account for the total phosphorus reserves held within soils, often built up over decades of fertiliser application and manure use. This pilot was therefore designed to explore whether measuring Total Phosphorus could provide additional insight into these legacy nutrient pools and support more informed, long-term nutrient management.

The project was led by Herefordshire Rural Hub and funded by Herefordshire Council, building on a strong foundation of collaborative working across the county. Delivery was undertaken in partnership with Cobb Agri, who supported coordination of soil sampling and laboratory analysis, alongside sampling undertaken for Lancaster University. Through the REPHOKUS research programme, Lancaster University has been investigating phosphorus dynamics and legacy nutrient behaviour across the Wye catchment for a number of years, supported by Environment Agency funding. The Total Phosphorus pilot combines and extends the Total P soil testing by providing additional farm-scale data from commercial systems, helping to bridge the gap between scientific investigation and practical farm management.

The integration of these datasets is particularly valuable. The REPHOKUS work provides a scientific framework for understanding how phosphorus accumulates, is stored and is mobilised within soils and catchments, while the pilot contributes further real-world evidence on the scale and variability of these processes across working farms. Together, they strengthen the evidence base required to understand legacy phosphorus and its implications for both agricultural productivity and water quality.

The pilot also sits within a wider landscape of innovation and collaboration taking place in Herefordshire. It has been strongly informed by the work of the Herefordshire Agri Group, a

farmer-led knowledge exchange network that has been operating for the past three years. Through regular meetings, on-farm discussions and shared learning, members of the group have been actively exploring how to better understand nutrient loading within their systems and identify practical opportunities to reduce losses to water. This included hosting Defra's Water Quality team in the catchment during 2024 to outline the practical knowledge gaps on the ground between soil management, nutrient dynamics and water quality outcomes. That engagement helped articulate the case for further soil-focused research and contributed to the framework that later developed into the £1m Defra Living Labs soil research opportunity in the Wye. While awaiting the award of that programme, the Herefordshire Agri Group continued to build momentum through this pilot and related work over the following 12–18 months. The Total Phosphorus pilot emerged directly from these conversations, reflecting a farmer-driven appetite to go beyond standard metrics and develop a deeper understanding of the resources held within their soils.

In parallel, the pilot aligns closely with the ambitions of the Wyescapes Landscape Recovery project, which is developing a coordinated, catchment-scale approach to improving water quality, enhancing biodiversity and supporting resilient farm businesses. A key component of Wyescapes is the exploration of new mechanisms to address legacy nutrient issues, including approaches to nutrient drawdown and export that may, in time, be financially supported where they deliver wider public and private benefits. The Total Phosphorus dataset provides a useful evidence base to inform that work, while the forthcoming Defra Living Labs programme creates an opportunity to build on this pilot through more structured on-farm research, monitoring and knowledge exchange.

Looking ahead, the findings from this pilot are highly relevant to the forthcoming Defra Living Labs soil research programme which will launch in the Wye during 2026. The Living Labs initiative aims to support collaborative, on-farm research that integrates scientific expertise with farmer knowledge and practical testing. There is clear potential to integrate Total Phosphorus testing with wider monitoring and experimentation, including soil biology assessments, nutrient balance tracking and hydrological monitoring, to develop a more complete understanding of phosphorus cycling within farming systems.

In this context, the pilot should be seen not as a standalone exercise, but as part of a broader, evolving programme of work across the Wye catchment.

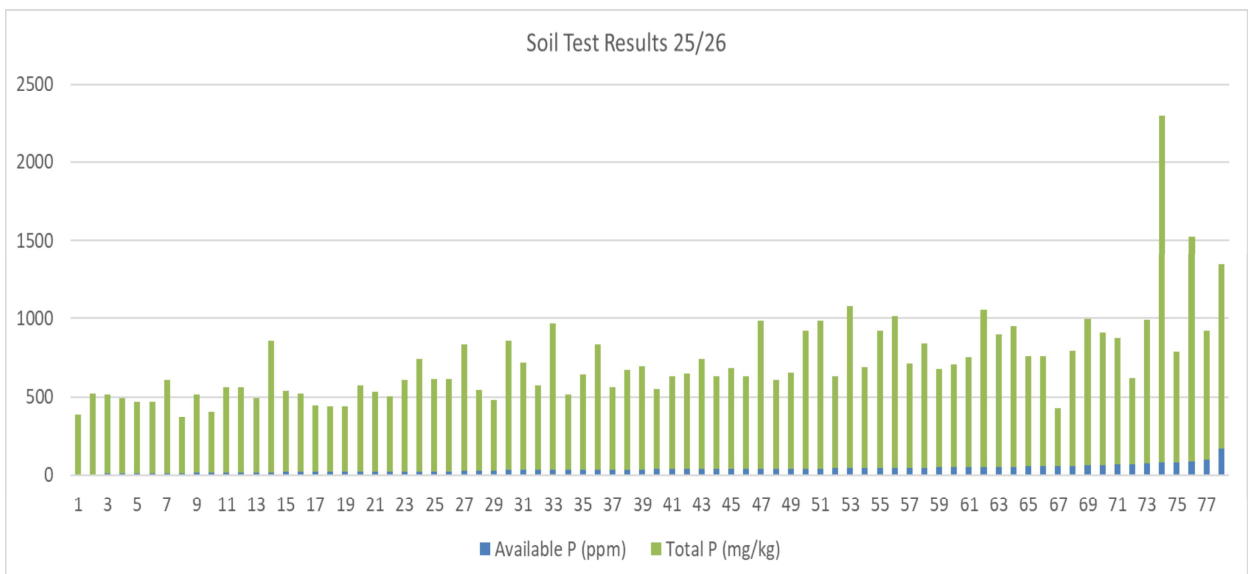
## 2. Dataset Description

The dataset used in this report represents a combined body of work delivered across multiple partners and funding streams within the Wye catchment. Soil samples were collected by Cobb Agri from a total of 16 participating farm holdings, bringing together analysis undertaken through two complementary initiatives. The first comprises samples collected as part of the Herefordshire Rural Hub-led pilot funded by Herefordshire Council, while the second includes samples collected through Lancaster University's research activity under the REPHOKUS programme, funded by the Environment Agency. The integration of these datasets provides a

broader picture of soil phosphorus status across a range of commercial farming systems within the county.

This collaborative approach has enabled the creation of a dataset that spans different farm types, management systems and soil conditions, while maintaining consistency in sampling and analytical methods. By aligning farmer-led activity with academic research, the dataset provides both practical relevance and a degree of scientific consistency, although it remains limited in size and should not be treated as fully representative of the wider catchment.

Across the dataset, both plant-available phosphorus and total phosphorus were measured, allowing comparison between the immediately accessible nutrient pool and wider phosphorus reserves held within the soil. The average plant-available phosphorus concentration across samples was approximately 36.0 ppm, while mean total phosphorus concentration was 691 mg/kg. The highest observed value exceeded 2219 mg/kg, demonstrating that some soils contain very large phosphorus reserves accumulated through historic nutrient inputs. However, a small number of very high values materially influence averages, and median values, ranges and the shape of the distribution should therefore be considered alongside headline means when interpreting the dataset.



Importantly, the dataset captures not only fields with elevated phosphorus levels, but also those with more moderate or lower concentrations, allowing comparison across a spectrum of nutrient status. This supports a more nuanced understanding of phosphorus dynamics and enables identification of both higher-risk areas and those where nutrient levels appear more balanced. The dataset should therefore be viewed as an initial baseline against which future monitoring, testing and on-farm trials can be developed.

### 3. Analytical Approach, Assumptions and Limitations

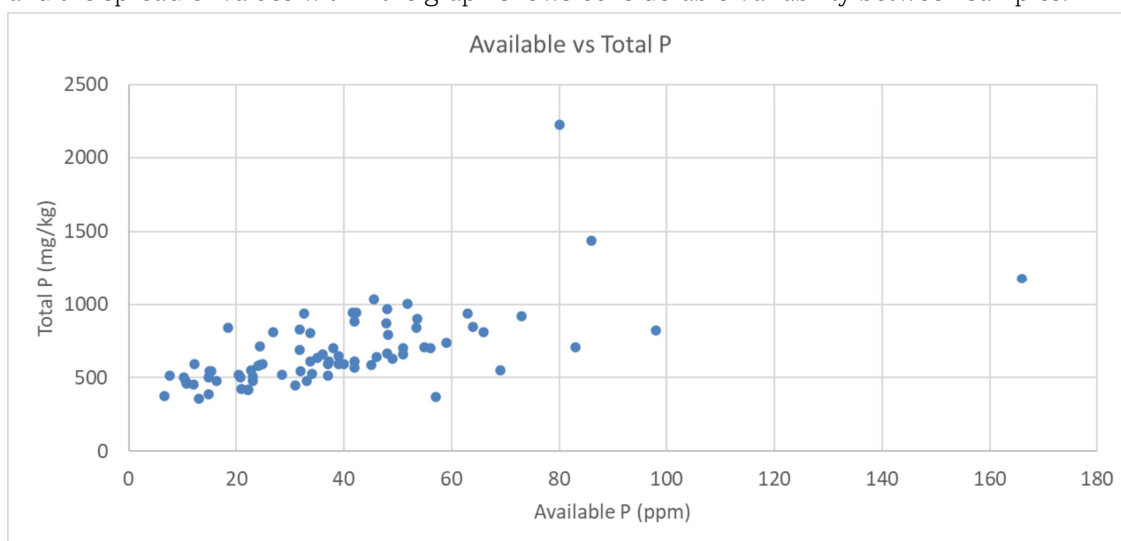
This report uses simple descriptive and exploratory analytical methods to help interpret the dataset. These methods have been selected deliberately to provide proportionate insight from a relatively limited sample, but they also carry important limitations which should be made explicit.

First, the dataset is modest in scale and includes observations from a limited number of holdings. It should therefore not be assumed to be statistically representative of all soils, farm systems or phosphorus conditions across the wider Wye catchment. Secondly, a small number of very high total phosphorus values have a disproportionate influence on averages and on the appearance of trends within the graphs. No formal exclusion of outliers has been undertaken in this report because the available information is insufficient to determine whether such values are analytical anomalies or genuine field conditions; however, their influence should be recognised explicitly when interpreting the findings.

Thirdly, the correlation and regression analyses presented are exploratory rather than predictive. They are useful for visualising the broad relationship between variables within this dataset, but they do not establish causation and should not be relied upon as statistically robust predictive models without further validation, replication and stratification by soil type, land use and management history. Finally, the dataset does not directly measure phosphorus loss pathways to water. Any suggestion of environmental risk should therefore be treated as indicative only and considered alongside hydrology, soil structure, management practice and field connectivity.

### 4. Correlation Analysis

A correlation analysis was undertaken to explore the relationship between plant-available phosphorus and total phosphorus across the dataset. The analysis indicates a moderate positive relationship, suggesting that, in general, soils with higher total phosphorus tend also to exhibit higher levels of plant-available phosphorus. However, the strength of this relationship is limited, and the spread of values within the graph shows considerable variability between samples.



This variability is a key finding in itself. Soils with similar levels of plant-available phosphorus can contain markedly different total phosphorus reserves, which means that standard agronomic phosphorus measures do not fully explain the wider nutrient status of a field. In practical terms, two fields presenting the same RB209 phosphorus index may still have very different underlying nutrient histories and different longer-term responses to reduced fertiliser inputs.

Given the size and structure of the dataset, the correlation should be interpreted as indicative rather than statistically robust. It is useful for highlighting that a relationship exists, but not for concluding that total phosphorus can be inferred reliably from plant-available phosphorus alone. This supports the wider conclusion that standard soil testing provides only a partial picture where legacy phosphorus is concerned.

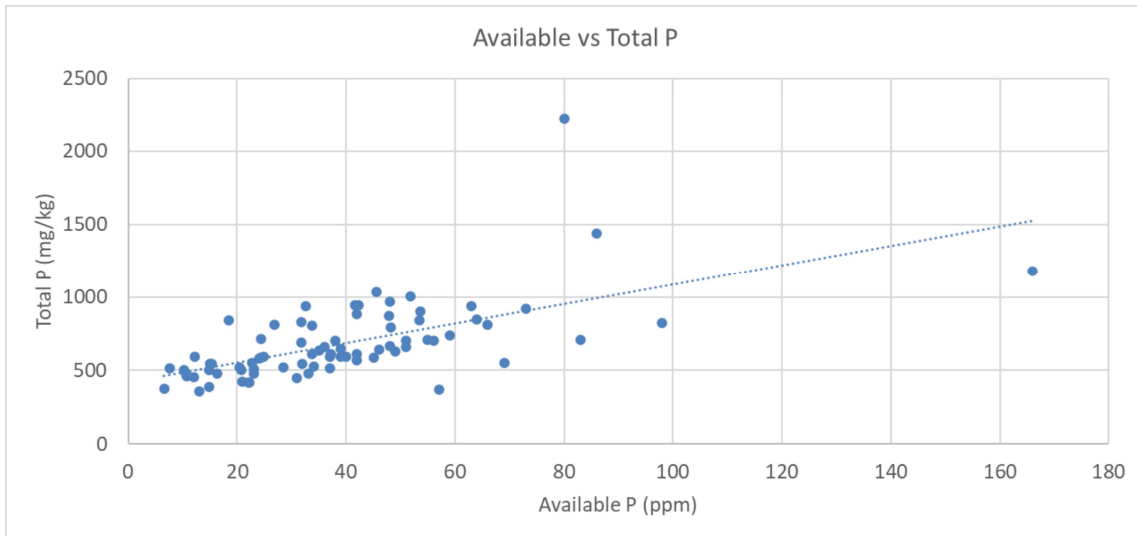
In the context of the Wye catchment, this finding is particularly relevant. It suggests that reliance on plant-available phosphorus alone when planning nutrient requirements on farm may not fully capture the scale of nutrient loading within soils, nor the potential for future phosphorus mobilisation. The results therefore support the need for a more integrated approach to nutrient assessment, combining standard soil tests with a broader understanding of legacy phosphorus reserves.

## 5. Regression Analysis

To explore the relationship further, a simple regression line was plotted between plant-available phosphorus and total phosphorus. The trend line confirms an overall positive relationship between the two variables; however, the degree of scatter around that line is substantial. This means that while total phosphorus tends to increase as plant-available phosphorus increases, the regression is weak as a predictive tool and should not be interpreted as a robust forecasting model.

The spread of data points reflects the influence of historic management and site-specific conditions. Fields with similar plant-available phosphorus levels can sit on very different points along the regression line, likely reflecting differences in fertiliser history, manure inputs, soil chemistry, soil type and the extent to which phosphorus has been fixed into less available forms. The graph is therefore best used as a visual aid to demonstrate complexity rather than as evidence of a simple linear rule.

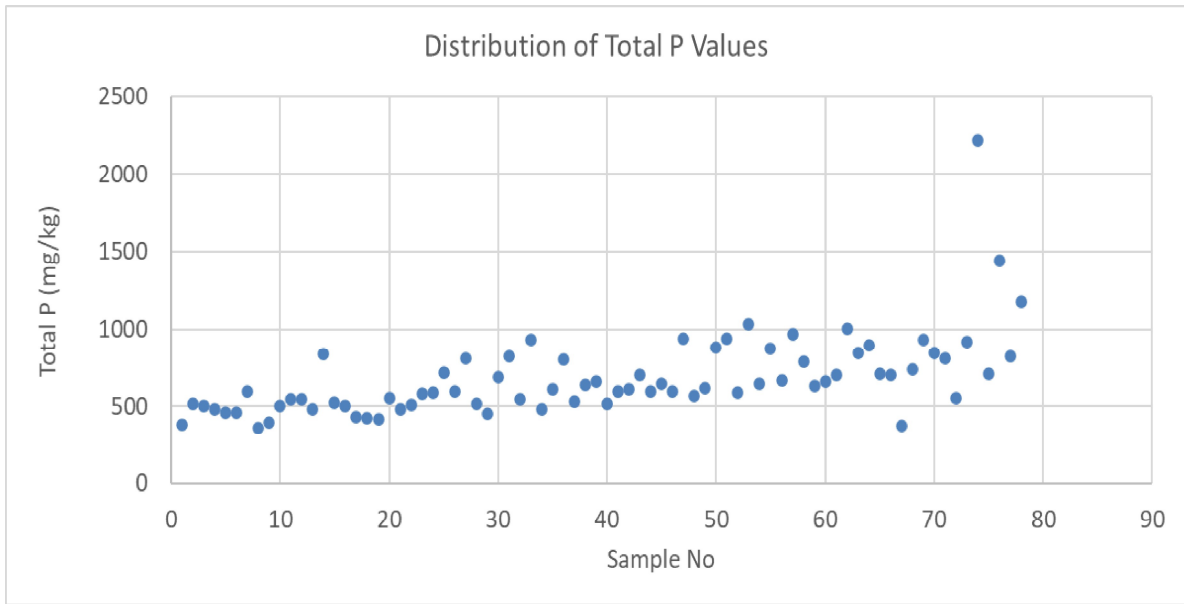
For this reason, any decisions arising from the report should avoid assuming that one measure can be converted directly into the other. Instead, the regression reinforces the case for further field-based investigation, repeat sampling and more detailed stratified research through future programmes of work.



## 6. Identification of High-Phosphorus Outliers

Analysis of the dataset reveals a number of very high total phosphorus results that stand apart from the majority of observations. In some cases, values exceed 2000 mg/kg, indicating exceptionally large phosphorus reserves within the topsoil. These observations are highly material to interpretation because they have a disproportionate influence on summary statistics such as the mean and can visually dominate trend analyses.

At present, these high values have not been removed from the dataset because there is insufficient evidence to classify them confidently as analytical anomalies. They may represent genuine field conditions associated with historic nutrient loading, such as repeated manure applications, livestock handling areas or other long-term concentration of inputs. They may have been contaminated during sampling and showing erroneous results. Nevertheless, they should be treated cautiously until further field verification is undertaken, including review of sampling history, land use and repeat sampling where appropriate.



From a reporting perspective, these high-phosphorus observations are best understood as higher-priority fields for follow-up rather than as definitive evidence of wider catchment conditions. They are useful for identifying where further investigation may be justified, but should not be used on their own to generalise about all soils or farming systems represented within the report.

## 7. Data Insights

The findings from this pilot provide useful insight into the behaviour of phosphorus within agricultural soils and reinforce a growing body of evidence that standard agronomic measures capture only part of the wider nutrient picture. In many cases, plant-available phosphorus appears to represent only a fraction of the total phosphorus held within the soil, supporting the concept of legacy phosphorus.

This aligns with the wider direction of Lancaster University's REPHOKUS research, which has been investigating phosphorus dynamics across the Wye catchment and has highlighted the significance of historic nutrient accumulation and the role of soils as both sinks and potential sources of phosphorus. The farm-scale dataset presented here complements that work by providing practical evidence from commercial farming systems. However, it should be recognised that this report is not a scientific research paper and does not attempt to test hypotheses to the standard required for definitive academic conclusions.

Looking ahead, the dataset offers a strong foundation for the Defra Living Labs soil research planned in the Wye during 2026. The value of this pilot lies not in proving a final answer, but in helping define the right questions for more structured collaborative research. These include how legacy phosphorus behaves under different management regimes, how quickly it may be drawn upon by crops, and under what circumstances high-phosphorus soils may contribute to actual losses to water. In that sense, the pilot is most valuable as a baseline and as a bridge between farmer experience, advisory evidence and future scientific research.

## 8. Potential Nutrient Rundown Strategies

The findings from the Total Phosphorus pilot highlight that many soils across the dataset contain substantial legacy phosphorus reserves, often accumulated over decades of fertiliser use and manure applications. While these reserves can support crop production, they also represent a long-term environmental risk where soils are saturated or where pathways for phosphorus loss to water exist. As such, there is a clear opportunity to move beyond static nutrient management and towards more active strategies that gradually rundown these accumulated nutrient loads over time.

A key emerging approach within the county is being developed through the Wyescapes Landscape Recovery project. This initiative is exploring how targeted land management changes, supported by blended public and private finance, can deliver environmental improvements while maintaining viable farm businesses. Within this framework, a particularly innovative concept is the financial incentivisation of nutrient offtake, whereby farmers are supported to actively remove phosphorus from soils through biomass production and export.

This approach recognises that legacy phosphorus cannot be addressed solely through reducing inputs; in many cases, there is a need to actively rundown nutrients from the system. Wyescapes is therefore trialing and developing models where farmers are rewarded for adopting management practices that increase nutrient removal, particularly in fields identified as having high Total Phosphorus levels and elevated risk of runoff or leaching.

In practical terms, this may include increased silage cutting frequency, with forage removed from the field and utilised elsewhere, either within the farm system or exported off-farm. Similarly, in arable systems, there is potential to optimise crop rotations and harvest strategies to maximise nutrient removal through grain and straw. In some cases, more targeted approaches may be appropriate, such as establishing temporary high biomass crops specifically designed to draw

down soil nutrient levels over a defined period. These could include forage crops, herbal leys or other deep-rooting species capable of accessing and mobilising phosphorus within the soil profile.

What distinguishes the Wyescapes approach is the integration of these practices within a financial framework that recognises and rewards nutrient rundown as an environmental service. Rather than placing the burden of change solely on farmers, the model seeks to create new income streams linked to improved water quality outcomes, flood resilience and broader ecosystem benefits. This is particularly important given that nutrient drawdown is often a medium- to long-term process, and the financial returns from reduced fertiliser use alone may not be sufficient to incentivise early adoption.

The Total Phosphorus dataset generated through this pilot provides a critical evidence base to support this approach. By identifying fields with the highest legacy phosphorus loads, it becomes possible to target interventions more effectively and to prioritise areas where nutrient rundown is likely to deliver the greatest environmental benefit. In this way, Total Phosphorus testing acts as a diagnostic tool, enabling a more strategic and spatially targeted approach to land management.

There is significant potential for this model to act as a blueprint for the wider county. If scaled effectively, a coordinated programme of nutrient rundown could contribute to a measurable reduction in phosphorus losses at a catchment level, complementing existing regulatory and advisory approaches. Importantly, it also offers a pathway for farmers to engage positively with environmental objectives, positioning them as active contributors to solutions rather than passive recipients of regulation.

To achieve this, further work will be required to refine the mechanisms through which nutrient rundown is quantified, verified and rewarded. This includes developing robust methodologies for measuring crop offtake, linking soil phosphorus data to nutrient removal rates, and ensuring that monitoring and reporting requirements remain proportionate and practical. There is also an opportunity to align this work with existing initiatives such as FarmGate nutrient balances and emerging private markets for environmental services, creating a more integrated and coherent framework for delivery.

## 9. Communication Recommendations

Effective communication of the findings from the Total Phosphorus pilot is critical to ensuring that the insights generated are interpreted accurately and used constructively. The results highlight complex soil nutrient dynamics and should therefore be communicated in ways that are tailored to different audiences, recognising varying levels of understanding, confidence and readiness to act.

### 9.1 Participating Farmers:

For those farmers who participated in the testing pilot and have already demonstrated a high level of engagement, the engagement focus for this group in the next 6months will move from baselining to focus on enabling action. These farms are ideally positioned to act as early

adopters and demonstration sites, where the implications of Total Phosphorus testing can be explored in a practical and evidence-based way. The presence of elevated Total Phosphorus levels indicates that many soils already contain substantial nutrient reserves, and that there may be scope to reduce reliance on imported fertilisers without negatively affecting productivity.

The next phase of work with these farms should therefore focus on structured tests and trials. This could include the establishment of side-by-side comparisons where phosphorus applications are reduced or removed entirely, allowing the impact on crop yield, forage production and overall system performance to be monitored over time. Alongside this, monitoring of crop offtake—both for forage and arable systems—would provide valuable insight into the quantity of phosphorus being exported from the field each season. When combined with existing FarmGate nutrient balance work, this would enable a much clearer understanding of whole-farm phosphorus dynamics and the rate at which legacy phosphorus reserves may be drawn down.

There is also a strong opportunity to integrate environmental monitoring into these trials. In particular, targeted monitoring of land drains and field-edge runoff on selected high-risk fields would help to determine whether elevated Total Phosphorus levels are translating into actual phosphorus losses to water. This is a critical evidence gap within current catchment management approaches. By linking soil phosphorus data with real-world loss pathways, participating farms could play a pivotal role in strengthening the evidence base for both local and national nutrient management policy.

Over time, repeat soil testing will also be important. Annual measurement of plant-available phosphorus, combined with periodic reassessment of Total Phosphorus, would allow changes in soil nutrient status to be tracked and would help to demonstrate the buffering capacity of soils. This would provide valuable insight into how quickly soils respond to reduced inputs and whether legacy phosphorus reserves can sustain crop production over the medium term. Collectively, these activities would position participating farmers as leaders within the catchment, generating practical evidence that can be shared more widely and helping to build confidence across the sector. Alignment of this work with the Defra “Living Labs” soil research which is due to start later this year will be key as could provide the successful deliverer a spring board for that program.

## 9.2 Wider Farming Community:

For the broader farming community, communication should take a different approach. The priority here is to raise awareness and understanding, while avoiding unnecessary complexity or concern. The key message is that many soils contain more phosphorus than standard tests alone would suggest, and that this represents an opportunity. Total Phosphorus testing provides an additional layer of insight that can help farmers make more informed decisions about nutrient management, particularly in the context of rising input costs and increasing environmental scrutiny.

It is important that this message is communicated in a clear and practical way. Rather than focusing on the technical aspects of soil chemistry, communication should draw on real farm examples and demonstrate what the findings mean in practice. Case studies from participating farms will be particularly powerful in this regard, especially where they can show that reductions in phosphorus inputs have been achieved without compromising productivity. This peer-to-peer approach is likely to be far more effective than top-down messaging and will help to build trust and confidence among farmers who may be less familiar with the concept of Total Phosphorus.

The financial dimension should also be emphasised. For many farm businesses, the ability to reduce nutrient inputs without affecting output represents a significant opportunity to improve margins and reduce exposure to volatile input prices. At the same time, improved phosphorus management can contribute to reduced risk of nutrient loss to water, supporting compliance with existing regulations and positioning farms more favourably in the context of future policy developments. In this way, Total Phosphorus testing can be framed not only as an environmental tool, but as a means of improving business resilience.

Across both tiers, there is a clear opportunity to link the findings of this pilot to wider catchment-scale objectives. By supporting a group of engaged farmers to test and demonstrate new approaches, and by communicating these findings effectively to the wider farming community, Herefordshire Rural Hub aims to translate this complex scientific data into practical, farm-level action. This approach aligns closely with our existing work on FarmGate nutrient balances and with the broader ambition to improve water quality within the Wye catchment.

### **9.3 Wider Stakeholders:**

In addition to engagement with farmers, there is a clear need to communicate the findings of the Total Phosphorus pilot appropriately to wider stakeholders operating at a catchment and strategic level. This includes forums such as the Nutrient Management Board, the Wye Catchment Partnership, local authorities, regulators and water companies, all of whom contribute to shaping policy, investment and delivery across the catchment.

For this audience, it is important that the findings are presented in a balanced and contextualised way. The dataset provides useful additional evidence to support understanding of phosphorus within agricultural soils, particularly in relation to the presence of legacy nutrient stores. It highlights that a proportion of phosphorus within soils is held in forms that are not immediately plant-available, and that this may influence longer-term nutrient behaviour. However, it should be recognised that the dataset represents a snapshot in time and should be considered alongside other sources of evidence when drawing conclusions at a catchment scale.

Communication should therefore focus on positioning the dataset as a complementary contribution to ongoing research and monitoring, including work undertaken through the REPHOKUS programme and other catchment initiatives. The alignment between these strands of work is helpful in building a more complete understanding of phosphorus dynamics, but care should be taken to avoid overgeneralisation from a relatively limited sample set. The value of the

pilot lies in its ability to provide real-world, farm-scale insight that can inform and refine wider discussions, rather than to serve as a definitive assessment in isolation.

It is also important to present the findings in a way that recognises both the complexity and variability of agricultural systems. The data demonstrates that phosphorus levels vary considerably between fields and holdings, reflecting differences in soil type, management history and farming practice. As such, it supports a more differentiated approach to nutrient management, where interventions are informed by local conditions rather than applied uniformly across the landscape.

The findings also have relevance in the context of emerging delivery approaches, such as those being explored through the Wyescapes Landscape Recovery project. In this case, the dataset can help to inform where targeted management changes or trial activities may be most appropriate. When presented alongside practical examples of on-farm testing and innovation, it contributes to a broader narrative around collaborative, farmer-led approaches to addressing nutrient challenges.

Looking ahead, there is a clear opportunity for this work to inform future research and policy development, particularly through programmes such as the Defra Living Labs initiative. The pilot demonstrates the value of integrating farmer participation with scientific investigation and provides a useful baseline for further study. Sharing the findings through established catchment forums will help to ensure that this work is understood within the appropriate context and can contribute constructively to ongoing discussions.

## 10. Conclusions

The Total Phosphorus soil testing pilot has provided a valuable and timely contribution to understanding nutrient dynamics within agricultural soils in Herefordshire. By combining farmer-led sampling with advisory support and alignment to academic research, the project has generated an evidence base that offers new insight into the scale and variability of phosphorus held within soils, beyond that captured through standard agronomic testing.

At the same time, the report must be read in line with its limitations. The dataset is exploratory in nature, includes a limited number of holdings, and contains some very high values that materially affect averages and trends. The analysis presented here is intentionally proportionate and transparent rather than definitive. It helps identify useful patterns, questions and priorities for future work, but does not in itself provide conclusive scientific proof or prescriptive recommendations.

The most appropriate next step is therefore not to over-interpret the current findings, but to build on them through structured follow-up activity. This should include on-farm tests and trials on selected holdings, particularly where farmers are motivated to explore reduced phosphorus inputs, crop offtake monitoring and repeat soil testing over time. There is also a clear case for

targeted monitoring on selected higher-interest fields, including where appropriate land drain or runoff monitoring, to improve understanding of how soil phosphorus status relates to actual loss pathways.

Continued support for farmer knowledge exchange will be equally important. The Herefordshire Agri Group has provided the forum through which many of these questions first emerged, and it remains well placed to support peer learning, interpretation of results and practical discussion of trial findings. Sharing results carefully and proportionately with wider stakeholders, including catchment forums and research partners, will also help ensure that the work contributes constructively to the wider evidence base without being overstated.

There is clear value in aligning the next phase of work with Wyescapes, REPHOKUS and the forthcoming Defra Living Labs programme so that future monitoring and research build on the baseline now established. In this way, the pilot can play an important role in moving from initial indication to more rigorous understanding, while keeping farmers centrally involved in shaping the next stage of inquiry.

## **11. Next Steps and Key Actions**

### **11.1. On-Farm Tests and Trials**

A priority for the next phase is the development of structured on-farm tests and trials with participating farmers. These should focus on building practical evidence around the management of legacy phosphorus and the implications for both productivity and environmental outcomes.

Key areas of focus should include:

- Trials to assess the impact of reduced or ceased phosphorus fertiliser applications on crop yield and quality
- Monitoring of crop offtake for both forage and arable systems to quantify nutrient removal
- Integration of soil testing over time to track changes in plant-available phosphorus in response to management changes
- Targeted monitoring of higher-risk fields, including consideration of drainage and runoff pathways, to better understand potential links between soil phosphorus status and nutrient loss

These activities will be critical in moving from data collection to actionable insight, and in building confidence among farmers that changes in nutrient management can be made without compromising system performance. This approach could be progressed through both the Defra Living Labs soil research and the proposed Defra Farmer Collaboration fund. Ensuring alignment between these initiatives will help to maximise the value of the pilot and avoid duplication of effort.

### 11.2. Support for Farmer Knowledge Exchange

The Herefordshire Agri Group provides a strong foundation for continued knowledge exchange and could play a central role in the next phase of delivery. Ongoing facilitation of this group will be essential to:

- Share emerging findings from on-farm learning
- Enable peer-to-peer knowledge exchange and discussion
- Explore practical challenges and opportunities associated with nutrient management changes
- Support farmers in interpreting their own soil data and making informed decisions

There is also an opportunity to expand engagement beyond the initial group, using participating farmers as demonstration hosts and case study examples to support wider learning across the county. It is anticipated that this element can be enabled through support from Dwr Cymru’s collaboration funding and Defra’s new Farmer Collaboration Fund launching later in 2026.

### 11.3. Targeted Communication and Dissemination

The findings from the pilot should be communicated in a way that is appropriate to different audiences, ensuring clarity, accuracy and proportionality in messaging.

For farmers, communication should focus on practical implications, including opportunities to reduce inputs, improve efficiency and manage risk. For wider stakeholders, including catchment partnerships and policy forums, the emphasis should be on how the dataset contributes to a broader evidence base and supports more targeted and informed approaches to nutrient management.

In all cases, it will be important to present the findings within their appropriate context, recognising both the value of the dataset and its limitations, and avoiding overgeneralisation.

## 12. Delivery Cost

Description	Hours	Cost
Farmer Recruitment and Coordination with Cobb Agri	6	159.96
Herefordshire Agri Group meeting preparation & attendance	9	239.94
Data analysis & Liaison with Lancaster University	6.5	173.29
Prepare Project Report & Disseminate Findings	16	426.56
Organisational Overheads @ 20% of staff time		199.95
Soil Testing Costs		£3,090
<b>Total</b>		<b>£4,289.70</b>

### 13. Disclaimer

This report has been prepared by Herefordshire Rural Hub to provide an initial exploration of total phosphorus within agricultural soils in the Wye catchment. The primary purpose of this work is to initiate a process of gaining further insight into the scale and behaviour of legacy phosphorus in soils, using available data and proportionate analysis. The findings presented are based on a basic assessment of the dataset and are intended to support discussion, learning and the development of future work. They should not be interpreted as definitive scientific analysis, nor as prescriptive agronomic or environmental recommendations.

The intended recipient of this report is Herefordshire Council. While the findings may be of wider interest, any further distribution or use of this report should be agreed in advance with Herefordshire Rural Hub to help ensure that the content is interpreted appropriately and within its intended context.

All data included within this report has been anonymised. Individual farm identities, locations and specific field details have been removed to protect the confidentiality of participating businesses. The results should therefore be considered in aggregate and not attributed to any specific holding or location.



**The effects of gypsum application to agricultural soils on water extractable phosphorus and Olsen extractable phosphorus concentrations**

Dr Ben Surridge, Lancaster Environment Centre, Lancaster University. March 2026.

Soil incubations and laboratory analyses undertaken by Dr Catherine Wearing and Dr Vassil Karloukovski, Lancaster Environment Centre, Lancaster University.

**1. Background**

This project is a collaboration between Herefordshire Council and Lancaster University, funded by Herefordshire Council. In 2025, Herefordshire farmer Ben Taylor-Davies approached Herefordshire Council to share his awareness of the potential for gypsum to influence water soluble phosphorus concentration within soil. Herefordshire Council and Lancaster University co-designed the approach described below to provide a rapid analysis of the hypothesis utilising Herefordshire soils. These trials also build on emerging academic research that has highlighted the potential for gypsum application to reduce water soluble phosphorus concentrations within soil, such as the GYPREG project within land draining to the Baltic Sea (<https://www.raceforthebaltic.com/gypreg>)

**2. Approach**

*Gypsum application and incubation of soils*

Four soils were supplied by Herefordshire Council to Lancaster University for testing on 22<sup>nd</sup> October 2025. These soils were coded F1 SaL; F2 CL; F3 SaScL; and F4SiCL. Hereafter, these soils are coded F1, F2, F3 and F4. On receipt, the soils were air-dried under ambient laboratory conditions for 18 days to achieve constant weight. The soils were then sieved to 4.75 mm in order to remove large stones and vegetation fragments from the samples. For each of the four soil types, 1 kg sub-samples of the sieved soil were added to four foil trays, creating a total of 16 samples across the four soil types. For each soil type, the four 1 kg soil samples were treated to provide:

1. One tray containing a control soil treatment, receiving no gypsum addition (Control)
2. One tray containing soil receiving the equivalent of 1 tonne gypsum/hectare (G1)
3. One tray containing soil receiving the equivalent of 3 tonnes gypsum/hectare (G3)
4. One tray containing soil receiving the equivalent of 5 tonnes gypsum/hectare (G5)

Gypsum for application to the soils was supplied by Herefordshire Council to Lancaster University. The required mass of gypsum to achieve the application rates described above (Control = 0 g; G1 = 0.48 g; G3 = 1.43 g; and G5 = 2.38 g) was weighed and distributed evenly across the surface of the 1 kg sub-samples of soil in the foil trays. The soil and gypsum amendment was then thoroughly mixed by hand using a plastic scoup within each foil tray, for a uniform period of 2 minutes. The appropriate volume of deionized water was then added to each of the 16 foil trays to achieve the equivalent of 80% water holding capacity in the soils, using a fine mist spray bottle to distribute the water approximately evenly across the soil surface in each foil tray. Deionised water was applied to the surface of the soil on four individual dates: 20<sup>th</sup> November; 26<sup>th</sup> November; 9<sup>th</sup> December and 22<sup>nd</sup> December 2025, with samples allowed to dry under ambient laboratory conditions and return to air-dry conditions between

each application of water. This approach meant that four wet-dry cycles, ranging between air-dry and 80% water holding capacity conditions, were imposed on soils within each individual tray.

#### *Soil extraction and analysis*

Following the incubations described above, each 1 kg sample of soil was sieved to 2 mm. Subsequently, three \* 2 g samples of soil from each of the 16 foil trays were weighed into new 50 ml HDPE centrifuge tubes for determination of water extractable phosphorus (WEP). To each centrifuge tube, 20 mls of >18.2 M  $\Omega$  milliQ water was pipetted and samples were shaken in a constant temperature incubator for 1 hour at 20 °C. After the extraction, samples were filtered using new, 0.45  $\mu$ m pore size polyethersulfone syringe filters and filtrates collected for soluble reactive phosphorus (SRP) analysis within 24 hours. A further three \* 2 g samples of <2 mm soil from each tray were weighed into separate new 50 ml HDPE centrifuge tubes for Olsen-extractable phosphorus analysis. To each centrifuge tube, 40 mls of 0.5 M NaHCO<sub>3</sub> solution that had previously been adjusted to pH 8.5 was added. Samples were shaken in a constant temperature incubator for 30 minutes at 20 °C. After the extraction, samples were filtered using new Whatman number 2 filter papers and filtrates collected. These filtrates were diluted 1:10 using >18.2 M  $\Omega$  milliQ water and stored for SRP analysis within 24 hours.

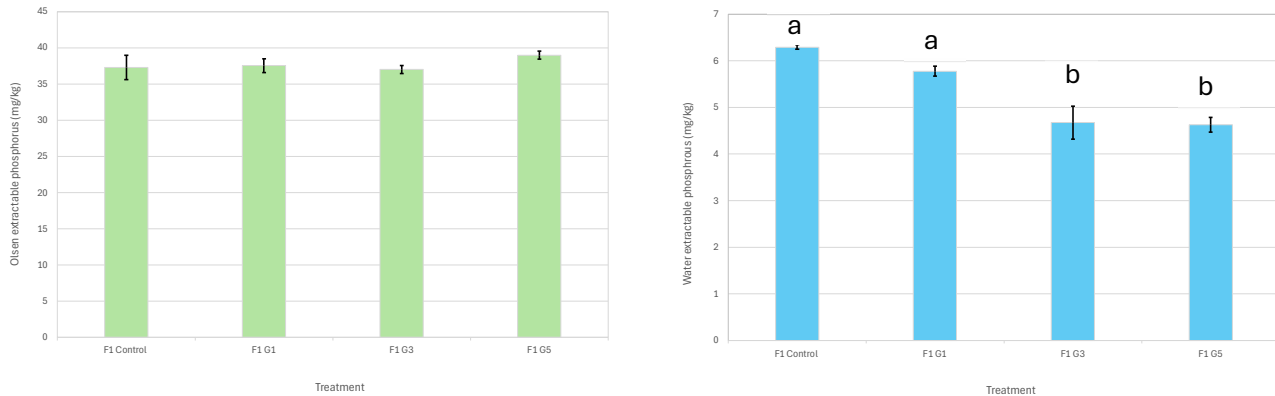
The concentration of SRP in both WEP and Olsen-P filtrates was analysed colourimetrically on an AQ2 Discrete Analyser (SEAL Analytical). Analysis of SRP was equivalent to USEPA Method 365.1 in which phosphate ions react with an acidic molybdate reagent to form an antimony phospho-molybdate complex, which is chemically reduced by ascorbic acid. Calibration standards for SRP were created using TraceCERT® certified phosphorus reference materials and validated using two independent check standards made from potassium dihydrogen orthophosphate salt. A difference between observed values and expected values for both check standards of <10% was deemed to represent an acceptable instrument calibration. A random selection of 10% of samples were subjected to repeat analyses to quantify precision of the SRP data, with coefficients of variation typically below 10%.

### **3. Results**

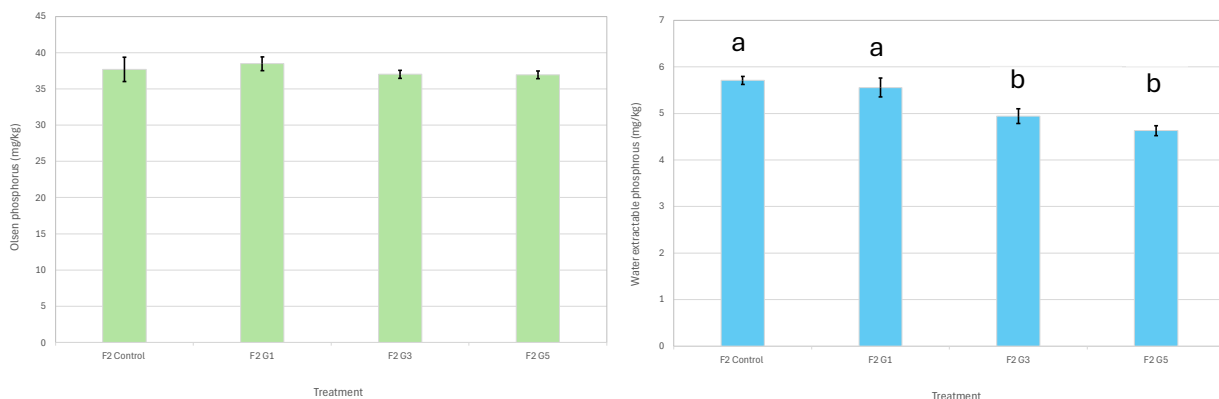
Figures 1-4 below report results for Olsen extractable P and WEP across each of the four soil types analysed in the research reported here. Average concentrations of Olsen extractable P and WEP were similar within soils F1 and F2 (c.38 mg/kg for Olsen extractable P and c.5 mg/kg for WEP), but increased significantly within soil F3 (c.63 mg/kg for Olsen extractable P and c.9 mg/kg for WEP) and again within soil F4 (c.112 mg/kg for Olsen extractable P and c.20 mg/kg for WEP).

Considering data from across all four soil types together, the application of gypsum to soils at G1, G3 or G5 rates resulted in significant decreases in WEP concentration compared to control soils, although WEP concentrations following G3 and G5 treatments did not differ significantly from each other. However, the specific patterns across G1, G3 and G5 treatments did vary between individual soils. In soils F1 and F2, WEP concentrations only decreased significantly compared to control soils following gypsum applications at G3 and G5 rates, with no significant difference found between G3 and G5 treatments in these two soil types. In contrast, within both

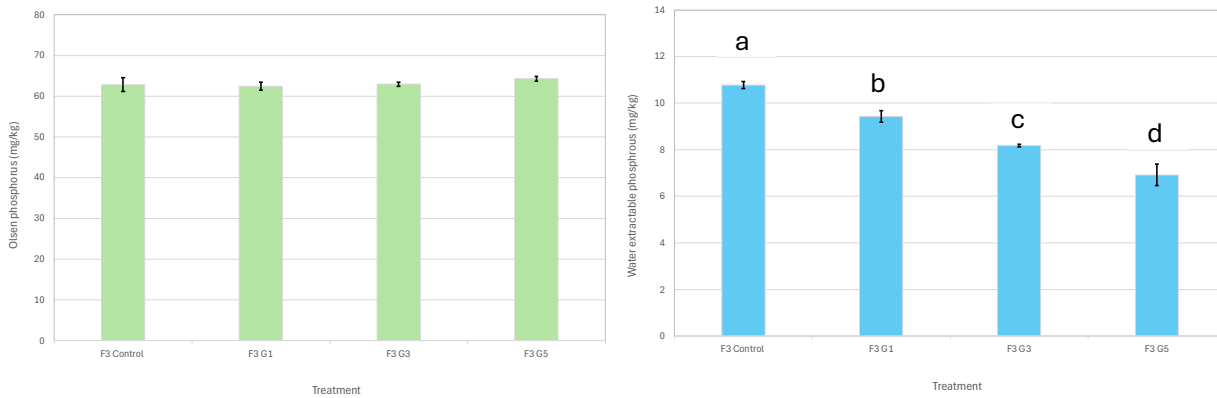
F3 and F4 soils, gypsum application at G1, G3 and G5 rates was associated with significant decreases in the concentration of WEP compared to control soils. For soil F3, significant decreases in the concentration of WEP were observed as gypsum application increased from G1 to G3 and from G3 to G5. For soil F4, significant decreases in the concentration of WEP were observed between G1 and G3/G5 applications, although no significant change in WEP concentration was observed between G3 and G5 applications for this soil. The average decrease in the concentration of WEP ranged between 3 and 13% compared to control soils for G1 applications, but reached between 18 and 36% following G5 applications (Table 1).



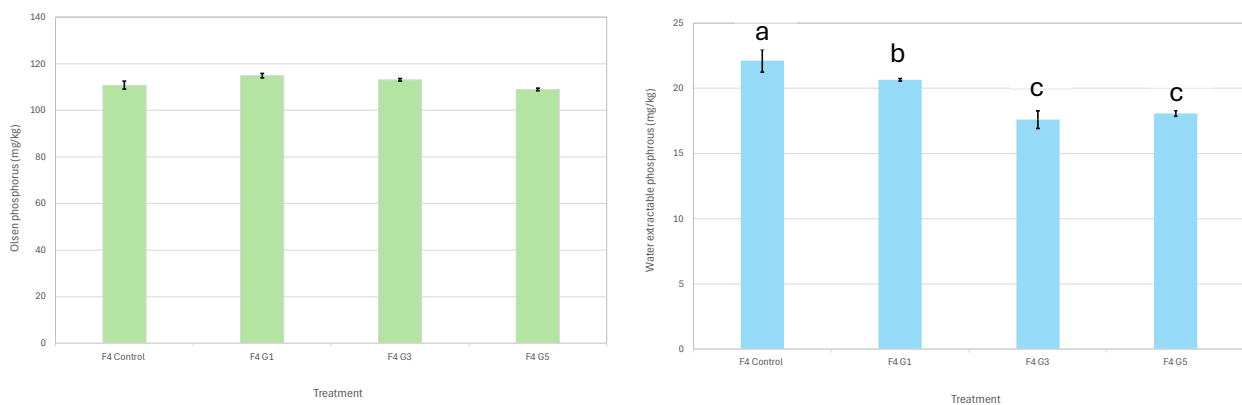
**Figure 1.** Olsen extractable phosphorus and water extractable phosphorus concentrations for F1 soil following Control, G1 (1 tonne/hectare), G3 (3 tonnes per hectare) and G5 (5 tonnes per hectare) applications of gypsum. Error bars show one standard deviation and columns show average concentrations from three replicate analyses of each treatment. Letters above each column denote significant differences between treatments, absence of any letters shows no significant difference across any treatment.



**Figure 2.** Olsen extractable phosphorus and water extractable phosphorus concentrations for F2 soil following Control, G1 (1 tonne/hectare), G3 (3 tonnes per hectare) and G5 (5 tonnes per hectare) applications of gypsum. Error bars show one standard deviation and columns show average concentrations from three replicate analyses of each treatment. Letters above each column denote significant differences between treatments, absence of any letters shows no significant difference across any treatment.



**Figure 3.** Olsen extractable phosphorus and water extractable phosphorus concentrations for F3 soil following Control, G1 (1 tonne/hectare), G3 (3 tonnes per hectare) and G5 (5 tonnes per hectare) applications of gypsum. Error bars show one standard deviation and columns show average concentrations from three replicate analyses of each treatment. Letters above each column denote significant differences between treatments, absence of any letters shows no significant difference across any treatment.



**Figure 4.** Olsen extractable phosphorus and water extractable phosphorus concentrations for F4 soil following Control, G1 (1 tonne/hectare), G3 (3 tonnes per hectare) and G5 (5 tonnes per hectare) applications of gypsum. Error bars show one standard deviation and columns show average concentrations from three replicate analyses of each treatment. Letters above each column denote significant differences between treatments, absence of any letters shows no significant difference across any treatment.

**Table 1.** Summary of water extractable phosphorus (WEP) and Olsen extractable phosphorus concentrations for soils F1-F4 following Control, G1 (1 tonne/hectare), G3 (3 tonnes per hectare) and G5 (5 tonnes per hectare) applications of gypsum.

Treatment	Average WEP (mg/kg)	Standard deviation WEP (mg/kg)	Change in WEP compared to control soil (%)	Average Olsen extractable P (mg/kg)	Standard deviation Olsen extractable P (mg/kg)
F1 Control	6.29	0.05	n/a	37.28	1.70
F1 G1	5.77	0.11	-8.2	37.53	0.96
F1 G3	4.67	0.35	-25.8	36.99	0.55
F1 G5	4.63	0.16	-26.5	38.97	0.55
F2 Control	5.71	0.09	n/a	37.72	1.34
F2 G1	5.56	0.20	-2.6	38.48	0.01
F2 G3	4.94	0.16	-13.4	37.01	1.11
F2 G5	4.63	0.11	-18.9	36.94	0.41
F3 Control	10.78	0.15	n/a	62.84	0.76
F3 G1	9.43	0.24	-12.5	62.42	1.04
F3 G3	8.18	0.06	-24.1	62.94	2.11
F3 G5	6.92	0.46	-35.8	64.27	0.95
F4 Control	22.12	0.87	n/a	110.82	4.26
F4 G1	20.66	0.09	-6.6	114.84	0.29
F4 G3	17.60	0.67	-20.4	113.17	1.12
F4 G5	18.07	0.23	-18.3	108.99	3.61

In contrast to WEP, the treatment of soils with gypsum had no significant effect on the concentration of Olsen-extractable P compared to control soils that received no gypsum.

#### 4. Conclusions

The trials reported here reveal that significant decreases in water-extractable phosphorus concentrations in soil can be achieved via the application of gypsum to soil. These decreases can reach up to 36% compared to control soils, depending on soil type and gypsum application rate. Importantly, no significant change in the agronomically-relevant Olsen extractable P concentration was observed in the trials reported here, meaning that gypsum application appeared to have no impact on the crop-available forms of P determined by Olsen extraction.

The impacts of gypsum application on water-extractable P do depend on soil type and were observed during relatively short-duration laboratory experiments in the work reported here. Therefore, the following areas of additional work are recommended in order to build on these highly positive initial laboratory trials:

1. Testing the effects of gypsum application on water-extractable and Olsen-extractable P across a wider range of soils from Herefordshire, to confirm the positive impacts reported here from initial laboratory trials.

2. Undertaking larger-scale plot or field trials under realistic agricultural production systems and weather (e.g. rainfall) conditions is required, to determine the longer-term and larger-scale impacts that follow gypsum application to soil.
3. Work to determine the impact of gypsum application to soil on a wider range of chemical, biological and physical soil properties is required, to fully understand both the environmental and agronomic impacts of gypsum application.