River Phosphate Aspects of Poultry Farming in Herefordshire

In two earlier reports, I have looked at the likely impact on river phosphate levels caused by the poultry industry in Powys. In the first report, I outlined the agricultural practices involved and determined how these would affect river phosphate levels. I also introduced a simple physical model to describe the way in which phosphate moves through the soil. In the second report, I used data from the Powys CC planning portal (with considerable assistance from CPRW) to extend the calculations to the whole industry within Powys. I analysed the impact on individual rivers, including modelling the likely time dependency on two of these.

Both the Severn and Wye catchments featured in these earlier reports. However, for the Wye catchment, we also need to consider the contribution from Herefordshire poultry operations – which are considerable.

In this report, I have analysed planning applications on the Herefordshire CC planning portal (again with support from CPRW), spanning the period 2005-2019. As before, I've taken bird numbers declared and, using standard data, calculated the resulting additional phosphate load on each river. In the final section, I have totalled the Powys and Herefordshire data to look at the total phosphate load on the Wye catchment.

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Introduction

Powys

In my previous reports [3],[4], we discovered why poultry operations are bad news for phosphate pollution:

- Poultry operations are almost always additional to existing livestock activities.
- Poultry are fed on a high-phosphate diet and their manure consequently contains high levels of phosphate.
- Intensive poultry units (IPUs), as the name suggests, represent a very high stock density. A typical broiler unit of 100,000 birds occupies maybe 1 hectare and produces four times more manure phosphate than all of the cattle and sheep on a typical 150 ha farm.
- The almost universal practice is to spread the poultry manure on the land, up to the national limit of 250 kgN/ha. This results in a phosphorus application rate of 150 kgP_2O_5/ha, compared to the best practice value of 20 kgP_2O_5/ha for pasture stated in *RB209* [1]. In other words, poultry farmers are *spreading as a means of waste disposal*.

We also saw how the planning process has let these schemes through over 25 years, despite *spreading as a means of waste disposal* being identified as unsustainable by NRA[1] in 1995 [5]. In particular:

- Compliance with the 250 kgN/ha spreading limit appears to be the only criterion which EA/NRW have used to assess planning applications.
- Best practice nutrient management, as detailed in *RB209* [1], appears to not be required, despite the Wye catchment being an SAC & SSSI.
- Neither Powys CC, nor EA/NRW appear to have assessed diffuse phosphate pollution of surface water.
- Neither Powys CC, nor EA/NRW appear to have considered the cumulative impact of IPU projects.

Herefordshire

In this report I will focus exclusively on the Wye catchment. Whilst there are a few Herefordshire IPUs within the Severn catchment, I have excluded them from this work. The bulk of Herefordshire is drained by the Wye and its tributaries.

A key point of differentiation from Powys, is that the Wye catchment in Herefordshire is a nitrogen vulnerable zone (NVZ). The relevant consequence of this is that the maximum spreading limit is reduced to 170 kgN/ha. The corresponding phosphorus application rate for poultry manure is thus 103 kgP_2O_5.

A second differentiator is the dominant type of agriculture. In Powys, we found pretty much exclusive livestock farming, generally a mix of cattle and sheep. Pasture needs relatively little phosphate addition. On this basis I approximated that all the poultry phosphate was additional, and therefore would ultimately run off to the river. Herefordshire, on the other hand, is predominantly arable. Arable crops take up significant quantities of phosphate which needs to be replaced.

[1] NRA: National Rivers Authority was responsible for rivers up to 1996, when it was absorbed into the new Environment Agency (EA). In 2013, following the establishment of the Welsh Assembly, Natural Resources Wales (NRW) was split off from the EA to take responsibility for Wales.

Therefore, some of the poultry phosphate is replacing previously imported fertiliser. I will return to this later.

The Data

Overview

Once again, I am indebted to the CPRW[2] for provision of the bulk of the data, which originates on the Herefordshire CC planning portal. I have however checked each planning application to verify bird numbers, acquire additional farm details and establish what is to happen to the manure. Where available, I have downloaded the manure management plan (MMP) for review.

Just as for Powys, records before about 2005 are sketchy. Also similar is the fact that there seemed to be no universal requirement for MMPs prior to around 2015.

In total, over the period 2005-2019, there are 69 relevant planning applications, 58 of which fall within the Wye catchment and were approved (6 approved applications fall within the Severn catchment; these are not considered further in this report).

Bird numbers used in the calculations include both the additional birds resulting from the planning applications and the stated original number of birds if applicable. I've been careful to track multiple planning applications for the same farm, to avoid any double counting. But clearly, I have no visibility of IPUs prior to 2005, which have not submitted expansion plans since 2005. Therefore, the bird numbers I've used are inevitably somewhat lower than reality.

Disposal of poultry waste

From my review, it is clear that the overwhelming majority of poultry operations are disposing of manure by spreading up to the NVZ limit. Smaller farms, who cannot stay under the limit, are distributing the surplus to neighbours. This is exactly the same pattern as in Powys.

Project types

Herefordshire IPUs within the Wye catchment break down as follows:

Project type	*Number of projects*	*Number of birds*
Breeders	6	173,000
Broiler rearers	34	7,201,000
Egg producer	18	553,000
Totals	*58*	*7,927,000*

Table 1: project types in Herefordshire

This shows a much higher proportion of broiler units than Powys, which is more egg-dominated. Broiler units are much larger than egg units. The result is approximately twice the number of birds spread across half the number of IPUs.

[2] CPRW: the Campaign for the Protection of Rural Wales

Phosphate analysis

Calculation of emissions

The different types of bird produce differing amounts of manure. Here I reproduce a table from my earlier report [4], to which the reader should refer for explanation.

Project type	*kgN/year per 1000 birds*	*kgP_2O_5/year per 1000 birds*
Breeders	700	425
Broiler rearers	330	200
Egg producer	530	322
Pullet rearers	210	128

Table 2: N & P emissions from different types of poultry

Knowing the number and type of birds for each planning application, it is then a simple matter to apply the appropriate numbers to calculate the relevant N and P_2O_5 emissions from that IPU.

Arable phosphate offset

As discussed in my first report [3], there are only two output streams for soil phosphate. The first is phosphate exported with the crop (offtake). The second is run-off to the river[3]. For the pastureland of Powys, crop offtake is minimal. There is relatively little phosphorus in livestock and the stock densities are low. So, in terms of kgP_2O_5/ha, this is small compared to the additional poultry phosphate. This allowed me to make the approximation that the additional poultry phosphate emission is equal to the additional poultry phosphate run-off.

But, as I pointed out in the introduction, arable crops have significant phosphorus offtake – which I need to account for in the calculation. So how much is it? The following table shows recommended phosphorus additions for different crops, taken from *RB209* [1]. Incidentally, Soil Index 2[4] is the optimum for all these crops. If the soil is above Index 2, then no phosphorus addition is required.

Crop type	*kgP_2O_5/ha (at soil index 2)*
Winter wheat (8t/ha)	55
Winter barley (6.5t/ha)	55
Oilseed rape (1.5t/ha)	30
Peas	40
Average	*45*

Table 3: P_2O_5 best practice P application rate for different crops (taken from RB209)

Now the crops listed above are not a random selection. They are the most common selection from the farms which submitted IPU planning applications in Herefordshire. So, I feel justified in taking the average of these to use as an offset.

But there is another subtlety to this. The bulk of the farms building IPUs are already mixed arable and livestock – meaning that we should not apply this offset to everything. Typically, 75% of the farm will be arable and 25% pasture. So, my offset calculation works like this.

[3] As in my earlier reports [3], [4], I use the term run-off to include both surface run-off and percolation through the soil. All soil self-evidently drains downhill to the nearest ditch, stream or river via the local water table. If this were not so, the river would only flow when it rains.

[4] Soil Index is a banded measure of P concentration in the soil.

Average best practice rate	45	kgP_2O_5/ha
NVZ max P application rate	103	kgP_2O_5/ha
Fraction arable land	75%	
Offset	75% x 45 / 103 = 33%	
Runoff fraction	*67%*	

Table 4: P_2O_5 offset calculation for a typical Herefordshire mixed arable & livestock farm

In other words, only 67% of the poultry phosphate applied to the land ends up running off to the river, the remaining 33% being exported with the crop. This correction has been applied to all of the Herefordshire data which follows.

Project locations

The following table shows how Herefordshire's Wye catchment IPUs break down by river:

River	*Number of projects*	*Number of birds*	*kgP_2O_5/year*
Arrow	13	2,252,000	310,764
Frome	9	1,194,000	170,504
Lugg	12	1,444,000	179,420
Monnow	4	551,000	75,471
Wye	20	2,486,000	360,138
Totals	*58*	*7,927,000*	*1,096,297*

Table 5: allocation of Herefordshire projects, birds & phosphate emissions by river; P emissions in the final column include the arable offset calculation above

It is immediately apparent how blighted the Lugg system is. The Lugg, Arrow and Frome together account for 63% of the birds and 55% of the excess poultry phosphate within the Herefordshire Wye catchment. IPUs draining to the main stem of the Wye are distributed along the river from Hay, down to below Ross. The Monnow IPUs are all in the upper reaches, the lower river running through Monmouthshire; meaning there are probably more to discover on the Monnow.

The bottom line is that the 7.9M Herefordshire birds identified in this report are dumping 1,195 tonnes per annum of P_2O_5 into the Wye catchment.

Phosphate concentrations

We can now take these phosphate run-off volumes and see what the resulting river concentrations would be. The process is exactly as used in my earlier reports [3], [4]. First, we convert from the agricultural metric kgP_2O_5/year to the scientific metric mgP/s. Then we divide by the mean annual flowrate for the river, taken from the *National River Flow Archive* website [6]. The results are shown in the following table:

River	Phosphate flow (mgP/s)	River flow (m^3/s)	Phosphate concentration (mgP/litre)
Arrow	4.303	2.4	1.82
Frome	2,361	1.2	2.04
Lugg	2,484	5.9	0.42
Monnow	1,045	5.9	0.18
Wye	4,986	48.0	0.10

Table 6: calculated total phosphate concentrations (Herefordshire IPUs only)

Before commenting on these numbers, I will replicate a table from my earlier reports showing the classification scheme used by EA and NRW. This is taken from the *Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*. There are some river-dependent subtleties to this, but the classification is approximately as per the following table:

Class	Min	Max	Description
High	-	0.01	Near natural condition
Good	0.01	0.03	Slight change due to human activities; no impact on fisheries and wildlife
Moderate	0.03	0.09	Moderate change due to human activity; some impact on fisheries and wildlife
Poor	0.09	0.75	Major changes from natural condition; moderate impact on fisheries and wildlife
Bad	0.75	-	Severe changes from natural condition; major impact on fisheries and wildlife; many species absent

Table 7: WFD phosphate classification; units are mgP/litre of reactive phosphate

The UK target for rivers generally is 'good' classification (below 0.03mgP/l). However, because the Wye catchment is an SAC, Natural England can set site-specific targets. One might reasonably assume that such targets would be tighter for an SAC, but not so. In recognition of the fact that the Lugg system has been a phosphate blackspot for years, the pass threshold for the Lugg and the Wye downstream of the Lugg confluence is increased from 0.03 mgP/l up to 0.05 mgP/l.

Irrespective of this regulatory bar-lowering, we see that three of our rivers, the main stem of the Wye, the Monnow and The Lugg are all in the 'poor' zone. The Arrow and the Frome are well into the 'bad' category; veritable phosphate sewers, potentially suffering major impact on fisheries and wildlife. And this is solely courtesy of excess manure spreading by IPUs within Herefordshire. It takes no account of other phosphate sources: wider farming activities, sewage treatment works effluent, or the cumulative contribution flowing downstream from Powys. This last point I will pick up in the next section.

Adding together Powys and Herefordshire

The Arrow, Lugg and Wye all flow into Herefordshire from Powys, where there is also a large poultry industry. The following table shows what is flowing into Herefordshire from Powys on these rivers.

River	Number of projects	Number of birds	kgP_2O_5/year
Upper Arrow	6	107,500	36,952
Upper Lugg	11	451,600	94,446
Wye at Hay	137	3,106,300	778,141
Totals	*154*	*3,665,400*	*909,530*

Table 8: Poultry phosphate load flowing into Herefordshire from Powys

Note that the figures for the Wye at Hay, include the contributions from all of the upstream tributaries. It is immediately apparent that the total phosphate loads from the two counties are similar. The disparity in number of birds reflects the fact that Herefordshire is biased towards broiler rearing and Powys towards egg laying. Egg layers produce considerably higher nutrient emissions than young broilers.

The following graphics illustrate how the quantities from both counties build up as we go downstream. The first shows tonnage per annum of P. The second shows resulting river concentrations.

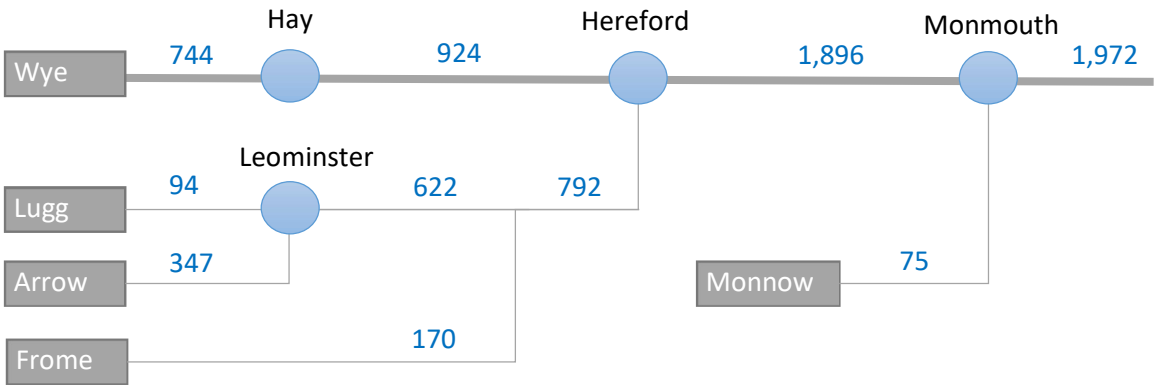

Figure 1: Poultry phosphate load (tonnes P_2O_5 per annum), as it accumulates down the catchment

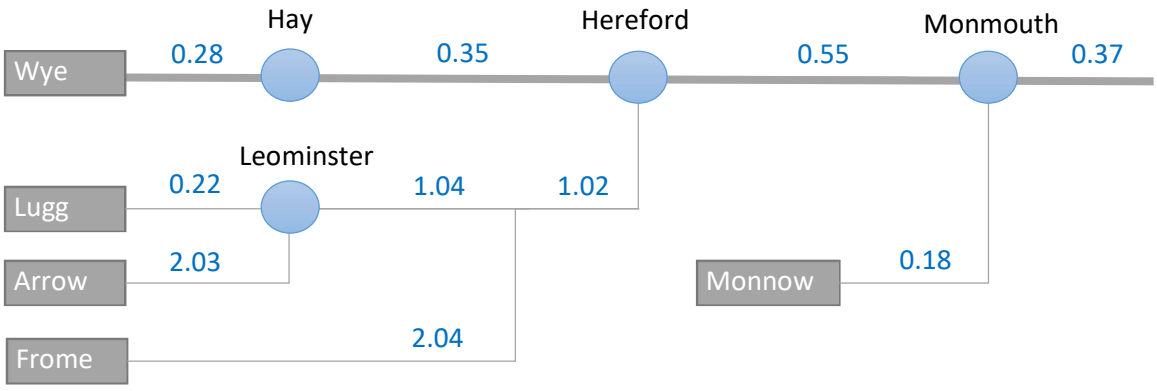

Figure 2: Poultry-related total phosphate concentration(mgP/litre), as it varies down the catchment

Looking first at Figure 1 then. On the main stem of the Wye, we start with the input load from Powys arriving at Hay and being progressively topped up all the way to Monmouth. The Lugg load above Leominster again is flowing in from Powys. But this gets dwarfed by the Herefordshire contribution below Leominster. The Arrow is similar. Around 90% of its load originates in Herefordshire.

I need to emphasise the magnitude of these numbers. These are tonnes per annum of P_2O_5 equivalent; gratuitously applied to land as a means of waste disposal; massively in excess of any reasonable crop needs; and inevitably over time finding its way into the rivers which drain said land. It is the equivalent of taking a 20-tonne truck load of synthetic chemical P_2O_5 and dumping it into the river off Hereford bridge, twice a week, for ever.

Finally, in Figure 2, I have used the respective river flows to translate this tonnage into total phosphate concentrations. The Arrow, Frome and most of the Lugg fall into the 'bad' WFD classification. The remainder are all in the 'poor' classification. These concentrations represent an ecological disaster in the making.

In my previous report [4], I described a model of the time dependence of phosphate run-off. The upshot of this was that there is a lag of several years between the commencement of manure spreading and the rate of run-off reaching its new equilibrium level. So, it is important that we are not fooled by current phosphate levels being lower than the predictions of figure 2. We have already had a severe algal bloom on the Wye last year. If we do nothing, then these will get progressively worse until we have major fish kills, by which point it will be too late.

Conclusions

Number and type of IPUs

- In the period 2005-2019 Herefordshire CC have approved around 58 planning applications for IPUs with the Wye catchment. These IPUs house approximately 7.9 million birds.
- Broiler rearing appears to dominate the poultry industry in Herefordshire (cf. Powys, which has a much larger proportion of egg laying units).
- The 58 planning applications identified clearly miss a lot of pre-existing IPUs. Nevertheless, they are sufficient for the purposes of the calculations performed. Just as in Powys, the numbers are of necessity an underestimate.

Manure disposal

- The practice of *spreading manure as a means of waste disposal* is the norm in Herefordshire, just as in Powys. The same cynical calculations are to be found in the manure management plans.
- Mitigating against this is the fact that the Herefordshire Wye catchment is an NVZ, so maximum spreading rate is reduced to 170kgN/ha.
- Furthermore, as an arable farming area, Herefordshire has legitimate need to apply higher levels of nutrients than is the case for pastureland (e.g. Powys). An appropriate allowance has been factored into the calculations.

Planning process

- Manure management plans have been approved by EA on the basis of compliance with the NVZ maximum spreading rate above.
- Risks of diffuse pollution to surface water are dealt with by claiming compliance with *DEFRA Guidance to reduce water pollution* [7]. However, this is concerned mainly with prevention of surface run-off during excess rainfall. Whereas we should also be concerned with sub-surface drainage via the water table. Algal blooms tend to occur during hot, dry weather when the river is low. Self-evidently the required phosphate does not get there via surface run-off.
- The *DEFRA Guidance* [7] does if fact reference *RB209* [1]. But the principles of best practice nutrient management are completely at odds with the calculations presented in the MMPs. This contradiction seems to be swept under the carpet by applicants and by regulators.
- Because of the Wye SAC status, Herefordshire CC are required to ensure, with scientific certainty, that there are no likely adverse effects from the project, either taken alone or in combination with other plans and projects. In other words, the precautionary principle applies for SACs. If this has been done, then the reasons for approval are opaque.

The rivers

- The phosphate emission totals for the catchment are huge; integrated numbers always will be. The difference here is that the integration is meaningful because this is exactly what the rivers do. They integrate the pollution across the area of their catchment and funnel it down into a channel a few metres wide. The estimated impact on river phosphate concentrations (figure 2) is therefore the key output parameter from these calculations. The results are horrendous. Just from IPUs. Without including wider agriculture or STW contributions.
    - The main stem of the Wye is predicted to carry 10x the phosphate load required for 'good' status.
    - The Arrow and Frome are at 40x that level.
- We have been steadily increasing IPU numbers for years. But it also takes many years for the soil concentration to build up and thus increase the run-off concentration. The effect is therefore that river phosphate loads lag many years behind the construction of new IPUs. The phosphate measurements we observe today are the result of what we did maybe ten years ago. So, if current spreading practices continue, they will get much worse – even if we were to build no more IPUs.

The action

The point of this research is not to attack IPUs as such. I have no agenda beyond the desire to protect our precious rivers. But there is a pressing need for IPUs to dispose of their waste in a manner which does not cause pollution.

- IPUs are essentially industrial operations which happen to be located on farms. Being on a farm confers several financial benefits (no business rates, no inheritance tax, red diesel, etc), but it also enables waste (poultry manure) to be disposed of in ways which would not be allowed on the local industrial estate.
- The poultry industry must be made to carry the cost of responsible disposal for their waste.
- Nutrients should be applied to the land following the best practice guidance of *RB209*. If this occurs, then we have a fighting chance of keeping our rivers in the WFD 'good' range and thus avoiding dangerous algal blooms. Spreading manure up to the NVZ maximum is putting twice as much phosphorus into the land as typical arable crops require. On pasture, the multiple is five times. In Powys, which is not yet working to NVZ status, the multiples are even higher.
- The practice of *spreading as a means of waste disposal* has to stop. And it has to stop quickly if we are to avoid disaster. The practice amounts to little more than fly-tipping on your own land.

References

[1] RB209: Nutrient Management Guide link

[2] DEFRA guidance: July 2018,
Code of good agricultural practice (COGAP) for reducing ammonia emissions link

[3] G. Green report, March 2021,
River phosphate aspects of poultry farming in Powys: a case study

[4] G. Green report, April 2021,
River phosphate aspects of poultry farming in Powys: Part 2

[5] The River Teme Catchment Management Plan Consultation Report 1995 link

[6] The National River Flow Archive link

[7] DEFRA guidance: April 2018
Rules for farmers and land managers to prevent water pollution link