REPORT

River Clun SAC Phosphate Mitigation Solutions for Residential Development

Assessment of mitigation solution options for residential development

Client: Shropshire Council

Reference: PC3212-RHD-ZZ-XX-RP-Z-0001

Status: Final/00

Date: 04 April 2022

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Document title:	River Clun SAC Phosphate Mitigation Solutions for Residential Development
Document short title:	River Clun Phosphate Management Strategy
Reference:	PC3212-RHD-ZZ-XX-RP-Z-0001
Status:	00/Final
Date:	04 April 2022
Project number:	PC3212
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Date:	01/04/2022
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Date:	04/04/2022

Classification	Confidential
Project related	

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Abbreviations

Abbreviation	Description
CJEU	Courts of Justice of the European Union
Dutch-N	Dutch Nitrogen Case
EQS	Environmental Quality Standards
HRA	Habitats Regulations Assessment
NAVs	New Appointments and Variations
NFM	Natural Flood Management
P	Phosphate
PE	Population Equivalent
PR19	Price Review 19
PTP	Package Treatment Plants
SAC	Special Area of Conservation
SAGIS	Source Apportionment Geographical Information System
SIMCAT	Simulated Catchment
SPA	Special Protection Area
SPD	Supplementary Planning Document
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
STW	Severn Trent Water
TP	Total Phosphate
WFD	Water Framework Directive
WwTWs	Wastewater Treatment Works

Glossary

Name	Description
Diffuse	The movement of ions or molecules from an area of higher concentration to an area of lower concentration
SuDS	Sustainable Drainage Systems (SuDS) are drainage solutions that provide an alternative to the direct channelling of surface water through networks of pipes and sewers to nearby watercourses.
Point Pollution	Any single identifiable source of pollution from which pollutants are discharged, such as a pipe

EXECUTIVE SUMMARY

Introduction and purpose of this report

1. Following the Dutch Nitrogen Case[1] ('Dutch-N') in the court of Justice of the European Union (CJEU), which ruled that where an internationally important site (i.e. Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar Sites) is failing to achieve condition due to pollution, the potential for a new development to add to the nutrient load is "necessarily limited". The Dutch-N case has informed the way in which regulation 63 of the Habitats Regulation 2017 should apply to projects or plans which give rise to pollutants. This has resulted in greater scrutiny of proposed developments that are likely to increase nutrient loads to internationally important sites where a reason for unfavourable condition is an excess of a specific pollutant.

2. The River Clun SAC covers an area of ~15 km^2 and is characterised by inland water bodies (standing or running water: 33%), improved grassland (55%) and broad-leaved deciduous woodland (12%). The site is designated for its population of freshwater pearl mussel (*Margaritifera margaritifera*) for which the area is considered to support a significant presence (JNCC, 2021). The SAC is currently in 'unfavourable declining' condition due to the continued depletion of the freshwater pearl mussel (FPM) population as a result of declining water quality. Modelling shows that the main reasons for declining water quality are excessive phosphorus from agriculture, with additional inputs of wastewater from wastewater treatment works.

3. This report sets out suitable mitigation options that could potentially be used to offset the additional phosphorus load from new development proposed in the Draft Shropshire Local Plan (2016-2038) within the catchment of the River Clun SAC, including potential strategic options to manage phosphorus inputs and allow residential development to proceed.

4. Two separate documents accompanying this report also set out a River Clun Phosphate Calculator and a River Clun Phosphate Budget. These have been prepared for Shropshire Council by Royal HaskoningDHV to complement the options discussed here and support a future River Clun Supplementary Planning Document (SPD)

Potential phosphate mitigation options

5. Following a detailed review of scientific literature and best practice guidance, a range of different phosphate management solutions were identified. Following an initial screening exercise, in which the potential viability of solutions was evaluated, the following types of solutions were identified as potentially viable for use in the River Clun catchment:

   a. Nature-based: solutions that would be implemented within a catchment to reduce diffuse- and point-source phosphate loadings, including wetland creation.

[1] *Joined Cases C-293/17 and C-294/17 Coöperatie Mobilisation for the Environment UA and Others v College van gedeputeerde staten van Limburg and Others*

b. Wastewater and drainage: solutions that apply to wastewater and drainage and will require targeted interventions (excluding nature-based and wetland solutions) or specific local policies to be implemented.

6. Multiple potential phosphate management solutions that could potentially be used in the River Clun catchment have been identified. These range from measures that could be implemented in the short term, to more complex measures that would require considerable design, monitoring and consenting and therefore have longer implementation timescales.

***Table 0-1** Phosphate management solutions implementation timescales*

Phosphate management solutions	
Short – medium term implementation timescales	Medium – long term implementation timescales
• Taking land out of agricultural use • Riparian buffer strips • Wet woodlands • Cover crops • SuDS • Portable treatment works • Package treatment plants • Cesspools	• Water company improvements • Willow buffer areas • Alternative wastewater provider • Constructed wetland creation • WwTWs additional treatment wetlands • Highways drainage improvements

Housing proposals

7. In order to understand the phosphate mitigation required to support the delivery of residential development in the Clun catchment, there is a need to understand the level of residential development proposed. As such, a review of the draft Shropshire Local Plan and associated evidence base documents was undertaken to identify the level of residential development proposed within the Clun catchment. The additional phosphate loading from the proposed residential development was then calculated using the Phosphorous Budget Calculator (2022). Worst-case scenarios were assumed to ensure the phosphate loading value is not underestimated.

8. This found that 304 dwellings require mitigation which accounts for dwellings on sites with Planning Permission that still require phosphate mitigation (i.e. those with outline permission or drainage conditions), dwellings on existing/proposed allocated sites without Planning Permission and windfall allowances for settlements with residential development guidelines, until the end of the plan period in 2038. This is equivalent to 20.65kg/yr of phosphate mitigation.

Conclusions and next steps

9. The following sets out the next steps required in order to develop the solutions presented within this report to functioning phosphate mitigation solutions:

a. Identification of the preferred solutions to be delivered and the likely costs, timescales and delivery mechanisms. This is presented in a separate document.

b. A tool to track the phosphate loading for each development and through what schemes this will be mitigated. This should include details of any agreements. The tool should be able to assign credits from various mitigation schemes at various stages of the development lifetime.

10. The above documents will inform a future SPD which will be prepared to support forthcoming Shropshire Local Plan policy on the safeguarding of the River Clun SAC.

1 Introduction

1.1 Nutrient neutrality and the Dutch N Case

11. Following the Dutch Nitrogen Case (the 'Dutch-N'), which ruled that where an internationally important site (i.e. SACs, SPAs and Ramsar Sites) is failing to achieve condition due to pollution, the potential for a new development to add to the nutrient load is "necessarily limited". The Dutch-N has informed the way in which Regulation 63 of the Habitats Regulation 2017 should apply to projects and plans which give rise to pollutants. This has resulted in greater scrutiny of proposed developments that are likely to increase nutrient loads to internationally important sites where a reason for unfavourable condition is an excess of a specific pollutant.

12. As a result, Shropshire Council is having to offset the phosphate loading that will be introduced as part of development under the Draft Shropshire Local Plan.

13. This report was drafted prior to the Local Planning Authority receiving a letter from Natural England sent on the 16 March, 2022 which relates to the Defra (2022) policy paper *Nutrient pollution: reducing the impact on protected sites*. The letter formally advised that both phosphorus and nitrogen are nutrients of concern in the catchment of the River Clun SAC, whereas previous understanding was that phosphorus was the only nutrient of concern. Due to the timings of receiving this letter it was not possible to incorporate nitrogen into this report. However, nitrogen shares many properties with phosphorus and is found in the same sources. Many of the established methods and processes to remove phosphorus will also remove nitrogen. Therefore, the solutions outlined in this report will be effective at removing both phosphorus and nitrogen.

1.2 The River Clun SAC

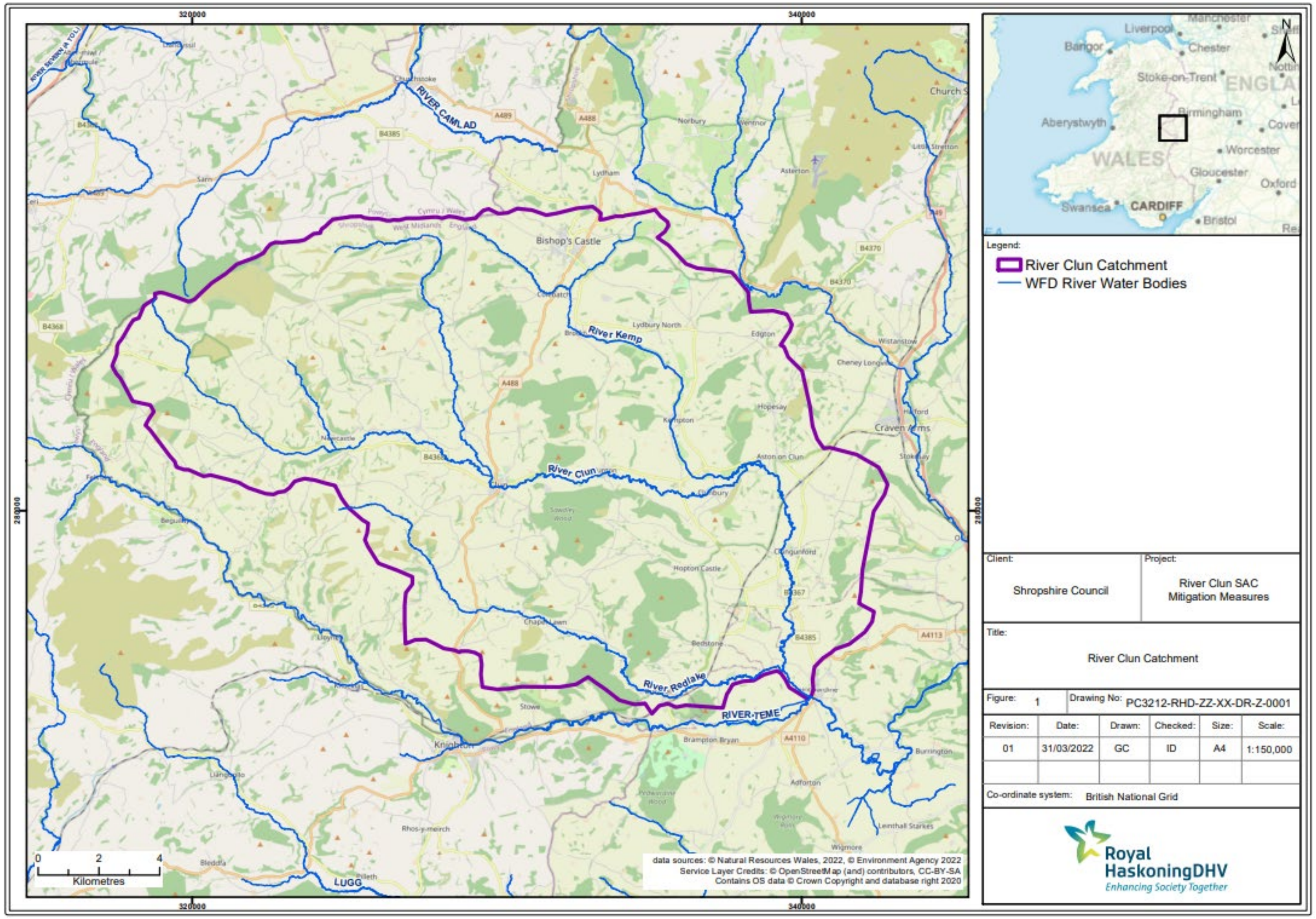
14. The River Clun SAC covers an area of ~15 km^2 and is characterised by inland water bodies (standing or running water: 33%), improved grassland (55%) and broad-leaved deciduous woodland (12%). The site is designated for its population of freshwater pearl mussel (*Margaritifera margaritifera*) for which the area is considered to support a significant presence (JNCC, 2021). The SAC is currently in 'unfavourable declining' condition due to the continued depletion of the freshwater pearl mussel (FPM) population as a result of declining water quality. Modelling shows that the main reasons for declining water quality are excessive phosphorus from agriculture, with additional inputs of wastewater from sewage treatment works (STWs).

15. A joint position statement from the River Clun Strategic Liaison Group which comprises senior representatives from the Environment Agency, Natural England, Shropshire Council and Severn Trent Water, states that whilst the favourable conservation targets recognise the unique environmental value of the River Clun SAC, there is also the need to recognise the value of the area as an important rural community. This means taking account of the requirement for new development to maintain and meet future community needs. Alongside the nature conservation requirement, there is therefore a need for a

balanced approach that recognises the needs of people and enabling this rural local community to thrive. The joint vision for the River Clun SAC is therefore for the whole catchment area to be restored to a functional unit where a nature recovery plan enables ecological and human needs to successfully interact, thereby balancing the needs of people, economy and the environment.

16. **Figure 1** shows the extent of the River Clun catchment.

Figure 1: *River Clun Catchment*



1.3 The Clun Catchment

17. The Clun catchment drains the eastern slopes of the Cambrian Mountains, and the River Clun flows in a south easterly direction until it joins the River Teme at Leintwardine. The total catchment area is 27km^2, and includes three main sub-catchments, namely Folly Brook, River Kemp, and River Redlake. In terms of assessing water quality, the Clun catchment has been divided into eight water bodies by the Environment Agency as per the requirements of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (as amended) (**Figure 2**).

18. Note that there appear to be slight discrepancies between the River Clun catchment boundary as defined by the River Clun Strategic Liaison Group and the sub-catchment boundaries as defined by the WFD River Water Body Catchments. We have used the boundary defined by the River Clun Strategic Liaison Group for consistency through this report.

19. Key catchment physical descriptors relevant to phosphate pollution include:

- Easily erodible soils. Most (35% of the catchment) is characterised by soils from the Barton series soil type, which has a large silt and fine sand content. This leads to capping during heavy rain and runoff then causes erosion on slopes. Risks greatest in spring before the crop cover is established and during summer storms which follow dry spells (Atkins, 2014).
- High catchment connectivity. The Clun catchment is highly connected to the surface drainage network, and a limited amount of land in the catchment is more than 1km from running water (Howells, 2011). The catchment is dominated by steep slopes and incised valleys. These provide numerous flow pathways and potential for expansion of the drainage network during wet periods.
- Land use. Land use is dominated by temporary grass (sown in last five years) and permanent pasture (over 5 years old). Cropping is dominated by wheat and barley, and livestock by fowl and sheep (**Table 1 1**).
- Land quality. Land in the west and south is generally Grade 4-5 (poor to very poor); land in northern, central and south eastern areas is typically Moderate to good (Grade 3) with very limited areas of Grade 2.

Table 1-1: *Crop, land use and livestock types in the Clun catchment (Atkins, 2014)*

Crop Type	Area (ha)
Wheat	1,366
Barley	1,396
Oats & rye	617
Maize	80
Potatoes	52
Oilseed rape	456

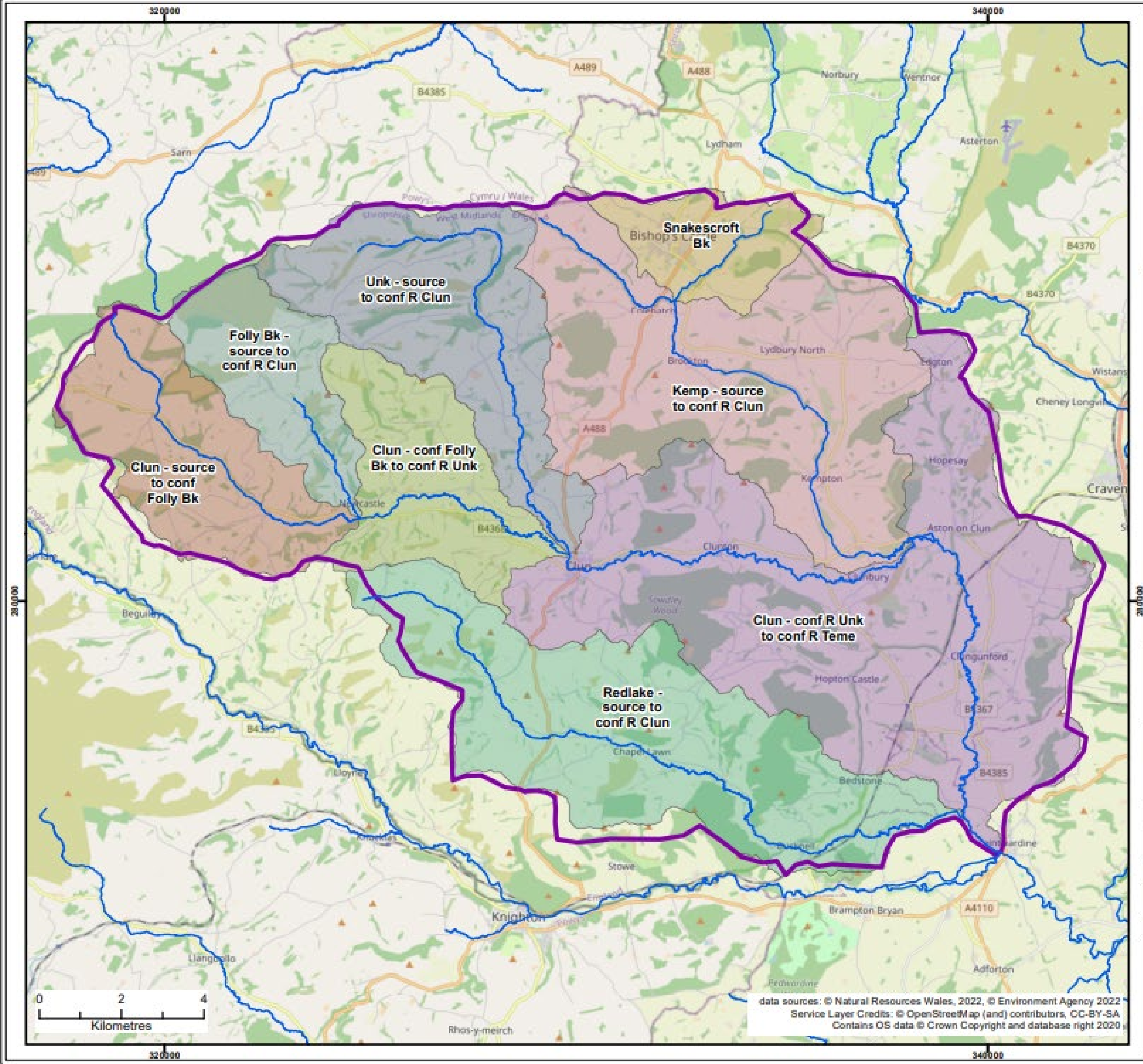
Crop Type	Area (ha)
Stock feed crops	129
Land use	Area (ha)
Temporary grass (<5 years old)	1,795
Temporary grass (>5 years old)	13,461
Rough grazing	250
Woodland	557
Livestock type	Area (ha)
Cattle	13,914
Sheep	159
Pig	119,282
Fowl	287,784

20. At a sub-catchment scale, the 2010 Defra agricultural census shows that:

- Arable land use is concentrated in the Kemp and Lower Clun sub-catchments.
- Cattle are spread throughout the catchment but are most concentrated in the Middle Clun.
- Sheep are most concentrated in the upper catchments (Upper Clun, Middle Clun, Folly Brook, River Unk).
- Fowl and poultry are restricted to the Lower Clun and Kemp – the density of animals in the Lower Clun is more than double that in the Kemp catchment.

21. The Clun catchment was a pilot catchment for the Catchment Sensitive Farming (CSF) initiative which started in 2005. CSF can provide a good route for delivery of advice to farmers on general diffuse pollution and capital grants to help with implementation, However, the CSF programme was not set up to specifically deliver reductions in agricultural phosphorus pollution in water bodies and as such is only so far estimated to have resulted in a small percentage reduction in in-river nutrient concentrations (Atkins, 2014).

Figure 2 *Water Framework Directive waterbodies within the River Clun catchment*



Legend:

- River Clun Catchment
- WFD River Water Bodies

WFD Water Body Catchments

- Clun - conf Folly Bk to conf R Unk
- Clun - conf R Unk to conf R Teme
- Clun - source to conf Folly Bk
- Folly Bk - source to conf R Clun
- Kemp - source to conf R Clun
- Redlake - source to conf R Clun
- Snakescroft Bk
- Unk - source to conf R Clun

Client:	Project:
Shropshire Council	River Clun SAC Mitigation Measures

Title: River Clun Catchment and WFD Water Bodies

Figure: 2 Drawing No: PC3212-RHD-ZZ-XX-DR-Z-0002

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	31/03/2022	GC	ID	A4	1:130,000

Co-ordinate system: British National Grid

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1.4 The need for mitigation

22. The Clun catchment has a long-term records of phosphate, nitrogen and suspended solids measured monthly at Leintwardine since 1995. As well as current WFD data, two key documents have been used to review water quality with respect to the Clun SAC:

- the Atkins (2014) Clun Nutrient Management Plan, and;
- the Natural England (2021) SAC water quality review.

23. Supplementary data reviewed includes an analysis of catchment population and STW permit limits.

24. Water quality conservation targets (Natural England, 2021) for the Clun SAC are set at 0.01mg/l for orthophosphate. This target must be met as an annual average, a 3-year rolling mean and as a growing season mean (Mar to Sept inclusive).

25. One of the key drivers of water quality monitoring in the Clun SAC is freshwater pearl mussel (FPM) habitat. This species lives buried or partly buried in coarse sand and fine gravel and requires clean, oligotrophic, fast-flowing and unpolluted water. The phosphate favourable condition target for FPM is expressed as mean annual Soluble Reactive Phosphorus (SRP) – The Environment Agency uses orthophosphate to estimate dissolved and soluble phosphate levels in rivers. Data covering the last three years (2018-2020 inclusive) is shown in **Figure 3**.

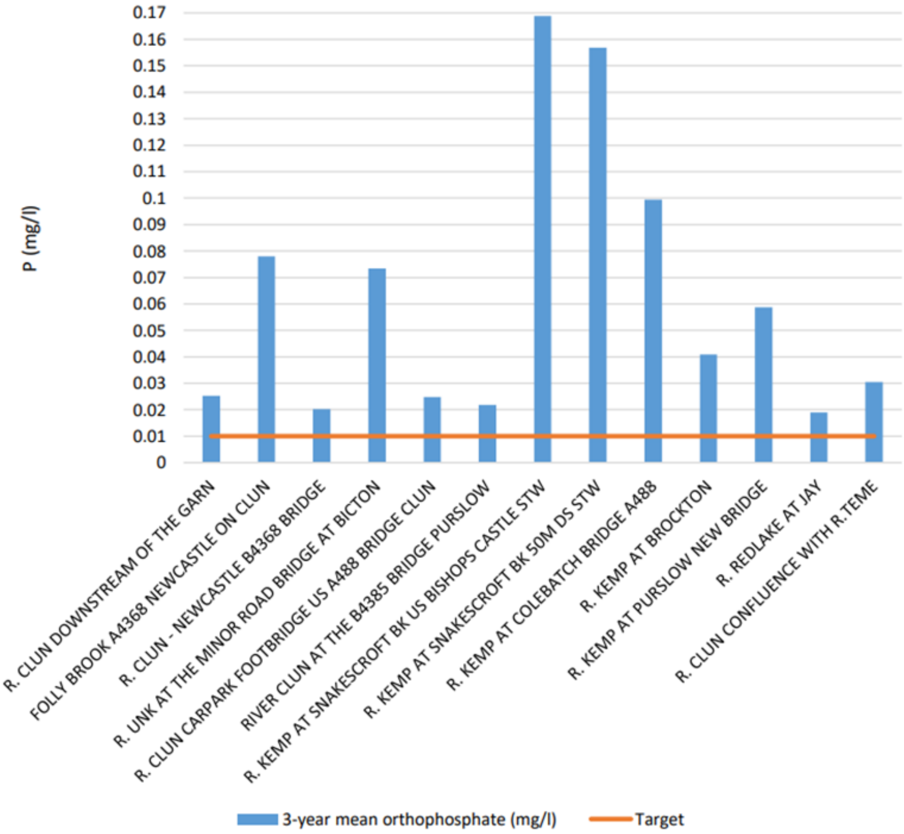


Figure 3: *Three year mean orthophosphate values throughout the River Clun Catchment (upstream to downstream) (Natural England, 2021)*

26. Key points identified through analysis of the Environment Agency's phosphate monitoring data include:

- Phosphate levels have declined as a result of AMP5 funded phosphate-stripping of the Bishops Castle STW (in 2007) and Bucknell STW (in 2010).
- Since 1990, application of fertilisers are reported to have declined by 67% on grassland and 51% on tillage land, while phosphate from manures is reported to have reduced by 20% between 1990 and 2012.
- Monitoring throughout the catchment shows a general downstream increase in mean annual phosphate levels. At locations downstream of Clun, phosphate levels were higher than those required for a functioning pearl mussel population. The highest concentrations were recorded in the River Kemp and in the Clun at Purslow.
- The latest 3-year mean orthophosphate (P) recorded within the SAC is 0.032mg/l, 320% of the site target of 0.01mg/l. Data suggests that the River Clun SAC is still far in excess of its nutrient targets, with little or no improvement since 2007 when a small reduction in phosphate occurred. Phosphate levels are consistently more than double the site target throughout the entire length of the River Clun (Natural England, 2021).

1.5 Purpose of this report

27. This report is intended to set out suitable mitigation options that can be used to offset the additional phosphorus load from a new development within the River Clun catchment. It will also assess potential strategic options to manage phosphorus inputs and allow further residential development to proceed. This report outlines the methodology used to identify potential solutions (**Section 2**) which are then evaluated in a long-list (**Section 3**) and subsequent short-list (**Section 4**). Housing projections are set out in **Section 5** and a summary and conclusions are provided in **Section 6.**

2 Methodology

28. A list of potential phosphate management solutions has been identified following a detailed review of literature and best-practice guidance. Other strategic approaches to Nutrient Management in rivers have also been consulted, including:

- River Avon Nutrient Management Plan;
- River Mease Developer Contribution Scheme;
- Advice on achieving Nutrient Neutrality for new development in the Solent Region;
- Advice on achieving Nutrient Neutrality for new development in the Stour Catchment;
- Herefordshire Council Interim Phosphate Delivery Plan Stage 2;
- Somerset Levels and Moors Phosphate Mitigation Solutions Report; and
- River Camel SAC Phosphate Mitigation Solutions Report.

29. This report outlines both short-term and long-term solutions that can be used to achieve phosphate mitigation. Typically, short term solutions cannot be achieved in perpetuity but can be used as an interim solution whilst larger, long term strategic solutions are being established. Natural England during consultation have acknowledged the importance of solution that can be delivered on a timescale of months as well as long term solutions. This report outlines solutions that can be used to achieve phosphate mitigation for the purpose of allowing planning applications to proceed. Some established solutions for phosphate management at a catchment scale do not provide the certainty that is required for mitigating new developments and were not assessed here. Examples include methods adopted by catchment sensitive farming such as farm audits / advice, tramline & wheeling disruption and controlled traffic movements. Solutions where there is the potential to comply with Natural England's HRA tests (detailed below) were assessed further

30. The solutions have been classified into the following two categories:

- Nature-based: solutions that would be implemented within a catchment to reduce diffuse- and point-source phosphate loadings, including wetland creation.
- Wastewater and drainage: solutions that apply to wastewater and drainage and will require targeted interventions (excluding nature-based and wetland solutions) or specific local policies to be implemented.

31. Each solution was assessed against the following criteria:

- Timescale for implementation;
- Timescale for duration of solution;
- Phosphate removal potential;
- Local / catchment constraints;
- Management / maintenance requirements;
- Additional benefits; and
- Indicative costs.

32. For a solution to be accepted by Natural England, as meeting the requirements of the Habitats Regulations, it will need to answer all of the following questions positively:

- Is the solution based on best available evidence?
- Is the solution effective beyond reasonable scientific doubt?
- Does it apply a precautionary approach?
- Can it be secured in perpetuity?

33. The solutions are given a time scale required for establishment / implementation. The time scales are defined as:

- Short term: immediate – 2/3 months;
- Medium term: months – 1 year; and
- Long term: >1 year.

34. The solutions are also given a timescale for the duration they are likely to be in place for. These timescales are defined as:

- Short term: immediate – 3 years;
- Medium term: 3 – 10 years; and
- Long term: 10+ years.

35. A mitigation scheme may utilise a combination of solutions to provide the required phosphate offsetting and ensure the mitigation is effective over the lifetime of the development. Natural England Guidance (2019) defines the lifetime of development as 80 – 125 years and suggests that mitigation should be maintained indefinitely thereafter. There may be some cases where there is uncertainty in proposed solutions, and until further investigation is carried out to determine their efficacy, suitable fallback options may be applicable.

36. Some solutions may only be suitable in the short term, which could be due to land take requirements or cost of delivering the solution. Whilst these solutions cannot deliver mitigation in perpetuity, where they have a short lead time, they can be used as a bridging solution until more permanent solutions can come online.

37. The potential implications of delivering phosphate mitigation on the financial viability of a development, and the potential for adverse effects on levels of affordable housing and contributions to health, education and highways should also be considered when assessing solutions.

3 Mitigation Options

38. A long list of solutions has been developed. These are presented in **Table 3-1**, along with a brief description and an indication of whether the solution was shortlisted for further assessment.

Table 3-1: *Long list of solutions*

Solution	Description	Shortlisted?	Reasoning
Nature-based solutions			
Taking land out of agricultural use	Involves the cessation of fertiliser and animal waste loading from agricultural land and replacing the land use with low P runoff values such as grassland, woodland or energy crops such as willow or *Miscanthus*. The River Clun catchment is dominated by land used for livestock farming.	Yes	Viable solution that can be utilised as a bridging solution.
Cessation of fertiliser / manure application	Farmers to cease application of fertiliser / manure as a short-term solution, whilst still farming the land to a lower yield. Short-term reduction in soluble phosphate runoff and longer-term reduction in particulate phosphate	Yes	Will require legal agreements and monitoring but offers a solution where farms can stay in use whilst delivering phosphate mitigation.
Farm-based measures	Conduct farm audits to encourage farmers to adopt measures to reduce phosphate runoff / inputs. Introduce measures to limit runoff from tramlines and control traffic movements.	No	Whilst this would deliver reduction in farm runoff, it does not provide the certainty required and could not be managed / monitored in perpetuity.
Silt traps	Installation of silt traps on agricultural land to remove particulate bound phosphate.	No	Prevention of soil erosion is a good practice measure that should already be in place so silt traps should not be required if good practice is being followed.
Beetle banks	Grass mounds constructed on agricultural land to control runoff. Can be planted across long or steep slopes or along natural drainage ways to minimise runoff and soil erosion.	No	Significant monitoring is likely to be required and there is a high level of uncertainty. There is also unlikely to be a high uptake amongst farmers because they need to be positioned in more productive areas in the centre of fields rather than in the margins.
Riparian buffer strips	Grass and woodland strips that separate an agricultural field/phosphate source from a watercourse.	Yes	Well established method for reducing pollution inputs to rivers.
Wet woodlands	Establish wet woodland areas along floodplains	Yes	Can remove significant amount of phosphate with little management / maintenance required.
Cover crops	Planting cover crops over the winter to avoid soil erosion and limit P runoff	Yes	Effective solution that will deliver phosphate reductions. However,

Solution	Description	Shortlisted?	Reasoning
			there is uncertainty in the phosphate removal values
Beaver introduction	Introducing beavers under a license to reduce phosphate loading. Beaver dams help to reduce flow of soil and nutrient from surrounding farmland into rivers.	No	Viable option but significant monitoring is likely to be required and phosphate reductions may not be deliverable in perpetuity. The solution also offers little certainty due to working with wild animals. Implementation would require third-party involvement. Sediment removal is likely to be required every 10-15 years and could adversely impact habitat.
Constructed wetland creation	Constructed wetlands to treat and filter water to remove pollutants through sediment fallout and plant uptake.	Yes	Frequently an effective solution for phosphate removal from watercourses. Dependant on relatively flat sites
WwTW additional treatment wetlands	Diverting WwTW effluent on to a constructed wetland for secondary treatment	Yes	Likely to achieve higher removal rates than wetlands located on rivers.
Wastewater and drainage solutions			
Use of bespoke (lower) bespoke housing residential s/dwelling rates	using densities values Restricting the number of people who can live in a new house instead of assuming that the national average occupancy rate (2.4 persons/dwelling) applies	No	Recent judgement suggests bespoke values would need to be used for all housing types and may not lead to a P reduction. Further, a bespoke value would be difficult to enforce. Further guidance is needed from Natural England.
Severn Trent Water Improvements	Increase the number of sites with P stripping infrastructure within the catchment, beyond that outlined in AMP cycle plans. Changes to Bishop's Castle treatment works to divert effluent from the Clun catchment.	Yes	Severn Trent Water have already delivered significant improvements to treatment works and are unlikely to deliver further improvements beyond those already identified in the AMP cycle up to 2025. However, Severn Trent Water are exploring an option to remove the effluent from the Bishop's Castle WwTW from the Clun catchment completely. This could deliver significant immediate phosphate reductions as well as ensuring future development utilising the Bishops Castle WwTW does not contribute phosphate either.
Willow buffer areas	Use willows to treat domestic and industrial wastewater.	Yes	Can be used as an alternative to septic tanks / package treatment plants
SuDS	SuDS are efficient sediment traps and reduce the amount of P entering main watercourses. e.g. basins, ponds, filter strips, swales, soakaways, infiltration	Yes	SuDS are likely to be an important solution. However, further guidance is needed from Natural England before this solution can be

Solution	Description	Shortlisted?	Reasoning
	basins, gravelled areas, porous paving and urban wetlands.		implemented throughout the catchment.
Reduce leakage from foul sewage system	Reduce the amount of sewer leaks; these have the potential to introduce raw sewage into the environment.	No	High uncertainty with values and measuring P offsetting.
Portable Treatment Works	Treatment works that can be moved within the catchment to provide additional treatment of wastewater.	Yes	Can be used at multiple locations within the catchment and represent a short-term solution
Alternative wastewater providers	Use of an alternative treatment works provider for large development sites	Yes	Viable option for larger developments
Setting restriction on water usage	Reducing water usage per person will reduce phosphate loading to WwTWs with P stripping.	Yes	Feasible option where there is a high degree of Local Authority control over water usage fittings / appliances (e.g. Local Authority housing or housing controlled by a Registered Provider).
Package treatment plants	Use of package treatment plants to treat wastewater and discharge to soil. These can be used in new developments as well as retrofitted.	Yes	Suitable solution in rural locations and for smaller scale development.
Cesspools	Use of cesspools to remove wastewater from the catchment	Yes	Technically feasible solution (providing conditions are met) but unsustainable and not cost effective.
Highway drainage improvements	Installing SuDS to high-risk (in phosphate terms) highway drainage discharge locations	Yes	Solution that will remove phosphate and is in the control of the Local Planning Authority.

4 Shortlisted Solutions

4.1 Nature-based solutions

39. Nature-based solutions include taking land out of agricultural use, placing silt traps and establishing riparian buffer zones. These solutions are typically short to medium term to implement and can be applied to the entire catchment. Nature-based solutions would need to be located appropriately upstream of Leintwardine to ensure that schemes remove phosphates from the main section of the River Clun SAC. This solution often involves working with farmers, and the ability to commit to medium - long term agreements to deliver mitigation schemes is a potential issue for many of the nature-based solutions.

4.1.1 Taking land out of agricultural use

40. Repeated applications of phosphorus fertilisers and animal waste to land results in the build-up of phosphorus in soil (commonly known as legacy P). Long-term field experiments have shown that a large proportion (> 70%) of the surplus phosphorus added via fertilisers remains in the soil, some in forms not readily available to crops (Pavinto *et al*., 2020). Long-term applications and accumulations of soil P is an inefficient use of dwindling P supplies and can result in nutrient runoff.

41. Taking land out of agricultural use involves the cessation of fertiliser application and animal waste in favour of semi-natural grassland, woodland or energy crops such as willow or *Miscanthus*. The latter produce much less phosphate than the previous agricultural activities. *Miscanthus* (a plant that resembles bamboo and has the additional advantage of being regularly cropped for biofuel) is also ideally suited to marginal land which otherwise provides little income. Soil erosion (which can lead to phosphorus mobilisation) is also likely to decrease with time as the soil is stabilised by a more continuous vegetation cover. The reversion of land currently in agricultural use to a more natural state will eventually reduce phosphorus leaching to natural background rates.

42. The time taken for soils to reduce to background phosphorus concentrations varies depending on soil types and the phosphate concentrations (Dodd *et al*., 2012). A study by McCollum (1991) indicated that soil concentration may not be reduced to background concentrations for at least 17 years, based on fine sandy loamy soils in arable production in the United States. The time taken to reach environmental targets purely by cessation of phosphorus fertiliser would be 26 – 55 years. This is consistent with Dodd *et al* (2012) which estimated that following cessation of phosphorus application to grassland, the time taken for surface runoff to reduce to acceptable levels is 23 – 44 years. Typically, soils with a greater initial phosphorus concentration decrease at a faster rate than those with a lower initial concentration.

43. Measures can be imposed which actively encourage phosphorus uptake and limit the impact of legacy phosphates. One proposed method is the uptake by vegetation: this also reduces the risk of soil erosion. Vegetation may include using the site for woodland, semi-natural grassland or energy crops. Other methods include blocking drains on drained land (or alternatively installing a field-wetland). Sharpley (2003) and Dodd *et al* (2014) suggested that

ploughing to reduce phosphorus stratification and redistribute and dilute enriched topsoil can decrease concentrations by half leading to reduced surface runoff losses.

44. Woodland planting is one mechanism of accelerating the transition to background phosphorus concentrations. Natural England suggest that woodland planting is a viable mitigation method that can be easily implemented. There is a minimum requirement for 20% canopy cover at maturity, which is equivalent to approximately 100 trees per hectare. Maintenance of woodland is easy to verify and well established. Woodland planting may be secured without land purchase (Natural England, 2020) and native tree species are the preferred choice. As there is a general lack of evidence on the reduction rates achieved through woodland planting, the level of phosphate reduction using the Phosphorus Budget Calculator (Royal HaskoningDHV, 2022) can be calculated by assuming a runoff coefficient of 0.02kg/ha/yr.

45. Energy crops such as *Miscanthus* are generally considered to have a higher soluble phosphorus uptake than woodland. There is also the potential to harvest the *Miscanthus* after 5 – 10 years and if sold as biofuel, to provide an income. However, this would have a lower biodiversity benefit and would be unable to receive as much income through potential monetised biodiversity schemes as more natural planting would.

46. Where grazing land is taken out of use, in order for there to be an actual reduction in phosphate loads, then livestock numbers would also need to be decreased. However, as it is assumed that farms typically operate close to optimal stocking densities this solution is best viewed as a short-term measure if livestock can be temporarily located outside of the catchment of the River Clun. Changes to grazing practices and stocking densities are more difficult to monitor and enforce in comparison to arable reversion to woodland or energy crops, and therefore provide a lower degree of certainty with regards to their effectiveness. By comparison, certainty regarding cessation of arable farming can be easily secured and verified using aerial imagery and site visits.

47. Farms should be operating according to best practice and phosphate removal calculations would be based on assumptions that this is the case. This is to ensure that potential pollution from agriculture is not traded to another sector, which would then discharge this load back in the catchment in the form of new housing. This will also ensure that phosphate mitigation schemes do not compromise the ability to either deliver long term WFD targets for phosphorus or restore the site to favourable conservation status.

48. In terms of changing land use on a farm, the phosphorus budget calculator (Royal HaskoningDHV, 2022) can be used to determine the phosphate mitigation achieved. Alternatively, Defra's Farmscoper Tool can be used to calculate phosphate reductions and the associated cost. Farmscoper was developed by the Agricultural Development and Advisory Service (ADAS) for Defra to enable the assessment of the cost and effect of one or more diffuse pollution mitigation methods at the farm scale. The tool estimates baseline emissions for a suite of different pollutants, predicts the mitigation potential against these pollutants and quantifies potential benefits for biodiversity. The tool can be set up to model most basic farm types by changing livestock numbers, crop areas, fertiliser rates, soil type and climate. In this way the effects of taking land out of production or changing land use can be assessed.

49. The average agricultural phosphorus runoff rate for the River Clun catchment is 0.31kg/ha/yr for freely draining soil and 1.72kg/ha/yr for impermeable soil, assuming an average rainfall between 900-1200mm/yr (**Table 4-1**). The catchment typically comprises lowland grazing farms on freely draining soils, with a phosphorous runoff rate of 0.19kg/ha/yr. The difference between the agricultural land runoff rate and the future runoff rate (which would be 0.02kg/ha/yr for reversion to woodland) is generally small. This means that a large amount of land would be required for woodland planting to offset development. However, there are some conditions where phosphate loading rates from agricultural land are higher, e.g., outdoor pig farming (**Table 4-1**) so the land take needed for woodland reversion would not be as significant.

Table 4-1: *Phosphorus runoff coefficients for agricultural land use (Derived from Farmscoper V.5)*

Land use	Runoff coefficient (kg-TP/ha/yr) (Assuming an average rainfall of 900-1200mm/yr)		
	Freely draining	Impermeable (Drained for Arable)	Impermeable (Drained for Arable & Grassland)
Dairy	0.26	0.54	1.85
Lowland grazing	0.19	0.35	1.42
Upland grazing	0.13	0.17	0.64
Mixed livestock	0.27	0.86	1.66
Outdoor pig	0.50	3.89	4.79
Roots and Combinable	0.34	1.80	1.92
Mixed combinable	0.32	1.73	1.80
Winter Combinable	0.38	1.91	2.03
Horticulture	0.25	1.24	1.39
Poultry	0.39	1.95	2.10
Indoor pigs	0.35	1.86	1.99
General Arable	0.32	1.67	1.79
Average	0.31	1.50	1.95

50. Farms considered for taking land out of agricultural use should preferably have the highest current phosphorus runoff rates in order to maximise phosphate removal and reduce land take requirements. This typically includes farms with higher average annual rainfall and those on impermeable soil.

51. Due to the significant land take that would be required to take agricultural land out of use, it is unlikely that this would provide anything more than a short-term solution to bridge the gap until more efficient and effective longer-term solutions can be developed. There is the potential for land to be leased for short term solutions without the need for purchase. Management agreements are likely to be needed to ensure the land remains out of agricultural use.

52. As taking land out of agricultural production is a well-established and relatively simple method to put in place and also one that could be implemented by Local Authorities, third parties and private developers there is therefore the potential for over-reliance on this as a short/medium term solution. Furthermore, there is the potential for long term inflated agricultural land prices if land is taken out of agricultural practice for more than 1-2 years (i.e. it is used as a long-term mitigation solution). This could be further exacerbated when coupled with the impact of mandatory biodiversity net gain which is due to commence in November 2023 and which is also likely to require taking land out of agricultural production. Therefore, it is important that other short-term solutions are identified, and clear guidance is given so that they can be easily implemented in order to minimise short-term inflation of land prices. Lastly, a consideration of in-combination effects needs to be given by all parties who would be implementing offsetting schemes.

4.1.1.1 Rental costs

53. There are two main types of agricultural tenancies:

- Full agricultural tenancies, which are subject to the Agricultural Holdings Act 1986; and
- Farm business tenancies, which are subject to the Agricultural Tenancies Act 1995.

54. Most tenancy agreements made after 1 September 1995 are subject to the Agricultural Tenancies Act 1995 and are commonly known as Farm Business Tenancies (FBT). **Table 4-2** presents the rental rates for farming types across England for 2018, 2019 and 2020 (the latest data available at the time of writing). Note that there is a degree of fluctuation in prices between the different years.

Table 4-2: *FBT rental rates (£/ha) for farming types in England (Source: Defra, 2022)*

Farm Type	Rental price (£/ha)		
	2018	2019	2020
Cereal	279	263	261
General cropping	329	298	367
Dairy	255	271	283
LFA Grazing livestock	71	79	81
Lowland grazing	190	128	166
All Farms	231	222	239

55. The average FBT rental price in the West Midlands during 2020 was £270/ha (**Table 4-3**).

Table 4-3: *Rental rates (£/ha) for FBT farms in the West Midlands (Source: Defra, 2022)*

Farm Type	Rental price (£/ha)		
	2018	2019	2020
West Midlands FBT	250	255	270

4.1.1.2 Purchase costs

56. The average value of land in the West Midlands was estimated to be £17.5k/ha in 2020 (Savills, 2021).

4.1.1.3 Capital and maintenance costs

57. Other capital costs associated with woodland planting, grass conversion and planting of energy crops may result in a short-term negative cash flow. Maintenance costs (e.g. harvesting, cutting) associated with energy crops are expected to be minimal and offset by sale of products.

4.1.1.4 Taking agricultural land out of use

58. **Table 4-4** presents a worked example of the mitigation achieved and equivalent housing for taking land out of agricultural use. This assumes that land is taken out of a mixed livestock, lowland grazing or arable use, on freely draining soil with an average annual rainfall between 900-1200mm/yr, and put into woodland / energy crop use. The findings indicate that farms in arable use can deliver more mitigation per hectare than farms in grazing use.

Table 4-4: *Phosphate mitigation and cost estimation for taking various agricultural land out of use.*

Farm Type	Area (ha)	Mitigation (kg/yr)	Cost estimation (£)	£/kg/yr	Housing equivalent (1mg/l)	£/dwelling
	1	0.25	17,500		3	
Mixed livestock grazing	5	1.25	87,500	70,000	15	5,833
	10	2.50	175,000		30	
	1	0.17	17,500		2	
Lowland grazing	5	0.85	87,500	103,000	10	8,750
	10	1.70	175,000		20	
	1	0.30	17,500		4	
General Arable	5	1.51	87,500	57,850	20	4,375
	10	3.03	175,000		40	

59. **Table 4-5** presents a range of considerations when taking land out of agricultural use for phosphate offsetting.

Table 4-5: *Taking land out of agricultural use key considerations*

Key considerations	
Delivery Timescale	Short-term
Duration timescales	Energy crops: Short-term Semi-natural grassland: Short-term Woodland: Medium to long-term

Key considerations	
P removal potential	Average banking opportunity of 0.29kg/ha/yr for freely draining soil and 1.70kg/ha/yr for impermeable soil.
Farm Typologies applicable	Unlikely to be applicable to indoor pig or poultry farms
Management / Maintenance requirements	• For *Miscanthus* growing – no fertiliser needs to be added until it is established and less needs to be applied than most farming practises. • Harvesting needs to be completed every 2-4 years. • Energy Crop Schemes are available. • Protection from animals and weed clearance will be required during establishment
Additional benefits	Reduced Nitrate loading.
Based on best available evidence?	Yes – Although some doubt may remain over legacy phosphates and may require further research or monitoring to gain a better understanding.
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes - Plantations may need to prove they can be in place for the lifetime of the development otherwise a fallback option will be needed
Cost estimation	• Initial start-up costs: £1500-£1700. • The average FBT rental price in the West Midlands in 2020 was £270/ha. Energy crop: • Harvesting costs: £170/ha. • An estimated range of net profits from *Miscanthus* grown for biofuel are £183-£211/ha per annum (minus haulage).[2] • As a long-lived plant, sustainable over 15-20 years of annual harvests, *Miscanthus* may bring in an annual profit without yearly establishment costs. • The average FBT rental price in the West Midlands in 2020 was £270/ha.

4.1.2 Cessation of fertiliser and manure application

60. Where full land abandonment is not available, a change of farming practices or cessation of fertiliser application may be applicable. Stopping fertiliser or manure will have an immediate short -erm impact by reducing the amount of soluble phosphate runoff that is usually lost following application, particularly during rainfall events. There will also be a longer-term impact on particulate phosphate loss should if implemented for consecutive years due to a reduction in soil phosphate reserves. Particulate forms of phosphorus are typically lost through soil erosion when phosphorus is bound to soil.

61. In a study of long-term (45 years) land use, cropping without fertilisation reduced legacy phosphorus significantly (Zhang *et al*., 2020). This was also confirmed in Zhang *et al* (2020) where after 11 years of cultivation, in which the yield and phosphorus uptake by maize-soybean crops was not affected by withdrawal of phosphate fertiliser down to the critical level, legacy phosphorus was significantly reduced. The study also found that reliance on legacy phosphorus improved farmers' economic margins and reduced the soil test phosphorus levels

[2] *Farming Connect (https://businesswales.gov.wales/farmingconnect/news-and-events/technical-articles/miscanthus-alternative-crop-welsh-farmers)*

to safe levels for surrounding catchments. Legacy phosphorus does serve as a potential source for crop use and could potentially decrease the dependence on external fertilisers. Cessation of fertiliser allows land to still be farmed whilst also providing phosphate reductions, with the loss of productivity from the lack of fertilisation balanced by income from phosphate mitigation. This could be secured as a short-term bridging solution. Legal agreements, e.g. Section 106 agreements, to cease fertiliser application for a set area and duration would be required and spot checks undertaken to monitor farming practices and phosphate concentrations in runoff. Monitoring would be required to ensure that estimated phosphate removal rates are being achieved and to validate that fertiliser / manure application has ceased. This is likely to comprise 3-4 visits per year, including an initial round of sampling to establish the baseline conditions. One round of sampling will be required in Spring following the usual period for fertiliser application.

62. This solution would be best implemented on farms in arable use but could also be extended to farms with grazing and mixed livestock. This method would have a significant negative impact on crop yields, with the greatest impact on responsive crops such as potatoes and some vegetables. This may increase the cost of this solution for these farming types.

63. Soluble phosphorus runoff reductions from the cessation of 100% of fertiliser application is estimated to be 50% (Newell Price *et al*., 2011). Soluble phosphorus constitutes the main proportion of the Total Phosphorus losses (Ekstrand *et al.,* 2010). Long-term studies in Sweden indicate that soluble phosphorus generally accounts for more than 80% of Total Phosphorus for sandy or loamy soils, which is the dominant soil type within the Clun catchment. This value drops to 60-70% for silty and clayey soils (Djodjic *et al*., 2004). In terms of land use types, White and Hammond (2009) found that soluble phosphorus accounts for 60% of the total phosphorus loss from improved grassland. However, on arable land particulate forms of phosphorus typically have more of an influence than on grassland areas, due to the lack of dense vegetation preventing particulate loss. Neal *et al*. (2010) studied the relationship between soluble and particulate phosphorus in nine major UK rivers and found that soluble phosphorus in agricultural and rural settings made up 50% of the Total Phosphorus. As such, taking a precautionary approach, and using the figures from the report it can be assumed that soluble phosphorus makes up 60% of Total Phosphorus for grassland and 50% for arable farms in the Clun catchment. Therefore, the total phosphorus removal values for cessation of fertiliser and manure application for grassland and arable farms is assumed to be 30% and 25%, respectively for the Clun catchment.

64. The phosphate removal that can be achieved for each farming typology in presented in **Table 4-6**. The average phosphate removal for the catchment is between 0.09kg/ha/yr and 0.55kg/ha/yr.

Table 4-6: *Phosphate removal from the temporary cessation of fertiliser and manure application*

Farm type	Phosphate removal from cessation of fertiliser / manure application (kg/ha/yr)		
	Freely draining	Impermeable (Drained for Arable)	Impermeable (Drained for Arable & Grassland)
Dairy	0.08	0.16	0.56

Farm type	Phosphate removal from cessation of fertiliser / manure application (kg/ha/yr)		
	Freely draining	Impermeable (Drained for Arable)	Impermeable (Drained for Arable & Grassland)
Lowland grazing	0.06	0.11	0.43
Upland grazing	0.04	0.05	0.19
Mixed livestock	0.08	0.26	0.50
Outdoor pig	0.15	1.17	1.44
Roots and Combinable	0.09	0.45	0.48
Mixed combinable	0.08	0.43	0.45
Winter Combinable	0.10	0.48	0.51
Horticulture	0.06	0.31	0.35
Poultry	0.12	0.59	0.63
Indoor pigs	0.11	0.56	0.60
Arable	0.08	0.42	0.45
Average	0.09	0.41	0.55

65. **Table 4-7** outlines the likely costs associated with this solution, both for arable and grassland farming. Cessation of fertiliser application to arable land is estimated to have a 50% reduction in yield on the affected area. Similarly, cessation to grassland is assumed to have a reduction of 30% to an average yield of 8t/ha (Newell Price *et al.,* 2011). The actual costs per farm are likely to differ due to the variety of variables, such as fertilisation rates, soil types, crop types, etc.

Table 4-7: *Cessation of fertiliser / manure cost estimation*

Description	Cost (£/ha/yr)	
	Arable	Grassland
Saving in fertiliser	-100.82	-35.96
Reduced use of fertiliser spreaders	-6.65	-6.65
Reduced yield / Forage replacement	781.86	311.12
Soil testing	600	600
Total	1,274.39	868.51

66. A 10ha arable farm on freely draining soil could deliver approximately 0.8kg-TP/yr of mitigation, which is equivalent to 9 dwellings draining to a treatment works with a permit level of 1mg-TP/l. Assuming the costs outlined in **Table 4-7**, this would be equivalent to £15,950 per kg-TP/yr mitigation for every year the solution is used or £1,415 per dwelling for every year the solution is used.

67. A 10ha grassland farm on freely draining soil in mixed livestock use could deliver approximately 0.6kg-TP/yr of mitigation, which is equivalent to 7 new dwellings draining to a treatment works with a permit level of 1mg-TP/l. Assuming the costs outlined in **Table 4-7**, this would be equivalent to £14,475 per kg-TP/yr mitigation for every year the solution is used or £1,240 per dwelling for every year the solution is used.

68. **Table 4-8** presents a range of considerations for cessation of fertiliser / manure application for phosphate offsetting.

Table 4-8: *Cessation of fertiliser and manure application key considerations*

Key considerations	
Delivery Timescale	Short-term
Duration timescales	Short-term
P removal potential	Average 0.09kg/ha/yr – 0.55kg/ha/yr
Farm Typologies applicable	Arable and Grassland
Management / Maintenance requirements	None
Additional benefits	Nitrogen reduction
Based on best available evidence?	Yes – monitoring likely to be needed to confirm
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	No – likely to be utilised as a bridging solution
Cost estimation	• Arable: £1,274.39 ha/yr • Grassland: £868.51 ha/yr

4.1.3 Riparian buffer strips

69. Riparian buffers are strips of land (minimum 5m wide) composed of permanent grass and/or woodland cover that act as a separation between the agricultural field and a watercourse. They can also act as a filter between point sources of phosphates and rivers. Phosphorus reductions are achieved through sedimentation of phosphate bound particles and uptake via vegetation. Vegetation within buffer strips decreases surface runoff and reduces runoff rates, which in turn promotes infiltration (Hoffman *et al*., 2009) and leads to reduced phosphate loading to watercourses.

70. Riparian buffer strips are typically located at field margins and are, therefore, more likely to be adopted by farmers. **Table 4-9** shows a summary of recent published research on phosphorus removal using buffer strips. Buffer strips composed of woody material as opposed to herbaceous material can store significant amounts of biomass phosphorus (Fortier *et al*., 2015), whilst woody buffers are more effective at trapping sediment than grasses (Hoffmann *et al*., 2009, Anguiar *et al*., 2015). Woodland buffers, particularly those containing willow, also have less onerous maintenance requirements than grassland buffers. The phosphorus removal rate is greatest within the first few metres of the buffer strip, furthest away from the

river. However, the highest total removal rates are typically only achieved in buffer strips 15m to 20m wide. Vought *et al.* (1994) found that in grass buffer strips the phosphorus removal in the first eight metres was 66%, and by 16m, 95% removal was achieved. To obtain maximum nutrient retention a buffer width of 10m to 20m is needed comprised of dense vegetation (Vought *et al*., 1994).

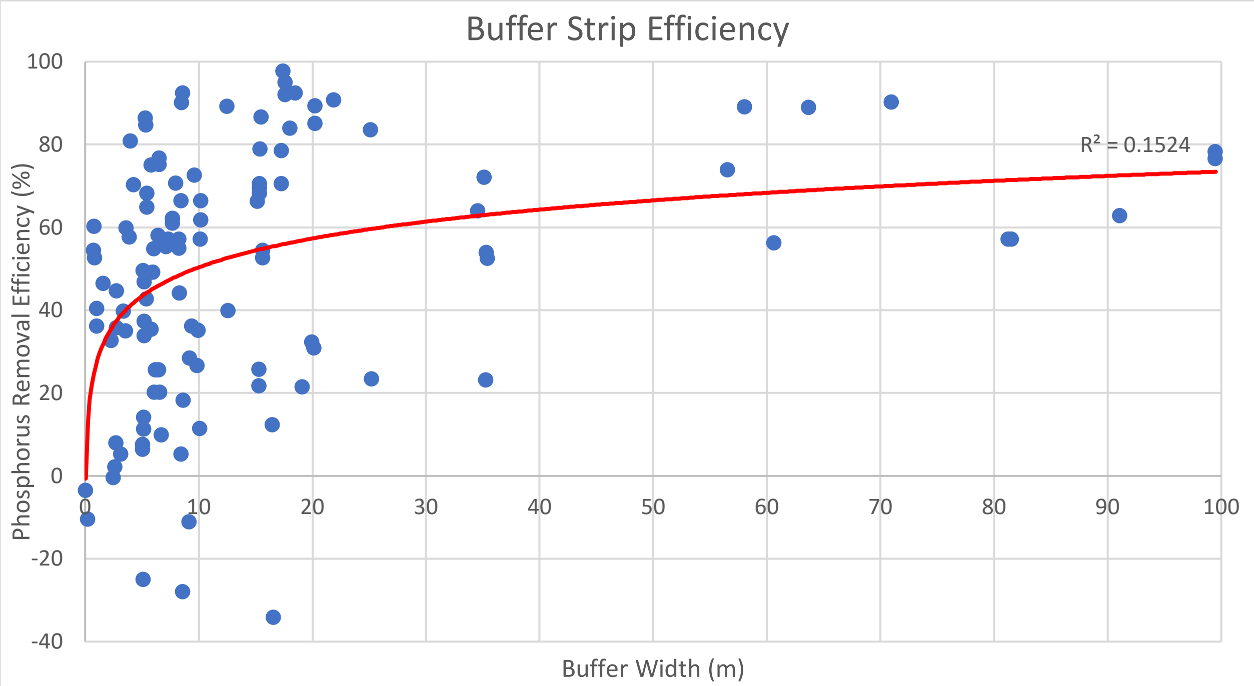
71. **Table 4-9** outlines the phosphorus removal efficiency achieved by riparian buffer strips depending on their major soil types and width (Zabronsky, 2016) . The major soil type does not appear to have a strong control over removal efficiency.

Table 4-9: *Riparian buffer effectiveness depending on buffer width and soil type (edited from Zabronsky (2016))*

Study	Vegetation Cover	Buffer Width	Phosphorus removal efficiency (%)	Major Soil Type
Chaubey *et al*., 1995	Grass	3.1	39.6	Silt
	Grass	6.1	58.4	Silt
	Grass	9.2	74.0	Silt
	Grass	15.2	86.8	Silt
	Grass	21.4	91.2	Silt
Meals, 1996	Grass	Unknown	86	Clay
Lee *et al*., 1998	Grass	3	39.5	Loam
	Grass	3	35.2	Loam
	Grass	6	55.2	Loam
	Grass	6	49.4	Loam
Lim *et al*., 1998	Grass	6.1	76.1	Silt
	Grass	12.2	90.1	Silt
	Grass	18.3	93.6	Silt
Lee *et al*., 2000	Grass / woodland	16.3	81	n/a
Patty *et al*., 1997	Grass	18	90	Silt
Peterjohn & Correll, 1984	Woodland	19	74	n/a
	Woodland	50	85	n/a
Vought *et al*., 1994	Grass	8	66	n/a
	Grass	16	95	n/a
Dillaha *et al*., 1989	Grass	4.6	61	n/a
	Grass	9.1	79	n/a

72. **Figure 4** Presents the findings from a study by Tsai *et al*. (2016) which reviewed phosphorus retention in riparian buffers of either grass and/or woodland. The data confirms that removal efficiency increases with buffer width and that buffer widths of 15m to 20m are most favourable. Beyond 20m the removal efficiency does not dramatically increase, and wider strips are less viable due to the amount of agricultural land take required.

Figure 4: *Buffer Strip Efficiency (Edited from Tsai et al. 2016)*



73. Site-specific factors also play a role in controlling the phosphate reduction of riparian buffer strips and should be taken into account when considering the most appropriate location for buffer strip placement. For example, the orientation of the buffers and the adjacent agricultural activity are important considerations. Typically, riparian buffers adjacent to agricultural land used for cropping will achieve the greatest real-world phosphate reduction rates due to the potential to remove a high degree of phosphate bound to sediment in the runoff.

74. Key risks associated with riparian buffer strips include the following:

- Where buffer strips are used as a long-term, in perpetuity solution, the long-term management of the adjacent fields presents a risk. Should the adjacent land be taken out of agricultural use or significant changes in agricultural practices occur (e.g. conversion to solar or wind farm) this could reduce the phosphate sources and subsequent total phosphorous removal figures.
- Improper upkeep of buffer strip vegetation, fencing and silt could reduce the total phosphorous removal figures.
- Should overland flow not be maintained, and flow becomes channelised, the buffer strip will not operate at optimum removal rates.

- Farmers may be unwilling to commit to 80 year agreements initially. Therefore, shorter agreements (e.g. 20 - 30 years) may be necessary to establish this solution, with the ability to renew agreements factored in.

75. Key considerations are summarised in **Table 4-10**. Riparian buffer zones need continued maintenance to ensure they achieve the desired phosphate removal rates – maintenance is mainly limited to cutting vegetation and removal of accumulated sediment. This is an important process to prevent the area from becoming a nutrient source rather than a sink. Monitoring of management practises and water quality may be required after establishment to ensure continued functionality. Riparian buffer strips could be implemented as both a short-term bridging solution and as a longer-term solution. Typical costs are shown in **Table 4-11**.

***Table 4-10:** Riparian buffer strips key considerations*

Key considerations	
Delivery Timescale	Medium-term
Duration timescales	Medium / long-term
P removal potential	Median TP retention rates for woody vegetation of 67% (Hoffmann *et al.*, 2009).
Farm Typologies applicable	All applicable
Management / Maintenance requirements	Cutting/vegetation removal
Additional benefits	• Stabilised river banks. • Water quality. • Reduced erosion. • Habitat creation. • Improved amenity value. • Carbon offsetting.
Based on best available evidence?	Yes
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes – management agreements may be needed where the solution is intended to provide a medium / long term solution to ensure it does not revert back to agricultural use and is maintained correctly.
Cost estimation[3]	Typical costs are £440 - £512 ha/yr based on annual Countryside Stewardship Grants that are available.

***Table 4-11:** Summary buffer strip costs*

Measure	Cost
Arable field margins (seed cost only)	Annual cost: £7.50 per 100m
Buffer strip vegetation planting	Capital cost: £3/m for 20m wide field margin
Buffer strip maintenance	Annual cost: £5/100m for 20m wide strip grass maintenance

[3] *Environment Agency. 2015. Cost estimation for land use and run-off – summary of evidence (Report –SC080039/R12). (https://assets.publishing.service.gov.uk/media/6034eefdd3bf7f264e517436/Cost_estimation_for_land_use_and_run-off.pdf)*

Measure	Cost
Fencing	£1/m fencing
Provide alternative drinking spots	Capital cost: £400 per stabilised drinking area

76. Where riparian buffer strips are already present within the catchment, through stewardship and environmental land management schemes[4], phosphorus 'credits' cannot be achieved as this is likely to represent double counting. However, buffer strips under stewardship and environmental land management schemes are typically up to 10m in width whereas the optimum width for buffer strips for phosphate mitigation are 15-20m. Therefore, riparian buffers for land management schemes could run adjacent to those for phosphate mitigation. Riparian buffer strip grants are available under Mid-tier and Higher tier Countryside Stewardship Schemes. These grants have a typical term of 5 years, after which point new grants can be applied for. From 2024 the Environment Land Management (ELMS) scheme will be in place. At the end of agreements, existing riparian buffers could be improved and extended for phosphate mitigation instead of payment schemes. This would reduce the need for significant areas of new riparian buffer strips.

77. Riparian buffer strips also have the added benefit of stabilising riverbanks and reducing erosion. This is achieved by dissipating energy in river flows and through stabilisation of soils by roots (Cole *et al*., 2020). This will also lead to a reduction in particulate bound phosphate entering rivers, although quantification of the reduction is difficult to predict. Buffer strips also provide habitats for wildlife.

78. **Table 4-12** outlines the rates received by farmers under the current Countryside Stewardship Grants.

***Table 4-12**: Annual Countryside Stewardship grants for riparian Buffer Strips*

Option	Description	£/ha/yr	£/ha/80yr
SW11 Riparian Management Strip	Riparian buffer up to 12m in width. Prohibits application of fertiliser and pesticides. Erection of permanent fencing to exclude livestock	440	35,200
SW4 12 to 24m buffer on cultivated land	12 to 24m buffer strip excluding vehicles or stock and prohibiting fertiliser and pesticides.	512	40,960

79. Receiving funding for riparian buffer strips from phosphate mitigation can be stacked alongside other schemes, such as biodiversity net gain, carbon offsetting and woodland planting schemes. It is not possible to receive further funding where Countryside Stewardship agreements or ELMS are in place. Stacking of different schemes is likely to reduce the cost of phosphate mitigation substantially, however, for the purposes of this assessment, it was assumed that phosphate neutrality compensation would be paid at the same rate as existing Countryside Stewardship agreement rates.

[4] https://www.gov.uk/government/publications/environmental-land-management-schemes-overview

80. It is estimated that that this solution could deliver phosphate reductions close to 3.5kg/ha/yr, based on a 20m wide buffer strip planted with a combination of grass and woodland. There are opportunities for riparian buffer strips (**Appendix A**) throughout the Clun catchment which could deliver significant phosphate mitigation. A 2.5ha buffer strip, located in an appropriate location, could deliver approximately 8.75kg/yr of mitigation, which is equivalent to 102 new dwellings draining to a treatment works of 1mg/l. Assuming riparian buffers are paid at the same rate of current Countryside Stewardship grants, this would result in a total cost of £102,400 over 80 years, equivalent to £11,700 per kg/yr mitigation or one off cost of £1,000 per dwelling.

4.1.4 Wet woodlands

81. Wet (floodplain) woodlands occur on soils that are permanently or seasonally wet, either because of flooding, or because of the landforms and soil type. They are found on river floodplains, in peaty hollows and at the margins of fens, bogs and mires (Woodland Trust, 2022). Phosphate removal strategies utilising wet woodlands involve working with either existing floodplain woodland or creating new areas of planting (**Figure 5**). Natural flood management (NFM) interventions can also be used to divert water out of the channel and into the floodplain wetland (**Figure 6**) to enhance sediment and pollutant deposition. The role of wet woodlands in water quality management is to increase hydraulic roughness, which slows flow velocities and allows sediment and particulate bound pollutants to fall out of suspension and enter storage on the floodplain, or in a designed wetland setting (Cooper *et al*., 2021).

82. Similar gains (for managing diffuse pollution and flood risk) can be expected from extending fingers of riparian woodland into upstream source areas and intermittent flow/run-off pathways, although limited data is available to quantify impacts at a catchment scale (Nisbett *et al*., 2011).

83. Wet woodlands are closely related to riparian buffer strips but are typically more permanently or seasonally wet and are only found in floodplains. Similarly, taking agricultural land out of use for woodland creation can be undertaken anywhere in the catchment whereas wet woodlands are confined to floodplains and comprises tree species which are best suited to boggy grounds.

4.1.4.1 Tree species

84. In the UK, the most suitable trees for creating wet woodlands are native species best suited to boggy ground. For the main canopy this includes alder (*Alnus glutinosa*), crack willow (*Salix fragilis*), white willow (*Salix alba*), and downy birch (*Betula pubescens*). Understory species may typically include grey willow (*Salix cinerea*), osier (*Salix viminalis*) and a range of grasses (e.g., purple moor grass (*Molinia caerulea*)) (Woodland Trust, 2022). However, it is uncertain how these species cycle and potentially uptake floodplain phosphates.

Figure 5: Area of wet woodland created in Salford in 2016. The project led to the attenuation of pollutants by biodegradation (Natural Course, 2017).

***Figure 6:** Traditional NFM structures, such as leaky barriers, can be used to enhance channel-floodplain connectivity to encourage pollutant deposition.*

4.1.4.2 Removal rates

85. Data on phosphate removal rates in wet woodlands are scarce. Olde Venterink (2006) analysed various floodplain communities in terms of their relative abilities to influence water quality through nutrient retention and denitrification. The results showed that productivity and nutrient uptake were high in reedbeds, intermediate in agricultural grasslands, ponds and semi-natural grasslands, and very low in woodlands (only understorey). Furthermore, conversion of agricultural land into ponds or reedbeds will probably be more beneficial for downstream water quality (lower P-concentrations) than conversion into woodlands or semi-natural grasslands. Note that this study refers to woodland, not wet woodland, so comparisons are uncertain and do not necessarily reflect UK soils or climate. This study does not consider more effective sediment trapping in wet woodlands and associated standing water. Removal rates for these may have some similarities to riparian buffer strips.

4.1.4.3 Additional benefits

86. Wet woodland creation, or expansion of existing riparian woodland, has several co-benefits, such as: carbon sequestration, watershed regulation, biodiversity conservation, landscape and amenity, air pollution reduction and reduced flood risk (Nisbett *et al*., 2011). One of the major potential benefits of using wet woodland to improve water quality is the opportunity to supplement farm income by utilising short rotation coppice for biofuel (Mackenzie and McIlwraith, 2013).

4.1.4.4 Costs

87. Bare root stock suitable for tree planting programmes for typical wetland species are in the range of £2-3 per tree. Typically, bulk orders from suppliers reduce these unit costs to less than £1. Bulk order tree guards are a similar price. For broadleaved trees, planting density is recommended at 1,600 to 2,500 trees per hectare respectively (Creating Tomorrow's Forests, 2021). However, these figures are for general woodland creation, not floodplain wet woodland where additional space may be needed for wetland landscaping (e.g., pools and scrapes). Typical planting costs (trees + guard) may be ~£5,000 per ha. Grants of up to £10,000 per ha could be available through the government's England Woodland Creation Offer (Gov.uk, 2022) and phosphate mitigation credits may need to match this figure.

4.1.4.5 Management

88. Wet woodlands by their nature thrive on non-intervention and limited to no management. Light management includes:

- Coppicing some areas to create a more diverse woodland structure with some clearings;
- Allowing woodland edges to grade upwards from grass, through scrub, to woodland;
- Coppicing to provide wood fuel;
- Managing areas of willow and scrub to maintain some open areas and wet scrub; and
- Controlling invasive species (e.g., Himalayan balsam *Impatiens glandulifera*).

89. **Table 4-13** presents a range of considerations for using wet woodlands for phosphate offsetting.

Table 4-13: *Wet woodlands key considerations*

Key considerations	
Delivery Timescale	Medium-term
Duration timescales	Medium / long-term
P removal potential	Uncertain
Farm Typologies applicable	Riparian land holdings (withing FZ3)
Management / Maintenance requirements	Minimal – some coppicing to encourage understory growth; removal on invasive species (e.g., Himalayan balsam)
Additional benefits	• Recreation • Carbon sequestration • Biodiversity conservation • Air pollution reduction

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Key considerations	
	• Flood risk reduction • Biofuel
Based on best available evidence?	No – there is doubt over removal rates (lack of research and data)
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes – land suited to wet woodland is very unlikely to revert to any other land use
Cost estimation	Cost of trees and guards. In the region of £5,000 per ha. A typical leaky dam to enhance floodplain connectivity is £50-£100 depending on design and materials

4.1.5 Cover crops

90. Surface runoff and soil erosion represents the principal mechanism for phosphorus loss from many agricultural systems. The risk of runoff is primarily controlled by timing, rate and method or fertiliser or manure application, as well as post-application rainfall. Natural factors such as slope, surface roughness, infiltration capacity and magnitude of erosion also have a strong control. Bare soils are very prone to erosion and cover crops help maintain soil cover during the autumn and winter. They are especially useful to mitigate erosion on high risk sloping land typically found in upland areas. Cover crops act to encourage infiltration and reduce overland flow velocity. They are best employed where land would otherwise be left bare during the crop rotation process. They are typically used either prior to main production cycle (e.g. potatoes, sugar beet) or post-harvest (e.g. cereals).

91. Phosphorus reduction rates are variable within the literature. Some studies suggest significant phosphorus removal can be achieved, such a study by Novotny and Olem (1994) which suggested phosphorus removal of 30-50% and Sharpley and Smith (1991) which found an average reduction of 77% from four different studies. However, other investigation concluded that phosphorus removal was not significant (e.g. Kleinman *et al*, 2005). Cover crops also provide winter cover and habitat for birds, mammals and insects.

92. Maintenance costs associated with cover crops include seeds costs, preparation, planting, destruction and cultivating. Cover crops are not harvested for cash like other crops are.

93. Validation of cover crops can be achieved through satellite imagery, photographs and drive by visits. Due to the uncertainty in removal values, monitoring may be required to establish the baseline and identify actual phosphate reduction.

94. **Table 4-14** presents a range of considerations for using cover crops for phosphate offsetting.

Table 4-14: *Cover crops key considerations*

Key considerations	
Delivery Timescale	Short-term
Duration timescales	Short-term

Key considerations	
P removal potential	Large uncertainty
Farm Typologies applicable	Arable farms (particularly cereals)
Management / Maintenance requirements	Time and money costs associated with preparation, planting, destruction and cultivation.
Additional benefits	Water quality; habitat creation
Based on best available evidence?	No – Phosphate reductions estimates highly variable
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes – management agreements will likely need to be put in place, especially where land in leased.
Cost estimation	Maintenance costs: £150/ha/yr (AHDB, 2020) Monitoring costs: £450-600/ha/yr

4.1.6 Constructed wetland creation

95. Wetland creation is the best-established method for natural pollution reduction, including phosphate reduction (**Table 4-15**). There are numerous published nutrient removal rates for constructed wetlands. Luederitz *et al.* (2001) reviewed a variety of wetland types in different countries and found typical removal rates for total P are 40% to 60%, depending on wetland type and inflow loading. Similarly, Land *et al.* (2016) reviewed studies on a large number of wetlands and found that medium phosphorous removal rates of 12 kg/ha/yr were achieved. It was found that median removal efficiency was 46%, with a 95% confidence interval of 37% - 55%.

96. Constructed wetlands represent a medium to long term solution due to timescales associated with planning and consent, and the time it takes for the wetland to establish and become effective at phosphate removal. Wetland can be constructed in catchments where flow is taken from rivers for filtration prior to returning to the river. Alternatively, wetlands can be designed to take effluent from sewage treatment works prior to discharge to watercourses (see section 4.2.2). The phosphate reduction potential is greater than other solutions but can vary as it is dependent on factors such as wetland size, flow velocity, retention times, vegetation type, input concentrations, depth, aspect ratio and sediment removal potential (Land *et al.*, 2016). Therefore, a bespoke value should be predicted for each site and confirmed via monitoring which is likely to be required for 1-2 years. Phosphate removal is achieved through fall out of particulate P bound to sediment and plant uptake of bioavailable P.

97. Wetlands typically require relatively level land in close proximity to watercourses. Where there a site slopes significantly, then substantial reprofiling would be required which could make the wetland economically unviable. Similarly, wetlands should be fed via gravity to avoid cost implications from pumping. Where rivers are significantly incised, this can present an obstacle to wetland creation. Large parts of the western Clun catchment show significant elevation and

are likely to be unsuitable for wetland creation. Wetland construction would therefore need to be concentrated in the eastern areas of the catchment.

98. Wetlands require periodic maintenance to remove sediment build up (approximately every 5 – 10 years) and to replace vegetation to ensure they do not switch from a nutrient sink to a source. It is important to remove plants before they die and decompose to prevent phosphates from being re-released. Wetlands are subject to cycles of uptake and release and monitoring may be required to understand how the maintenance regime can achieve optimal phosphate removal (Land *et al.*, 2016). Monitoring is likely to be required for a period of 2/3 years at fortnightly intervals in order to provide enough data to account for seasonal variations. Management agreements will need to be put in place to ensure the wetland will operate at the intended rate. Natural England have advised that periodic monitoring may also be required throughout the lifetime of the wetland. However, this should assess the removal percentage (%) rather than the removal rate (kg TP/ha/yr) which could decrease in the future as other catchment-based solutions reduce the incoming concentration to the wetland.

99. The location of wetlands within a catchment is important to secure a source of phosphates in perpetuity. Natural England have advised that where a wetland is dependent on the input from a small number of farms / land uses for phosphates then this may not be achievable in perpetuity. This is due to uncertainties in the continued management / use of the sources over long periods of time. Instead, wetlands should be located further downstream within catchments if possible, where they are more likely to have a secured source of phosphates to remove. This may prevent wetland creation along the River Clun. However, this does not necessarily preclude their use for developments in other parts of the catchment (e.g. as a solution for a small development)(**Appendix A**).

100. In order to gain consent, wetlands are likely to require various permit / applications which are likely to include the following:

- Flood defence consents (varies depending on main river or ordinary watercourse);
- Flood risk activity permit;
- Impoundment license should more than 20 cubic meters be impounded per day; and
- Planning permission.

101. The solution also has the potential to provide added benefits such as increased flood resilience, amenity space, habitat creation and improved water quality. There is the potential to develop wetland alongside strategic flood alleviation schemes. Wetlands are a water dependant environment and have the capacity to operate at higher water levels for short durations of time, providing the reeds are not drowned and the silt trapping mechanisms are not compromised. Wetland creation is likely to be achievable in perpetuity providing management agreements and funds are in place.

102. **Figure 7** shows a typical example of a horizontal flow constructed wetland.

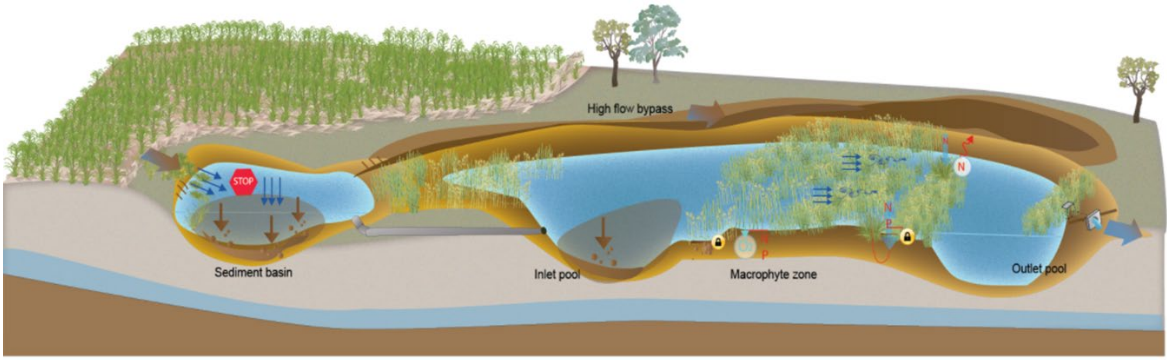

Figure 7: *Horizontal Flow Constructed Wetland (Source: Queensland Government)*

103. Where housing developments are phased (typically 200+ dwellings), then wetlands can be constructed alongside the phasing. An initial design that estimates the size of the wetland needed to offset the intended houses can begin construction and monitoring alongside the development. The design of the wetland can be altered, and the size increased and decreased as a greater understanding of the potential phosphate removal potential is established through monitoring. Starting the monitoring process as early as possible will reduce the time needed for bridging solutions.

104. One of the key risks with wetland creation is that the modelled removal potential overestimates the measured removal, and the scheme cannot deliver as much mitigation as initially proposed. Precautionary estimates should be used during the modelling stage to mitigate against this problem and be in a position where real world measured removal rates are outperforming the modelled rates. Other risks include improper maintenance of the wetlands. This can be mitigated by ensuring management and maintenance is undertaken by professionals with appropriate experience to undertake this task.

4.1.6.1 Cost estimations

105. The following cost estimates have been developed in relation to wetlands, noting that costs are highly dependent on location, extent, physical environment, and many other factors. The example below sets out the typical expected costs for 4.5ha wetland in the Clun catchment:

- Land purchase: £45,000;
- Consenting & design cost: £25,000;
- Construction costs: £30,000;
- Maintenance costs: Desilting £20,000 over 80 years. £1,250 upkeep and plant replacement every year - £100,000 over 80 years;
- Monitoring costs: £3,000 per year for years one to five. Intermittent monitoring for remaining duration - £30,000 (economies of scale will apply if more than one site is monitored by the same company); and
- Total estimated cost: £250,000.

106. Assuming a conservative removal rate of 8kg-TP/ha/yr, a 2.0ha wetland would deliver 16kgTP/yr of mitigation. Taking the costs outlined above, this would represent £15,625 per

kgTP/yr of mitigation. 16kgTP/yr of mitigation has the potential to offset approximately 159 dwellings draining to a wastewater treatment works of 1mgTP/l, equivalent to a one off payment of £1,575 per dwelling.

107. The cost for wetlands smaller or larger in size than the above estimates will vary, with the greatest changes mainly coming from land rent, construction and maintenance costs. Consenting and monitoring costs are unlikely to reduce/increase at the same rate due to inherent costs associated with these stages.

108. There is the potential for land prices to increase as a result of demand for offsetting schemes. Within the Stour sub-catchment, land that is suitable for offsetting sites or adjoining streams and rivers, can be worth more than the agricultural value if sold for nutrient off-setting.

109. The cost of offsetting will vary depending on the permit limit of the WwTWs the development drains to. WwTWs with a lower permit limit (typically large populations served) can accommodate far more dwellings for the same phosphate loading than WwTWs without a permit limit. There is a danger that if costings are calculated depending on the receiving WwTWs then some areas could be priced out for development.

110. **Table 4-15** presents the key considerations for wetland creation as a means for phosphate offsetting.

Table 4-15: *Wetland creation key considerations*

Key considerations	
Delivery Timescale	Long-term
Duration timescales	Long-term
P removal potential	Average removal efficiency of 46% (Land *et al*., 2016).
Farm Typologies applicable	All applicable – However, there remains some doubt over wetlands constructed on intensively farmed land with high legacy phosphate inputs.
Management / Maintenance requirements	• Periodic silt removal • Vegetation removal prior to dying and decomposing • Maintenance of the surrounding vegetation may be required more frequently until fully established.
Additional benefits	• Reduced Flood risk • Increased amenity value • Habitat creation • Community engagement • Educational / learning opportunities • Water quality
Based on best available evidence?	Yes
Effective beyond reasonable scientific doubt?	Yes – Monitoring will be necessary on a case-by-case basis to establish bespoke removal rates.
Precautionary?	Yes
Securable in perpetuity?	Yes – Management agreements are likely to be necessary, particularly where land is leased.

4.1.7 WwTW additional treatment wetlands

111. Wetlands that receive effluent directly from WwTWs have a significant mitigation potential due to the elevated phosphate concentrations of the effluent. There is the potential to divert the effluent from Severn Trent Water owned treatment works within the Clun catchment on to constructed wetlands for secondary treatment, prior to release into the rivers and streams.

112. WwTW secondary treatment wetlands are subject to monitoring maintenance requirements. It is unlikely that Severn Trent Water would accept any responsibility for the management or maintenance of the wetland. Additionally, to gain approval from Severn Trent Water it is likely that control structures to prevent back-up during blockages would be required and the ability to take water samples from the original outfall / wetland influent as required for compliance purposes.

113. Environment Agency guidance indicates that where wetlands are constructed for treating secondary effluent, and where this is not required for compliance with permit, then the wetland shall be treated as a waste treatment activity, and this would need an environmental waste permit to discharge to controlled water. This would be in addition to any existing water discharge permit of treatment works that may also need to be altered. The Environment Agency charging scheme would apply for a permit application, which would cost between £4,000 - £7,750 . Annual subsistence charges are also required which may be up to £2,000 - £3,000 per year.

114. Key considerations are outlined in **Table 4-16**.

***Table 4-16**: WwTW secondary treatment wetland key considerations*

Key considerations	
Delivery Timescale	Long-term
Duration timescales	Long-term
P removal potential	Average removal efficiency of 46% (Land *et al*., 2016).
Farm Typologies applicable	All applicable – However, there remains some doubt over wetlands constructed on intensively farmed land with high legacy phosphate inputs
Management / Maintenance requirements	• Period silt removal • Plant removal prior to dying and decomposing • Maintenance of the surrounding vegetation may be required more frequently until fully established • Ability to take water samples from original outfall • Control structures to prevent back up
Additional benefits	• Reduced Flood risk • Increased amenity value • Habitat creation • Community engagement • Educational / learning opportunities • Water quality
Based on best available evidence?	Yes – Monitoring will be necessary on a case by case basis to establish bespoke removal rates.

Key considerations	
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes – Management agreements are likely to be necessary, particularly where land is leased.

4.2 Wastewater and drainage solutions

4.2.1 Water company improvements and permit limits

115. Wastewater treatment works represent the second largest contributor of phosphate sources in the catchment (35%), although the contribution is significantly less than agriculture (56%) (Atkins, 2014). However, this historical data predated the phosphate stripping, and therefore it is likely to have a reduced contribution. Water company improvements and lower permit limits represent an opportunity for achieving mitigation. Any mitigation measures would need to be above and beyond what is agreed in the current AMP period. Phosphate mitigation could be achieved by the following mechanism:

- Increase the number of treatment works with P stripping infrastructure;
- Increase the phosphate stripping potential for treatment works with existing infrastructure;
- Reduce leakage from foul sewerage systems;
- Increase connectivity to mains sewerage; and
- Divert effluent outside of the catchment.

116. Severn Trent Water have already completed significant upgrades to treatment works within this catchment with some of the treatment works operating close to industry best practice discharge concentrations. The current permit limit and discharge concentrations for the Clun catchment are shown in **Table 4-17**. The data demonstrates that the treatment works are discharging effluent significantly below the permit limits and any upgrades would need to impact the discharge concentrations and not the permit limits in order to achieve an actual reduction in phosphate concentrations.

Table 4-17: *Wastewater treatment works within the Clun catchment (Source: Severn Trent Water)*

Wastewater treatment works	Current permit limit (mg/l)	AMP7 permit limit (mg/l)	Population served	Average discharge concentrations (2018-2021) (mg/l)
Bishops Castle	1	0.4	1817	0.37
Bucknell	0.34	0.34	943	0.15
Clun	0.5	0.5	699	0.13
Lydbury North	1	1	241	0.19
Newcastle on Clun	1	1	161	0.36

Wastewater treatment works	Current permit limit (mg/l)	AMP7 permit limit (mg/l)	Population served	Average discharge concentrations (2018-2021) (mg/l)
Aston on Clun	0.9	0.9	213	0.36
Clunbury	5	5	83*	5

* This is the recorded population for the area served by the sewerage system. However, billing information indicates that the majority of properties in the village are not connected to the sewer system.

117. Recent upgrades to treatment works have not seen a significant reduction in the phosphate concentrations within the river, which reflects the previously low discharge concentrations and limited impact from treatment works when compared to agricultural sources.

118. Further upgrades to treatment works are unlikely to take place at Bishop's Castle, Bucknell, Clun or Lydbury North due to the already low discharge concentrations. Upgrades to treatment works at Newcastle on Clun or Aston on Clun could reduce effluent concentrations closer to the other treatment works within the catchment. **Table 4-18** presents the phosphate mitigation that could be achieved through these upgrades. This assumes the treatment works are operating at the average discharge concentrations, water usage of 130 litres/person/day and future discharge concentrations of 0.2mg/l.

Table 4-18: *Potential phosphate mitigation from improvements to treatment works*

Wastewater treatment works	Current wastewater loading (kg/yr)	Assumed wastewater loading (kg/yr)	Mitigation achieved (kg/yr)
Newcastle on Clun	2.75	1.53	1.22
Aston on Clun	3.64	2.02	1.62

119. **Table 4-18** above indicates that upgrades to Newcastle on Clun and Aston on Clun will not achieve significant phosphate reductions for the work required in order to achieve the desired effluent concentrations. As a result, it is unlikely that upgrades to treatment works would be used to create phosphate mitigation.

120. Clunbury treatment works has the potential to serve a Population Equivalent (PE) of 83. However, it is estimated that the actual figure connected to mains sewerage is 25-30, with 53-58 served by septic tanks / package treatment plants. Connecting these properties from private sewerage onto the mains is likely to create a phosphate reduction. Assuming that 53 PE are connected to package treatment plants with an effluent concentration of 9.7 mg/l (May and Woods, 2016) and 30 connected to mains sewerage, the existing loading is 31.51kg/yr. Connecting the entire 83 PE to mains will have a loading of 19.69kg/yr, creating a phosphate reduction of 11.82kg/yr. Furthermore, Clunbury does not currently have phosphate stripping installed and so represents a potential location for installing phosphate stripping. Assuming the treatment works could operate at an effluent discharge of 1mg/l, the phosphate loading would be 3.94kg/yr, which would represent a total phosphate reduction of 27.57kg/yr. Changing private connections to the mains sewerage will likely require some encouragement and enforcement from either Shropshire Council Building Control or the Environment Agency.

121. Increasing connectivity to the sewer network for communities who predominantly use package treatment plant / septic tanks elsewhere in the catchment could achieve phosphate mitigation. Existing septic tanks without phosphate stripping typically operate at a higher effluent concentration than treatment works, especially treatment works with phosphate stripping in place. However, installing new pipelines to facilitate this would have significant costs and would only be a viable solution where new pipeline did not exceed approximately 500m and a significant number of dwellings would be impacted. Further investigation would be required in order to identify potential areas where this solution could achieve significant phosphate reductions.

122. Bishop's Castle treatment works currently discharges to a tributary of the River Kemp, to the southeast of the town. There is the potential to alter the effluent discharge location from here to the River Onny which is located approximately 4km to the east and not within the Clun catchment. This would require Defra approval and would not be deliverable until mid-2026. Initial engagement has confirmed that the project is technically feasible, and the receiving catchment has the capacity to accept the additional phosphate loading. The Bishop's Castle treatment works currently discharges approximately 31.90kg/yr of phosphate and this solution would remove this amount of phosphate from the catchment in perpetuity. Furthermore, any future development in Bishop's Castle would then not increase the wastewater loading to the river Clun. This would also reduce the mitigation required over the Shropshire Local Plan period by 3.07kg/yr. The cost of the works is likely to be significant, however, developer contributions could be taken to secure the phosphate reduction as mitigation.

123. Leakage from foul sewage into the subsurface has the potential to contribute to phosphorus loads to the environment. Leakages can occur through burst or damaged pipes, failures at pumping stations or due to insufficient capacity of the network. Reducing leakage rates will lead to phosphate reductions, however, further investigation would be needed to identify where any leaks are located and to quantify the phosphate reduction to rivers which could be achieved by fixing the leaks. It is also not possible to provide costs for implementation due to the highly variable nature of the work.

124. **Table 4-19** presents the key considerations for the water company improvements.

Table 4-19: *Water company improvements key considerations*

Key considerations	
Delivery Timescale	Medium-term
Duration timescales	Long-term
P removal potential	• Treatment works improvement: 2.84kg/yr • Connecting Clunbury properties & upgrading: 27.57kg/yr • Bishop's Castle effluent re-location: 31.90kg/yr
Additional benefits	Water quality
Based on best available evidence?	Yes
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes

Key considerations	
Securable in perpetuity?	Yes
Cost estimation	Capital costs: Majority of costs will sit with Severn Trent Water but these could be offset by developer contributions if the latter are secured as mitigation

4.2.2 Willow buffer areas

125. Short-rotation willow coppice can be used to treat wastewater whilst producing woody biomass for energy purposes. This solution can be used to treat domestic and industrial wastewater. It consists of vegetation filter strips of short-rotation willow coppice irrigated with wastewater. The willow is harvested on a two to five-year cycle, although most commonly every three years. The irrigation system will not completely eliminate wastewater pollution as some wastewater will run off or percolate into groundwater. As a result, timing and irrigation rates must be considered. Evapotranspirative willow systems have zero discharge and are an alternative to irrigated systems and are typically used to treat domestic wastewater from small settlements or individual households. When designed properly, all influent wastewater and precipitation are evapotranspired on an annual basis. They provide efficient wastewater treatment and do not require skilled personnel for operation and maintenance.

126. Short-rotation willow coppice filter strips achieve phosphate removal rates of 67-74% (Larsson *et al.,* 2003; Perttu, 1994), although initial reduction rates are often closer to 95%. Lachapelle-T *et al.* (2019) suggested a significant increase in available phosphate in the soil, suggesting the soil can become saturated over time. In the case of evapotranspirative willow systems, wastewater is constantly applied and stored at an elevated water level. Phosphate accumulation is expected and results in a phosphate rich substrate which can be reused as fertiliser. Initial studies suggest that phosphate stored in woody biomass is between 31 – 45% of the influent, whereas phosphate stored in soil, roots and leaves is between 55 – 69% (Istenic & Bozic, 2021). The recommend phosphate application to prevent saturation of soils is 24 kg/ha/yr (Caslin *et al.*, 2015), which is typically lower than what is applied directly from domestic wastewater. This solution could be used as a form of secondary treatment after domestic package treatment plants.

127. Harvesting of willow would be required every 3-5 years and replanting every 20-15 years. This solution typically sees a 30% increase in biomass yield (Buonocore *et al*., 2012).

4.2.2.1 Capital and maintenance costs

128. The cost for establishment is typically £2,500[5] per hectare. Operational costs including ploughing and cultivation and are likely to be £200 - £300 per ha per year. Potential returns vary hugely depending on many variables including price received for crop and drying requirements. Rising energy costs of oil and gas may provide greater future opportunities for willow chips as a fuel source.

[5] Short Rotation Coppice (SRC) | Crops for Energy (crops4energy.co.uk)

129. **Table 4-20** presents the key considerations for the use of willow buffers for phosphate reduction and / or offsetting.

***Table 4-20:** Willow buffer key considerations*

Key considerations	
Delivery Timescale	Medium-term
Duration timescales	Long-term
P removal potential	70% long-term
Management / Maintenance requirements	Harvesting every 2-3 years.
Additional benefits	• Water quality • Biodiversity
Based on best available evidence?	No
Effective beyond reasonable scientific doubt?	No – there is the potential for phosphate saturation within soils
Precautionary?	Yes
Securable in perpetuity?	Yes
Cost estimation	Capital costs: £2,500 per hectare, operational costs £200 - £300 per ha per year.

4.2.3 Sustainable Drainage Systems (SuDS)

130. **Table 4-24** outlines key considerations associated with SuDS. SuDS are efficient sediment traps and reduce the amount of runoff entering watercourses. Examples include basins and ponds, filter strips and swales, constructed wetlands, soakaways, infiltration basins, gravelled areas and porous paving. SuDS systems require design specific to a development site and the phosphate reduction efficacy can vary between options.

131. Many of the components of a SuDS design do not have a strong evidence base to determine removal efficiencies. Lucke *et al.* (2014) reported total phosphorus removal of 20 - 23% under runoff simulation, and reviewed a range of other published data and found slightly higher mean TP reduction of 48%. Moderate phosphorus reductions associated with swales suggest they would be best used alongside a suite of other measures to achieve a greater cumulative impact and achieve neutrality (e.g. as a part of SuDS schemes used in new housing developments). As such, it is the expectation that Natural England will provide phosphate removal figures for SuDS. SuDS are well-established and familiar to many developers and are likely to be an attractive method for achieving on-site mitigation.

4.2.3.1 SuDS typologies

132. SuDS wetlands should typically comprise an initial sediment fallout pond designed to have a variety of deeper zones and shallow macrophyte zones. The pond should also be able to accommodate additional volume for excess rain. Regular maintenance is also essential to ensure that removal rates are maintained and to ensure that an accumulation of phosphorus

enriched sediment does not become a source rather than a sink. Indicative cost estimates are presented in **Section 4.2.2.2**.

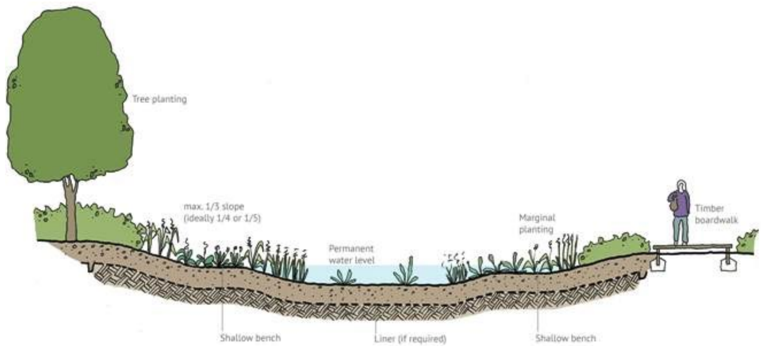

***Figure 8:** Example of a SuDS wetland (Source: Susdrain)*

133. Swales are shallow, relatively wide and vegetated depressions that are designed to store and convey runoff and remove pollutants. They can also be used as conveyance structures to transfer runoff into the next stage of the SuDS treatment process. They are fairly easy to incorporate, with low capital costs and simple maintenance. They are best suited to low gradients on both sides and can be enhanced by placing check dams across the swale to reduce flow rate.

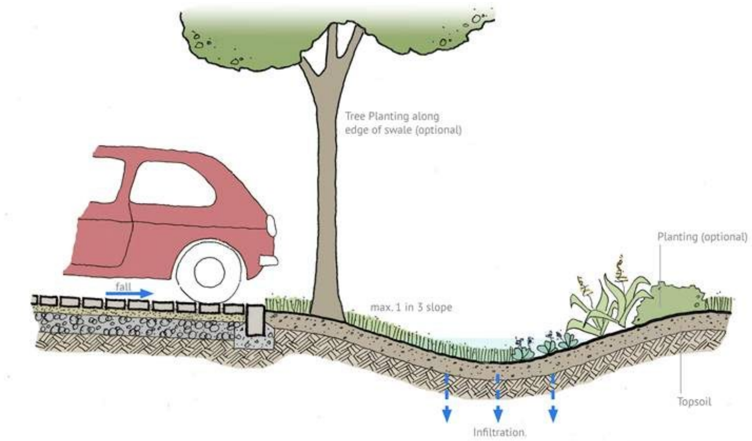

***Figure 9:** Example of swales and conveyance channels (Source: Susdrain)*

134. Filter strips are gently sloping, vegetated strips of land that slow conveyance and promote infiltration. They typically lie between hard-surfaces and a receiving stream / surface water collection. Runoff is primarily by overland sheet flow. They are easy to construct and have low capital costs. They are unsuitable where the slope gradient is steeper.

***Figure 10:** Example of filter strips (Source: Susdrain)*

135. Bioretention zones (also referred to as rain gardens) are landscaped depressions which use vegetation and filtration to remove pollution and reduce runoff. They are aimed at managing and treating runoff from frequent rainfall events. They are very effective at removing pollutants and flexible to install into the landscape.

***Figure 11:** Example of a bioretention zone (Source: Welshwildlife.org)*

136. Source control is also a key method in reducing runoff. Permeable paving can attenuate flow and increase infiltration. Green roofs also provide interception storage and treat some of the more frequent but smaller, polluting rainfall events.

137. As a general principle, SuDS systems that promote infiltration of water and settlement of sediment will have the greatest benefit for phosphorus removal. Similarly, SuDS that provide an environment for vegetation to uptake phosphorus will achieve good phosphorus removal

rates. SuDS used in combination and linked in a treatment train of different typologies (often culminating in a SuDS wetland), thus represent the most favourable scenario.

138. SuDS can be best incorporated into new developments where they can be designed to achieve the greatest impact. The use of SuDS should be encouraged as this will treat excess phosphorus on site. Natural England advice is that on-site solutions should be used in preference to off-site measures.

139. Urban retrofitting can be also used to install SuDS. To accommodate surface water run-off from existing developments and built up areas strategic driven retrofitting can achieve phosphorus reductions and can be combined with the need for urban regeneration and flood reduction.

140. SuDS can provide multiple benefits other than phosphorus removal. They mimic natural drainage process and reduce the quantity of runoff from developments as well as providing amenity and biodiversity benefits. Where appropriately designed and used, a SuDS treatment train will reduce runoff and storm flow, which can lead to a reduction in combined sewage overflows.

141. The long-term performance of SuDS would also need to be secured through maintenance agreements (e.g. via Section 106 rather than planning conditions given the required duration of these commitments). Key maintenance tasks are outlined in **Table 4-21**. Sedimentation will eventually compromise some aspects of the wetland's function and rejuvenation measures will be necessary (Kadlec and Wallace, 2009). Kadlec and Wallace (2009) indicate a sediment accretion rate in the order of 1cm/yr or 2cm/yr and give examples of rejuvenation after 15 and 18 years, but other wetlands have not needed any significant restoration in similar timespans.

***Table 4-21:** SuDS maintenance tasks*[6]

Activity	Indicative frequency	Typical tasks
Routine/regular maintenance	Monthly (for normal care of SuDS)	• litter picking; • grass cutting; and • inspection of inlets, outlets and control structures.
Occasional maintenance	Annually (dependent on the design)	• silt control around components; • vegetation management around components; • suction sweeping of permeable paving; and • silt removal from catchpits, soakways and cellular storage.
Remedial maintenance	As required (tasks to repair problems due to damage or vandalism) Removal of silt build-up, typically every 15-18 years	• inlet / outlet repair; • erosion repairs; • reinstatement of edgings; • reinstatement following pollution; and • removal of silt build up through digging out.

[6] *Susdrain (https://www.susdrain.org/delivering-suds/using-suds/adoption-and-maintenance-of-suds/maintenance/index.html)*

4.2.3.2 SuDS costs

142. **Table 4-22** and **Table 4-23** present the costs for various SuDS types.

Table 4-22: *SuDS costs for buffers, bunds and wetlands (edited from Vinten et al (2017))*

Measure	Recurrent costs	Capital costs
8m buffer	£495 ha/yr for 6m buffer	Nil
20m buffer	£495 ha/yr for 18m buffer	Nil
Detention bund	Nil	£7m bund £10.50m^2 excavation £5.50m^2 perimeter fence

Table 4-23: *Indicative capital costs (one off payments) for SuDS options (edited from Environment Agency (2015))*

SuDS Option	Cost estimation	Source
Green roofs	£80/m^2 - £90/m^2	Bamfield, 2005
Rainwater harvesting (water butts)	£100 - £243 per property	Stovin & Swan, 2007
Advanced rainwater harvesting	£2,100 - £3,700 per residential property £45/m^2 for residential properties	Environment Agency, 2007 RainCycle, 2005
Greywater re-use	£3,000 per residential property	Environment Agency, 2007
Permeable paving	£30/m^2 - £54/m^2	CIRIA, 2007 Environment Agency, 2007
Filter drains / perforated pipes	£120/m^2 £100/m^3 - £140/m^3	Environment Agency, 2007 CIRIA, 2007
Swales	£10/m^2 – £15/m^2	Environment Agency, 2007 CIRIA, 2007
Infiltration basin	£10/m^3 – £15/m^3 stored volume	CIRIA, 2007
Soakaways	£450 - £550 per soakaway	Stovin & Swan, 2007
Infiltration trench	£60/m^2 £55/m^3 - £65/m^3 stored volume	Environment Agency, 2007 CIRIA, 2007
Filter strip	£2/m^2 - £4/m^2	CIRIA, 2007
Constructed wetland	£25/m^3 - £30/m^3 stored volume	CIRIA, 2007
Retention pond	£16/m^3 pond £25/m^3 - £30/m^3 stored volume	SNIFFER, 2006 CIRIA,2007
Detention basin	£15/m^3 - £55/m^3 stored volume	CIRIA, 2007 Stovin & Swan, 2007
Onsite attenuation and storage	£449/m^3 - £518/m^3 for reinforced concrete storage tank	Stovin & Swan, 2007

143. **Table 4-24** presents the key considerations for the use of SuDS for phosphate offsetting or reduction.

Table 4-24: SuDS key considerations

Key considerations	
Delivery Timescale	Short-term
Duration timescales	Medium / Long-term
P removal potential	Highly variable and will likely need site specific calculations.
Management / Maintenance requirements	The long-term performance of SuDS would also need to be secured through maintenance agreements. Maintenance works would include desilting of swales, wetlands and basins to maintain their efficiency. Vegetation management of buffers would be necessary to maintain the optimum roughness/composition and sediment trapping efficiency.
Additional benefits	Water quality Reduced erosion Habitat creation Improved amenity value
Based on best available evidence?	No – monitoring may be required to determine the efficacy of specific schemes
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes – maintenance agreements may be required
Cost estimation	See Table 4-22 and Table 4-23.

4.2.4 Portable treatment works

144. Portable treatment works that can be used as a secondary treatment specifically for phosphate removal (**Table 4-25**). Typically used by water companies during upgrades (One container can typically serve up to 20,000 population equivalent (PE).. The containers are modular so can be used in parallel to handle any flow. They are typically built inside standard shipping containers making them easy to install and move to another site (**Figure 12**) They could be used as short-term solutions whilst other mitigations options are designed and developed. Other examples include portable vertical flow wetlands. Each treatment works plant typically has a footprint of <0.2ha.

145. Technically, the portable treatment works can be used for treating river water. However, there may be some difficulties in preventing plants, fish and invasive species from entering the system and pre-treatment, e.g. a series of coarse to fine (mesh) filters, would be needed to filter out any unsuitable material. In this case, the systems could be used on proposed wetland creation sites during the design and construction phase to deliver short-term phosphate mitigation.

Figure 12: Example of a portable containerised wastewater treatment works (Source: Vikaspumps.com)

4.2.4.1 Capital and maintenance costs

146. Given the bespoke nature of the systems for phosphate removal, it is likely that the systems would need to be purchased. Rental is available for standard systems, but it unlikely to be available for bespoke systems. Capital costs vary depending on the size and are expected to range from between £10,000 to £100,000. Maintenance costs of £1,000 - £5,000 are expected but vary depending on the size / number of plants.

***Table 4-25:** Portable treatment works key considerations*

Key considerations	
Delivery Timescale	Short / medium term – typically three months to deliver and set up
Duration timescales	Short / medium-term
P removal potential	Effluent to 0.5mg/l can be achieved.
Management / Maintenance requirements	Review of limited monitoring data may be required. Some maintenance on the system is required, equivalent to a few hours a week.
Additional benefits	Water Quality
Based on best available evidence?	Yes
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes
Cost estimation	Capital costs £10,000 - £100,000 depending on size. Maintenance costs £1,000 - £2,000 a year.

147. Effluent from portable treatment works can be treated to concentrations as low as 0.5mgTP/l. However, effluent discharge concentrations in the Clun catchment are already lower than 0.5mgTP/l. Therefore, portable treatment works are unlikely to achieve further

phosphate reductions and additionally are not suitable for placement downstream of existing permanent wastewater treatment works.

4.2.5 Alternative wastewater treatment providers

148. New appointments and variations (NAVs) are companies that provide sewerage services to customers in an area which is currently or has been previously provided by the incumbent monopoly provider. These companies are Ofwat regulated. Companies that are not defined by region and that can operate anywhere in England and Wales could potentially provide alternative wastewater solutions.

149. Alternative wastewater treatment works providers will treat all the waste from new developments by designing, consenting and building an alternative treatment works. They are typically reserved for large developments (minimum 500 dwellings). It is possible for multiple customers to make up the numbers to the minimum required, however, due to the significant cost of installing pipelines (£1million per km), the sites need to be neighbouring. The sewage effluent would not drain into the Severn Trent Water system and as such, would need to be located in close proximity to a watercourse. The customer would still receive potable water from Severn Trent Water and all maintenance of the treatment works would be paid for via normal sewage bills. The treatment works would need to comply with permits and ensure that visual and odour impacts are limited. Land uptake is often limited. However, the treatment works would need to be located within the boundary of a development.

150. Due to the minimum dwelling requirement, this is not a viable solution within the Clun catchment. Furthermore, effluent concentration are 0.3g/l which is above some of the current treatment works within the catchment and only marginally above some others.

Table 4-26: *Alternative wastewater providers key considerations*

Key considerations	
Delivery Timescale	Long-term – typically 2.5 – 3 years
Duration timescales	Long-term
P removal potential	Effluent to 0.3mg/l can be achieved
Management / Maintenance requirements	Maintenance paid through water bills
Additional benefits	Can be integrated with SuDS to deliver flood risk benefits and amenity space.
Based on best available evidence?	Yes
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes
Cost estimation	Capital costs: £1,950,000+

4.2.6 Setting restriction on water usage

151. **Table 4-27** shows key considerations associated with setting restrictions on water usage. Introducing water efficient appliances and fittings (e.g., taps, toilets, showers) will reduce the wastewater loading per person per day that requires treatment. This can be applied to new dwellings or retrofitted to existing dwellings.

152. When retrofitting water saving appliances, the water usage saved from the retrofitted properties will be replaced by the additional water from new dwellings. As a result, the volume of water entering the treatment works will stay the same and providing the treatment works operates to a permit limit, the effluent discharge concentration remains the same. This solution is not applicable to WwTWs without a permit limit. Similarly, WwTWs should be operating at close to capacity with little headroom. This is not the case in the treatment works in the Clun catchment. Furthermore, certainty over the efficacy of this method is difficult to achieve due to the limited ability to measure reductions and enforce them in private dwelling (householders may change fittings over time)Therefore, this solution is only applicable to existing dwellings where an organisation has control over fittings and any upgrade works (e.g. the Local Authority). Shropshire Council does not have any housing stock within the Clun catchment. As a result, this solution is considered unsuitable. However, it should be noted that whilst the use of water efficient appliances and fittings is not suitable, the Draft Shropshire Local Plan includes a requirement in draft policy DP20 for all new housing to meet the Building Regulations standard of 110 litres per person per day.

153. **Table 4-27** presents the key considerations for setting restrictions on water usage as a means for phosphate reduction and/or offsetting.

Table 4-27: *Setting restriction on water usage key considerations*

Key considerations	
Delivery Timescale	Medium-term
Duration timescales	Long-term
P removal potential	Wastewater reductions of 10-30% achievable. Phosphate reductions dependant on population served and permit limit of WwTWs.
Management / Maintenance requirements	Replacement parts of the same or better efficiency must be used.
Additional benefits	Sustainability Water resources
Based on best available evidence?	Yes – The government published calculator would be used for calculating water usage for appliances.
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes – It is unlikely this solution could be achieved in perpetuity unless the Local Authority or Registered Provider have ownership and control of dwellings that are due to be retrofitted with more water efficient fittings.

4.2.7 Package treatment plants

154. Package treatment plants (PTPs) can be used to treat wastewater on-site and are normally used where a connection to the mains sewerage system is not possible. Septic tanks are an alternative type of basic onsite wastewater treatment.

155. Natural England have provided criteria for assessing rural PTPs to determine whether they are likely to have an effect on the water environment[1]. Where a development can meet these thresholds, no likely significant effects on the River Clun SAC are predicted and the development may be permitted. Shropshire Council have produced guidance for development in the River Clun catchment which sets out what information is needed to show that these tests have been met. This is available at https://shropshire.gov.uk/environment/biodiversity-ecology-and-planning/guidance-for-development-within-the-river-clun-catchment/

156. PTPs with additional phosphate stripping have potentially high phosphorus removal rates and can provide substantial phosphate reductions. **Table 4-28** outlines some of the reductions available through leading brands. Furthermore, when combined with SuDS / wetlands, PTPs could achieve even greater removal. However, PTPs do not remove all of the additional phosphate from new developments and would need to be combined with other solutions.

Table 4-28: *Main PTP Manufacturers Phosphate removal rates*

System	Removal rate / concentration	Source
Graf One2clean plus	95.1% / 1.6mg/l	https://www.graf-water.co.uk/fileadmin/media/Catalogue_Wastewater_Treatment_Solutions.pdf
Graf Klaro E Professional KL24plus	94.5% / 0.4mg/l	https://www.graf-water.co.uk/fileadmin/media/Catalogue_Wastewater_Treatment_Solutions.pdf
Kingspan Klargester BioDisc	2 mg/l	Klargester Biodisc Sewage Treatment System | Kingspan | Great Britain
WPL HIPAF	3-6 mg/l	WPL HiPAF® Sewage System - WPL | WCS EE Division (wplinternational.com)

157. Replacing old PTPs and septic tanks in the catchment with high phosphate removal PTPs and septic tanks can achieve phosphate reductions. Older models without phosphate stripping will typically discharge effluent at 9.7 mg/l for PTPs and septic tanks at 11.6 mg/l (May and Woods, 2016). **Table 4.29** indicates that new package treatment plants can operate significantly lower.

158. Alterations to existing PTPs and septic tanks or installing new tanks to provide additional phosphate dosing could also deliver mitigation.

[1] *Guidance for development within the River Clun catchment | Shropshire Council*

Royal HaskoningDHV

4.2.7.1 Capital and maintenance costs

159. PTP costs vary according to the size required and PTPs with additional P stripping typically cost more than standard models. Upfront costs are typically £2,000 - £2,500 for plants serving 4/5 persons and up to £5,000 for plants serving 15/20 persons. Installation costs may vary but are likely to be £thousands. Average annual costs for PTPs with additional phosphate stripping for operating and maintenance (including emptying) are typically £400 - £600.

4.2.7.2 Phosphate reductions

160. Upgrading a single existing PTP that serves one dwelling and has a pathway to impact the water environment to a new PTP with phosphate stripping in place will deliver 0.86kg/yr mitigation. This would have an estimated cost of approximately £5,000 for the plant and installation costs. This is equivalent to £5,815 per kg/yr reduction.

161. **Table 4-29** presents the key considerations for the use of Package Treatment Plants for phosphate reduction and/ or offsetting.

Table 4-29: *Package Treatment Plants key considerations*

Key considerations	
Delivery Timescale	Short-term
Duration timescales	Long-term
P removal potential	95% of Wastewater / average 2mg/l
Management / Maintenance requirements	Annual cleaning required in most cases. Phosphate dosing may be required
Additional benefits	Additional water quality benefits. Flood risk, habitat creation, amenity space when combined with SuDS / Wetlands.
Based on best available evidence?	Yes
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes
Cost estimation	Capital costs: approx. £5,000 Operational costs: £100 - £200

4.2.8 Cesspools

162. Closed cesspool systems offer the possibility of tankering waste from dwellings within the catchment to registered waste facilities outside of the catchment. As a result, there would be no increase in wastewater loading from developments that use this approach. However, multiple criteria would need to be met in order for cesspools to be viable:

- Ensure it has a minimum capacity of 18,000 litres per two users (plus another 6,800 litres per each extra user);
- Waste would need to be transferred by a registered waste carrier;

- Waste would need to be transferred to a registered facility outside of the catchment;
- Planning permission would be required for installation;
- The cesspool would need Building Regulations approval, which includes the following:
    - Cesspools should only be considered where mains drainage is not practicable;
    - Sited at least 7m from any habitable parts of buildings;
    - Sited within 30m of vehicle access;
    - No opening except for the inlet;
    - Cesspools should be inspected fortnightly for overflow and emptied as required; and
    - An alarm must be installed to alert the user when they are nearly full.

163. Cesspools would need to be emptied regularly and the owner would be responsible to ensure they do not leak or overflow. Where a cesspool causes pollution it would break the law and the Environment Agency could take legal action under the Water Resource Act 1991. This can carry a fine of up to £20,000 and 3 months imprisonment. Similarly, the Environment Agency and Local Authority can enforce repairs or replacements of cesspools in poor condition.

164. Cesspools are an unsustainable solution that would have a significant associated carbon footprint, particularly for dwellings in the centre of the catchment where the distance from registered waste facilities will be the greatest. Furthermore, if water company infrastructure improvements allow for mains connection in the future, the water companies would be obliged to connect and wastewater would then be contributing to loads into the catchment, requiring further mitigation.

165. Where cesspools are used as a short-term bridging solution until longer term, more sustainable, solutions are in place, then details of these longer-term solution would be required at the time of granting permission.

166. Cesspools should only be considered when other alternatives such as Package Treatment Plants and Septic Tanks are not possible.

4.2.8.1 Capital and maintenance costs

167. Cesspool costs and installation vary depending on size but are likely to be between £3,000 - £6,000. Emptying requirements are dependent on the capacity of the pit and the average waste amount of the household. On average, emptying would be required every one to two months with a cost of £400 - £700 depending on location. This is likely to result in annual costs of £3,200 - £5,600, which over 80 years equates to £256,000 - £448,000[7] per property.

168. **Table 4-30** presents the key considerations for the use of cesspools for phosphate reduction and/or offsetting.

Table 4-30: *Key considerations for cesspools*

Key considerations

[7] How much does a cesspool typically cost? - GRAF UK

Delivery Timescale	Short-term
Duration timescales	Short / medium-term
P removal potential	100% of wastewater
Management / Maintenance requirements	Emptying every 1 – 2 months Regular inspection/ installation of an alarm
Additional benefits	None
Based on best available evidence?	Yes
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes
Cost estimation	Capital costs: approx. £3,000 - £6,000 Operational costs: £3,200 - £5,600 per year

4.3 Highways Drainage and Phosphates in the Clun catchment Improvements

169. Highways drainage represents a source of phosphate-bound sediment in the River Clun catchment. Installing measures to remove the sediment prior to it entering the water environment could be used to mitigate future residential development.

170. To gain an understanding of phosphate removal potential from retrofitting sustainable drainage systems (SuDS) to highways, outfalls and suspected pollution hotspots adjacent to highways were reviewed (maps provided by Shropshire Council).

171. Where possible, upstream catchment areas were calculated, and land use identified from aerial imagery. A range of land uses were included in the review (pasture, arable, woodland), which together with catchment areas, were then assessed using the River Clun Phosphate Budget Calculator (2022).

172. Due to the relatively small number of suspected hotspots and outfalls for which catchment areas could be easily identified and calculated (see **Section 4.3.1**), a series of theoretical catchment areas have been combined with land uses both documented in the Clun catchment (Atkins, 2014) and visible on aerial imagery.

173. Catchment areas used were 0.1 to 10ha in extent and land uses included dairy, mixed livestock, poultry, improved grass, rough grazing and woodland. Outputs from the phosphate calculator indicate potential loadings for a range of catchment areas draining specific land use types.

4.3.1 Limitations

174. The drainage outfall and suspected hotspot maps provided by Shropshire Council were reviewed to identify locations where the upstream catchments of these outfalls and suspected hotpots could be easily identified.

175. However, in most cases this was not possible as many of the locations relate to diffuse runoff from hillslope hollows, gullies and verges, which lack clear or easily identifiable upstream contributing areas. A more detailed study involving field survey, dye tracing and modelling will be needed to accurately characterise suspected hotspot source areas and runoff pathways.

4.3.2 Phosphate loads

176. Table 4-31 shows current phosphate loads for selected suspected pollution hotspot locations where upstream contributing areas could be easily identified. These range from 2.3ha to 6.25ha and the land use is primarily improved grass, although areas of woodland have been included at the River Redlake and Hobarris and some catchments include sections of road (Bedstone, Bucknell, A488 South). The average catchment size was 4.4ha.

177. Despite a relatively large catchment (5 ha) at the River Redlake, over half of the catchment is made up of woodland, which accounts for the relatively low phosphate loading (0.28kg/yr). Theoretical catchments and land uses (Table 4-32) also show that wooded catchments adjacent to roads will have very low phosphate loadings (mean of 0.07kg/yr).

178. The highest loadings adjacent to highways would be found in association with primarily urban (mean of 3.00kg/yr), lowland grazing (mean of 0.69kg/yr), poultry (1.41kg/yr) and arable (mean of 1.17kg/yr) land uses. Suspected roadside pollution hotspots and outfalls associated with these land use types should be a priority for intervention.

Table 4-31: *Phosphate loading for a range of catchment areas and land use types in the Clun catchment*

Hotspot	Area (ha)	Description	Land use	TP load from current land usage (kg/yr)
Bedstone	2.3	A shallow hillslope hollow draining pastures adjacent to the minor road from Mynd to Bedstone. Drains to the lower Clun.	Improved grass (90%) Road (10%)	0.58
Bucknell	5.2	A shallow hillslope hollow draining pastures adjacent the B4367 to Bucknell. Runoff connects to a field drain that discharges to the River Redlake.	Improved grass (95%) Road (5%)	1.15
River Redlake	5	A shallow hillslope hollow draining pastures and a small area of woodland that connects to the minor road from Bucknell to Chapel Lawn. Discharges to the River Redlake.	Woodland (50%) improved grass (50%)	0.28
Chapel Lawn	2.7	A narrow, shallow and steeply sloping hillslope hollow draining pastures that connect to the minor road from Chapel Lawn to the A488. Runoff connects by a series of ditches to the River Redlake.	Improved grass	0.51
A488 South	4.66	A narrow, shallow and steeply sloping hillslope hollow draining pastures beside the A488 South to New Invention. Runoff connects to the River Redlake.	Improved grass (70%) Road (30%)	1.78
Llanfair Hill	4.7	A narrow, shallow and steeply sloping hillslope hollow draining pastures adjacent to the minor road from	Improved grass	0.89

Hotspot	Area (ha)	Description	Land use	TP load from current land usage (kg/yr)
		Upper Treverward to Llwyn. Runoff connects to a headwater tributary of the River Redlake.		
Hobarris	6.25	Steeply sloping pastures and section of woodland that connect to the minor road from Menutton to Wheel Barrow Bridge. Drains to a headwater tributary of the River Redlake.	Improved grass (80%), Woodland (20%)	0.98

Table 4-32: *Phosphate loading from theoretical catchment areas combined with observed and recorded land use types in the Clun catchment*

Land use	Catchment area (ha)					
	0.1	1	2	5	10	*Mean*
-	Phosphate loading (kg/yr)					
Urban	0.08	0.83	1.66	4.15	8.30	3.00
Lowland grazing	0.02	0.19	0.38	0.95	1.90	0.69
Poultry	0.04	0.39	0.78	1.95	3.90	1.41
Arable	0.03	0.32	0.65	1.62	3.23	1.17
Mixed livestock	0.03	0.27	0.54	1.35	2.70	0.94
Woodland	0.00	0.02	0.04	0.10	0.20	0.07

179. Areas at risk of high sediment runoff are likely to contain more phosphate than is predicted above. In these cases, testing may be required in order to calculate accurate phosphate removal.

4.3.3 Highway SuDS options and costs

180. Depending on the area of land available to implement highway SuDS, a variety of solutions are available with a range of phosphate removal rates. Solutions and typical phosphate removal rates are shown in Table 4-33.

181. Where phosphate removal rates have been documented, typical values range from 25% for highway/ infield filter strips to 55% for in ditch wetlands. Phosphate removal efficiencies of well-designed SuDS acting as sediment traps are typically around 50%.

182. Highway SuDS are also effective at capturing nitrogen and settling out suspended solids (60-90%) – the latter is particularly important for improving water quality for freshwater pearl mussels.

183. For larger SuDS schemes, such as detention ponds/basins, sufficient space would be needed beside the highway (most likely on A roads). Many of the minor roads that cross the Clun catchment do not fall into this category, being both narrow in terms of road surface and verge width.

184. Costs vary depending on the size of the intervention. Roadside sediment traps would cost in the range of £400-500 each, grass swales would cost £10-15 per m3 and in-ditch wetland up to £5,000 for 30m. Most solutions would require some form of maintenance and monitoring to inform future management.

185. For a typical sediment trap, maintenance would involve removing trapped silt and harvesting/ removing wetland vegetation to prevent die back and return of phosphate to a receiving watercourse. Monitoring would involve analysis of entry and exit water and sediment quality, and discharge rates.

Table 4-33: *Highway SuDS methods, pollutant removal rates and highway retrofit applicability (after Natural England, 2013)*

Solution	Capital costs	P removal (%)	N removal (%)	Suspended solids Removal (%)	Highway retrofit
Infiltration trench/ soak away	£55-65/m3 stored volume	45	80	80	✓
Sediment traps/ infiltration basin	£400-500 excavated sediment trap	50	-	90	✓
Grass swales	£10-15/m3 for Swale area	-	-	-	Only wider highway corridors parallel to road
In-ditch wetlands	£5,000 for 30 m sedge wetland Widening of existing ditch to create in-ditch wetland digger and driver £300 /day	55	70	63	Only wider highway corridors parallel to road
Detention basin	Small basins typically £3,000	45	45	90	Only if sufficient space available beside the highway
Hedgerow/ hedgebank	New hedgebank establishment £800/15m (including filter drain) New hedge - Tree whips and guards £6/m	No data	No data	No data	The effectiveness of hedgerows could be increased by incorporating grass filter strips either on the field side or where there is space adjoining the highway.
Highway/in field filter strips	£32/ha	25	25	85	On wider highway corridors parallel to road
Relocation of roadside gateways	£300-400	-	-	-	✓

4.3.4 Phosphate Mitigation

186. The average catchment size of the highways drains assessed is 4.4ha. Assuming the land is in lowland grazing use on freely draining soils, the phosphate loading would be 0.84kg/yr. Assuming a reduction efficiency of 50%, installing SuDS to highways could deliver on average

0.42kg/yr of phosphate mitigation per drain. This would be enough mitigation to offset 4 houses draining to a treatment works with a phosphate permit level of 1mg/l.

Table 4-34 presents a range of considerations for using highways drainage infrastructure improvements for phosphate offsetting.

Table 4-34: *Highways Drainage Improvements key considerations*

Key considerations	
Delivery Timescale	Medium-term
Duration timescales	Medium / Long-term
P removal potential	Varies depending on method
Management / Maintenance requirements	Desilting will be required during the lifetime of the infrastructure.
Additional benefits	Water quality; habitat creation, sediment runoff
Based on best available evidence?	No – Phosphate reductions estimates highly variable
Effective beyond reasonable scientific doubt?	Yes
Precautionary?	Yes
Securable in perpetuity?	Yes – management agreements will likely need to be put in place
Cost estimation	Developer contributions will be needed to cover capital expenditure.

4.3.5 Recommendations

187. The following recommendations are applicable to highways solutions:

- Outfall and suspected hotspot locations should be prioritised by catchment size and land use as targets for implementing highway SuDS. **Table 4-34** suggests that larger runoff contributing areas close to highways that include significant proportions of urban, lowland grazing, poultry and arable land use will have the highest phosphate loads. Predominantly wooded catchments will have low phosphate loads.
- For high priority areas more detailed surveys will be required to delineate catchment areas. This may involve field survey, dye tracing and modelling to accurately characterise hotspot contributing areas and runoff pathways.
- Roadside sediment traps typically remove ~50% of incoming phosphate and could provide a useful tool to improve water quality in the catchment. Where more space is available beside highways, in-ditch wetlands and detention basins could be applicable. All highway SuDS measures are very effective at removing sediment, which although not needed as mitigation for development could contribute to restoring the River Clun SAC.

5 Housing proposals

5.1 Methods and assumptions

188. In order to understand the phosphate mitigation required to support the delivery of residential development in the Clun catchment, there is a need to understand the level of residential development proposed. As such, a review of the Draft Shropshire Local Plan and associated evidence base documents was undertaken to identify the level of residential development proposed within the Clun catchment. The additional phosphate loading from the proposed residential development was then calculated using the Phosphorus Budget Calculator (Royal HaskoningDHV, 2022). Worst-case scenarios were assumed to ensure the phosphate loading value was not underestimated.

189. The following assumptions were made:

- All new dwellings were assumed to be houses with an average occupancy of 2.36 persons per dwelling. It should be noted that this is a precautionary figure. 2011 Census data indicates an average household occupancy rate in Shropshire of 2.36, this reduces to 2.30 when excluding the population in communal establishments. The 2014-based sub-national population and sub-national household projections, which exclude those in communal establishments, indicate an average household occupancy rate in Shropshire of 2.31 in 2016, reducing to 2.26 in 2022 and 2.19 in 2038).
- The pre-development land use of the sites was identified using aerial imagery.
- The proposed land use was assumed to be predominantly urban, with on-site green open space provision equivalent to 30sqm per person (consistent with existing policy requirements in the adopted Local Plan and proposed policy requirements within the Draft Shropshire Local Plan).
- Permit limits were retrieved from Severn Trent Water published values for the current AMP cycle and the future permit limits due to be in place prior to 2025.
- PTPs would be used in some rural locations (particularly in the Abcot, Beckjay, Clungunford, Hopton Heath, Shelderton and Twitchen (Three Ashes) Community Cluster) and these PTPs would operate at a removal rate of 90%.
- The assessment took a conservative approach by assuming that there would be no reduction in surface runoff from SuDS.
- The soil drainage type was derived from Soilscapes and the dominant soil of the area was determined to be freely draining.
- The area of land required for the developments was estimated using aerial imagery, site layout plans and site allocation boundaries where possible.
- Where no plans exist (e.g. windfall), the area of land required was calculated by multiplying the projected number of dwellings by the plot size, which was assumed to be 0.036ha per dwelling. This is equivalent to 30 dwellings per hectare. It was assumed that a plot size of 0.036ha would provide a representative figure for the house, garden and accompanying roads / paths adjacent to the properties.
- The windfall allowances proposed in the Draft Shropshire Local Plan will be delivered in the Key Centre and Community Hub settlements with proposed residential development guidelines and are thus assumed to connect to the existing foul drainage system.

- The assessment includes residential development with planning permissions that still require phosphate mitigation (i.e., those with outline permission or consented but with drainage conditions).

5.2 Estimated phosphate loading

190. This assessment considers developments which are likely to be completed between 2022 and the end of the proposed plan period in 2038. The residential development guidelines were retrieved from the Draft Shropshire Local Plan which has been submitted to the Secretary of State for examination. These residential development guidelines will be achieved through a combination of; dwellings on proposed allocations within the Draft Shropshire Local Plan; dwellings on allocations within the Site Allocations and Management Development (SAMDev) Plan which was adopted in 2015 and which are not yet the subject of a planning permission (as at 31st March 2021) and are proposed to be saved as part of the Local Plan Review process; dwellings on sites with planning permission/prior approval (some of which still require phosphate mitigation i.e. those with outline permission or drainage conditions); and windfall allowances. Information on the location of allocated sites was taken from the Bishop's Castle Place Plan Area (S2) component of the draft Shropshire Local Plan (specifically draft Policies S2.1, S2.2, S2.3 and S2.4) and GIS data supplied by Shropshire Council. Windfall figures are derived from the total planning permissions for each settlement.

191. The total proposed housing delivery for the Clun catchment is provided in **Table 5-1**.

***Table 5-1**: Housing projections evidence base for the period 2022 – 2038.*

Location of Dwellings	No. of dwellings				
	Permissions (requiring mitigation)	Saved SAMDev Allocations	Draft Local Plan Allocations	Windfall	Total
Bishop's Castle	18	40	0	35	93
Bucknell	0	70	20	8	98
Clun	1	60	20	8	89
Lydbury North	9	11	0	0	20
Abcot, Beckjay, Clungunford, Hopton Heath, Shelderton and Twitchen (Three Ashes)	4	0	0	0	4
Newcastle and Whitcott Keysett	0	0	0	0	0
Total	32	181	40	51	304

192. Development within the River Clun catchment is primarily located in Bishop's Castle (Key Centre) and Bucknell and Clun (Community Hubs) with a smaller number of remaining planning permissions and saved SAMDev allocations in the Lydbury North and Abcot, Beckjay, Clungunford, Hopton Heath, Shelderton and Twitchen (Three Ashes) Community Clusters. In the Draft Shropshire Local Plan, Key Centres and Community

Hubs have site allocations, however, Community Clusters do not. Instead, any development within Community Clusters will need to meet the requirements of draft policy SP9 as well as provide a project level HRA (SAMDev policy MD12 and Draft Shropshire Local Plan policy DP12). The residential development guideline in SAMDev for the Abcot, Beckjay, Clungunford, Hopton Heath, Shelderton and Twitchen (Three Ashes) Community Cluster is not proposed to be saved in the Draft Shropshire Local Plan. It should also be noted that there are no planning permissions or allocations (either saved or proposed) for the Newcastle and Whitcott Keysett Cluster.

193. It was assumed that the sites with planning permission that require mitigation would be delivered by 2026 (i.e., within five years), as per the Shropshire Council Five Year Housing Land Supply Statement (2021). The Draft Shropshire Local Plan indicates that the allocations for Bucknell (site BKL008a) and Clun (site CLU005) are to be delivered in the long term (2035-2038).

194. The phosphate loading projections apply a precautionary principle and are likely to overestimate the actual loading from the proposed development. The following precautionary principles were adopted:

- That the new dwellings will either be occupied by people living outside the catchment, or in the case that someone living within the catchment occupies a new house, their existing house will be occupied by someone from outside of the catchment.
- An average occupancy rate of 2.36 was applied. Severn Trent Water have previously stated (River Clun Strategic Liaison Group meeting March 2022) that when this is used at a catchment scale it can overestimate the total loading. See methods and assumptions above also for additional precautionary assumptions.
- The discharge limit for the treatment works was assumed to be 90% of the permit limit. The treatment works within the catchment are all on average operating at less than 50% of their permit limit, with an average of 34%.
- A 20% precautionary buffer is applied to the total loading to account for any uncertainty in the figures used and to ensure there will be no adverse effect on site integrity.

195. The projected phosphate loading per settlement area is presented in **Table 5-2**. The total phosphate mitigation required for the period 2022 – 2038 is 20.65kg/yr.

***Table 5-2:** Total phosphate loading per settlement area*

Location of Dwellings	Total dwellings (2022 - 2038)	Total Phosphate loading (kg/yr)
Bishop's Castle	93	5.89
Bucknell	98	4.73
Clun	89	6.07
Lydbury North	20	2.50
Abcot, Beckjay, Clungunford, Hopton Heath, Shelderton and Twitchen (Three Ashes)	4	1.46
Newcastle and Whitcott Keysett	0	0

Location of Dwellings	Total dwellings (2022 - 2038)	Total Phosphate loading (kg/yr)
Total	304	20.65

196. A detailed breakdown of the projected phosphate loading per settlement area from 2022 to 2038 is provided in **Table 5-3**.

197. The total additional phosphate load from the projected houses is predicted to be 20.65kg/yr over the period 2022 – 2038. This assumes a precautionary occupancy rate of 2.36 but if the trend for a reduction in this (as identified in **Section 5.1**) continues, the total additional phosphate load will decrease. The model also assumes that the planned upgrades to the Bishop's Castle wastewater treatment works will be implemented by 2025. However, there is the possibility that this could be delayed due to an extension application relating to the potential to transfer this treatment works' effluent out of the Clun catchment entirely. Should the effluent be removed from the catchment, any future developments connecting to the Bishops Castle WwTW would not increase the phosphate loading to the river and would thus be effectively nutrient neutral. Additionally, the use of developer contributions to part-fund the removal of the effluent has the potential to fully mitigate all the proposed development in the Clun catchment identified in **Section 5** of this report, as well as making a proportionately large contribution to the restoration of the River Clun SAC.

Table 5-3: Detailed phosphate loading per settlement area

Location of Dwellings	Total dwellings (2022 - 2038)	Phosphate loading (kg/yr)				
		Short-term (2022 – 2026)	Medium-term (2027–2030	Long-term (2031-2034)	Long-term (2035-2038)	Total
Bishop's Castle	93	3.69	0.74	0.74	0.74	5.89
Bucknell	98	1.00	0.80	0.80	2.13	4.73
Clun	89	1.36	1.05	1.05	2.61	6.07
Lydbury North	20	1.66	0.28	0.28	0.28	2.50
Abcot, Beckjay, Clungunford, Hopton Heath, Shelderton and Twitchen (Three Ashes)	4	1.46	0.00	0.00	0.00	1.46
Newcastle and Whitcott Keysett	0	0	0	0	0	0
Total	304	9.17	2.86	2.86	5.76	20.65

6 Summary and conclusions

6.1 Conclusions

198. **Table 6-3** provides a summary of short-listed solutions that could be used to mitigate and offset additional phosphates arising from new developments that could adversely affect the River Clun SAC. It is likely that a combination of measures will be most effective in phosphate offsetting. For example, incorporating SuDS into new developments, whilst constructing wetlands and riparian buffer strips. A range of nature-based techniques could be used which are mainly aimed at slowing runoff and trapping sediment-bound pollutants. These range from measures with shorter lead in times (e.g., riparian buffer strips) and could therefore be implemented relatively quickly, to approaches that may have long lead in times (e.g., constructed wetlands) that would require considerable investigations, consultation or investment before they could be successfully implemented.

6.1.1 Suitability of solutions

199. **Table 6-1** Outlines the short-listed solutions that are likely to be the most suitable (in terms of phosphate removal and how applicable they are to the catchment) to adopt.

Table 6-1: *Suitability of solutions*

Solution	Suitability
Taking land out of agricultural use	✓
Cessation of fertiliser and manure application	✓
Riparian buffer strips	✓
Wet woodlands	✓
Cover crops	✓
Constructed wetlands	✓
Additional treatment wetlands	✓
Water company improvements	✓
Willow buffer areas	✓
SuDS	✓
Portable treatment works	-
Alternative wastewater providers	-
Restrictions on water use	✓
Package treatment plants	✓
Cesspools	-
Highways Drainage Improvements	✓

200. **Table 6-2** outlines the area of mitigation land required for each measurable long-term solution in order to achieve the 20.65kg/yr of mitigation needed to achieve nutrient neutrality during the Local Plan period. It is assumed that mitigation will need to be in place for 80 years.

Table 6-2: *Land area required for various solutions to deliver nutrient neutrality*

Solution	Total area required (ha)	Suitable area within the catchment (ha)	Area required as % of suitable land (%)	Estimated cost (£)	£/kgTP/yr	£/dwelling (one off payment)
Taking arable land out of use	68.25	4,096	1.67	1,194,375	57,839	3,929
Taking livestock land out of use	121.5	15,506	0.78	2,126,250	102,966	6,994
Cessation of fertiliser application (Arable)	344	4,096	8.40	35,071,213	169,8364	115,366
Cessation of fertiliser application (Grassland)	516.25	15,506	3.33	35,869,463	173,7020	117,992
Riparian buffer strips	5.90	3,659.00	0.16	241,664	11,703	795
Wet woodland creation	5.90	1,222.00	0.48	241,664	11,703	795
Wetland creation	2.58	197.75	1.31	280,000	13,559	921

201. An assessment of land suitable for mitigation revealed that there is a total of 19,602ha of agricultural land in the catchment, of which 15,506ha is used for grazing and 4,096ha for arable. Taking agricultural land out of use would require a larger land take when compared to other solutions, but still only represents a very small percentage of the agricultural land within the catchment. Cessation of fertiliser application requires a greater land take due to the small phosphate reductions, which in turn increases the price of this solution significantly. Cessation of fertiliser application does however represent a good short-term solution that can be used as a bridging solution while long-term solutions are established.

202. Mapping (using GIS) of riparian corridors and existing woodland within the catchment identified that there is 3,569ha of land which is suitable for conversion to riparian buffer strips. Approximately 5.9ha is needed to offset the proposed development identified in chapter (or section?) 5 of this report which accounts for just 0.16% of the total suitable land. Riparian buffer strips have the lowest £/kg/yr, despite a precautionary pricing assumption that does not account for contributions through other schemes such as biodiversity net gain and carbon offsetting. Similarly, a mapping exercise that considered topography and current designations revealed that approximately 197.75ha of land is suitable for conversion to wetland. The 2.58ha required to offset development represents just 1.31% of the total suitable wetland land.

203. The potential to improve wastewater treatment works in the catchment is limited. However, connecting all the existing residents of Clunbury to mains sewerage could deliver 19.69kg/yr, which would almost be enough to offset the development identified in **Section 5** of this report. Furthermore, upgrading the Clunbury treatment works (following

connecting works) would take the total phosphate reduction to 27.57kg/yr, which is greater than the amount required for mitigation. It would thus contribute to restoration of the SAC. Similarly, altering the discharge location of the Bishops' Castle treatment works could deliver a reduction of 31.90kgTP/yr, as well as reducing the mitigation required by 3.07kgTP/yr. In this event, this solution would mitigate all the proposed development as well as making a proportionately large contribution to restoration. Note: to enable improvements to wastewater treatment works to count as mitigation they could to be part funded by developer contributions. The Defra announcement (Defra, 2022) of 16th March 2022 (improving wastewater treatment works section) indicates that Ofwat is developing a proposal that could enable water companies to directly accept developer contributions for improvements to wastewater treatment works as a means of mitigating nutrient loads from new developments.

204. SuDS are also likely to form a key solution in this catchment by treating on-site phosphate loading, and could remove between 10-100% loading from the new land use. Developments should aim to reduce their phosphate load through on-site mitigation as much as possible, in order to reduce the area of land / scale of interventions required to deliver the remaining mitigation. Paring on-site SUDS with one or more of the measures identified above has the potential to deliver not only nutrient neutral development, but to provide a betterment – something that is encouraged by Natural England, particularly in the Clun catchment.

6.2 Next steps

205. The following sets out the next steps required in order to develop the solutions presented within this report to functioning phosphate mitigation solutions.

- Identification of the preferred solutions to be delivered and the likely costs, timescales and delivery mechanisms. This will be presented in a separate document
- A database or spreadsheet-based tracking tool to register and record the phosphate loading for each development and identify which schemes this will be delivered through. This should include details of any agreements. The tool should be able to assign credits from various mitigation schemes at various stages of a development's lifetime.
- The above documents will inform a future SPD which will be prepared to support forthcoming Shropshire Local Plan policy on the safeguarding of the River Clun SAC.

***Table 6-3**: Short-list solutions summary*

Solution	Development Timescale	Duration timescales	P removal	Farm type	Maintenance	Additional benefits	Best available evidence?	Effective beyond reasonable scientific doubt?	Precautionary?	In perpetuity?	£ / kgTP/yr	£/dwelling (one off payment)
Taking land out of agricultural use	Short-term	Short-term	Mean 1.01kg/ha/yr	Not indoor pig or poultry	Harvesting every 2-4 years	Energy crops	Yes	Yes	Yes	No	£11,700	3,929 - 6,994
Cessation of fertiliser / manure application	Short-term	Short-term	0.27kg/ha/yr	Arable and Grassland	None	Nitrogen reduction	Yes	Yes	Yes	Yes	£15,950 - £14,475 per kg/yr mitigation for every year	115,366 117,992
Riparian buffer strips	Medium-term	Medium / long-term	Mean ~67%	All	Vegetation management	Water quality Less erosion Habitats Amenity	Yes	Yes	Yes	Yes	£11,700 for 80 years of mitigation	795
Wet woodlands	Medium-term	Medium / long-term	Uncertain	Riparian land holdings (withing FZ3)	Minimal	Recreation carbon sequestration Biodiversity conservation Air pollution reduction Flood risk reduction Biofuel	No	Yes	Yes	Yes	Likely to be similar to riparian buffers	795
Cover crops	Short-term	Short-term	Uncertain	Arable farms	Preparation, planting, destruction, cultivation	Water quality Habitat creation	No	Yes	Yes	Yes	N/A	-

Solution	Development Timescale	Duration timescales	P removal	Farm type	Maintenance	Additional benefits	Best available evidence?	Effective beyond reasonable scientific doubt?	Precautionary?	In perpetuity?	£ / kgTP/yr	£/dwelling (one off payment)
Constructed wetlands	Long-term	Long-term	Mean 46%	All	Vegetation/ sediment management	Flood risk Amenity Habitats Community engagement Educational opportunities Water quality	Yes	Yes	Yes	Yes	£13,559	921
Secondary treatment wetlands	Long-term	Long-term	Mean 46%	All	Vegetation/ sediment management	As above	Yes	Yes	Yes	Yes	-	-
Water company improvements	Long-term	Long-term	Up to 40%	n/a	Monitoring	n/a	Yes	Yes	Yes	Yes	Developer contributions unknown yet	-
Willow buffer areas	Medium-term	Long-term	70% long term	n/a	Harvesting	Water quality Habitat creation	No	No	Yes	Yes	n/a	-
SuDS	Short-term	Medium / Long-term	Variable Site specific	n/a	Regular (e.g., desilting)	Water quality Reduced erosion Habitats Amenity value	No	Yes	Yes	Yes	n/a	-
Portable treatment works	Short / medium-term	Short / medium-term	Up to 0.5 mg/l	n/a	General system maintenance	Water quality	Yes	Yes	Yes	No	n/a	-

Solution	Development Timescale	Duration timescales	P removal	Farm type	Maintenance	Additional benefits	Best available evidence?	Effective beyond reasonable scientific doubt?	Precautionary?	In perpetuity?	£ / kgTP/yr	£/dwelling (one off payment)
Alternative wastewater providers	Long-term	Long-term	Effluent to 0.3mg/l	n/a	Paid for through water bills	Can be integrated with SuDS	Yes	Yes	Yes	Yes	n/a	-
Restrictions on water use	Medium-term	Long-term	10-30%	n/a	Replacement parts	Water resources Sustainability	Yes	Yes	Yes	Yes	n/a	-
PTPs	Short-term	Long-term	95% of wastewater	n/a	Annual cleaning Phosphate dosing	Water quality	Yes	Yes	Yes	Yes	£3,580	-
Cesspools	Short-term	Short / medium-term	100% of wastewater	n/a	Regular emptying and inspection	None	Yes	Yes	Yes	Yes	n/a	-
Highways drainage improvements	Medium-term	Medium / long-term	25 – 45%	n/a	Desilting required	Water quality, habitat creation, sediment runoff	No	Yes	Yes	Yes	n/a	-

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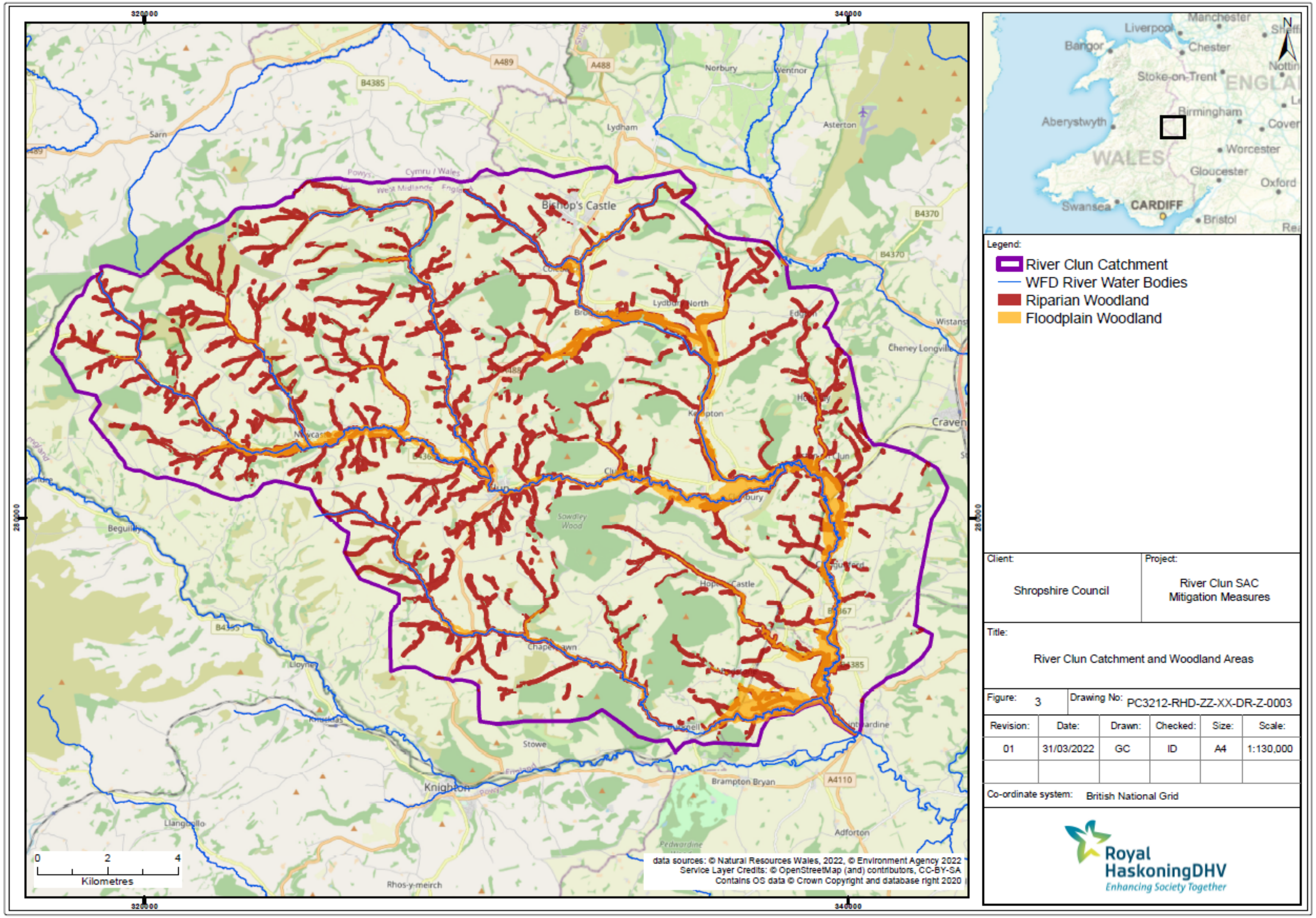
8 Appendix A: Figures showing areas within the River Clun catchment suitable for the implementation of woodland or wetlands to remove phosphate

Figure 13 Locations within the River Clun catchment suitable for the implementation of floodpain and riparian woodland for the removal of phosphate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River Clun Catchment
WFD River Water Bodies
Riparian Woodland
Floodplain Woodland
Client:
Shropshire Council
Project:
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River Clun Catchment and Woodland Areas
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Revision: 01
Date: 31/03/2022
Drawn: GC
Checked: ID
Size: A4
Scale: 1:130,000
Co-ordinate system: British National Grid
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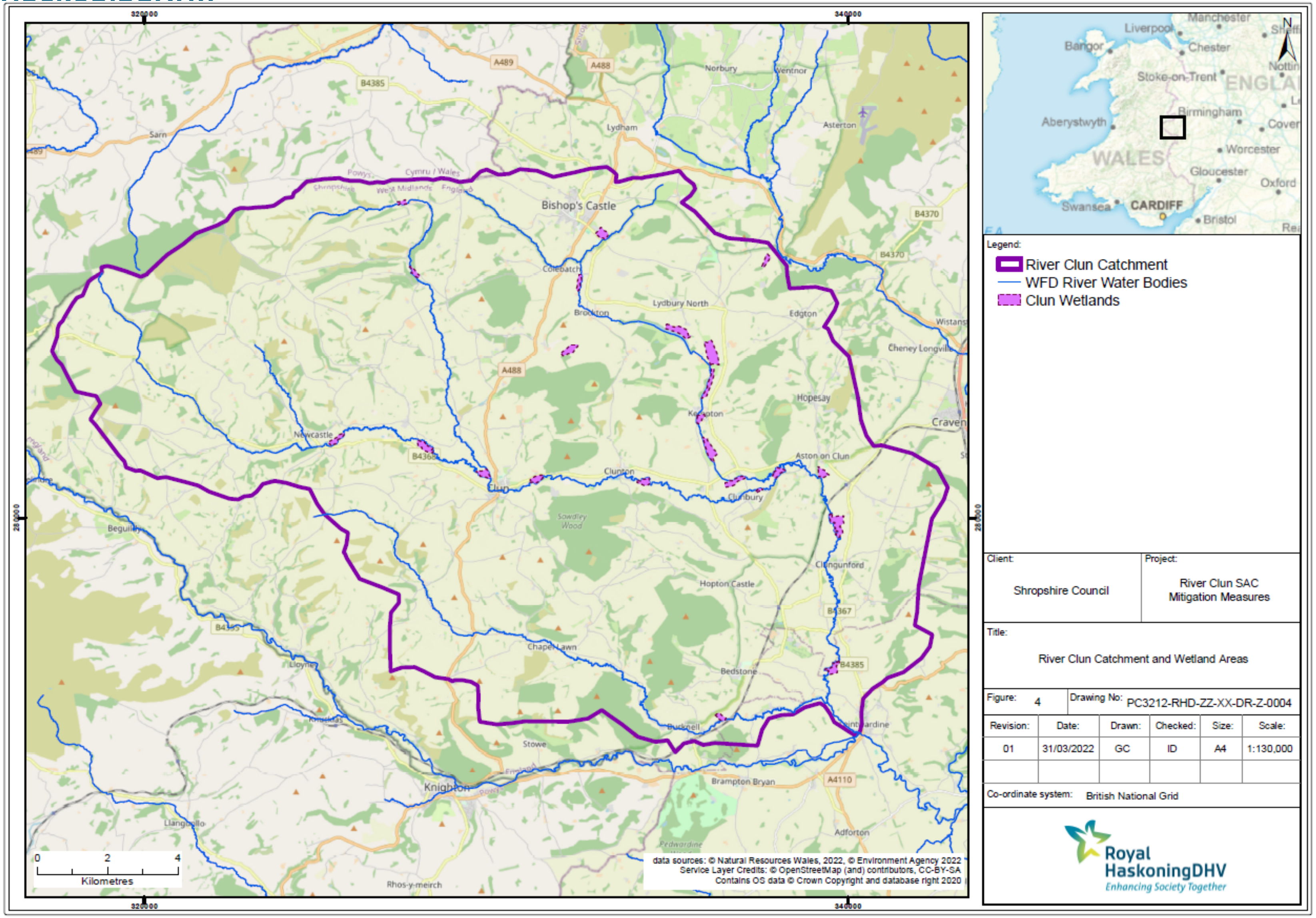
0 2 4
Kilometres
320000
340000
Bishop's Castle
Knighton
Manchester
Liverpool
Bangor
Chester
Stoke-on-Trent
Birmingham
Aberystwyth
WALES
Worcester
Gloucester
Oxford
Swansea
CARDIFF
Bristol

Figure 14 Areas in the River Clun catchment suitable for the implementation of wetland areas for the removal of phosphate



320000
340000
280000
Bishop's Castle
Lydbury North
Clun
Clunton
Clunbury
Aston on Clun
Clungunford
Hopton Castle
Chapel Lawn
Bedstone
Newcastle
Knighton
Brampton Bryan
Hopesay
Edgton
Craven Arms
Norbury
Lydham
Asterton
Sarn
Stowe
Adforton
A488
A489
B4385
B4368
B4367
B4370
A4110
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Kilometres
data sources: © Natural Resources Wales, 2022, © Environment Agency 2022
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Contains OS data © Crown Copyright and database right 2020
Liverpool
Manchester
Bangor
Chester
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Aberystwyth
Birmingham
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CARDIFF
Bristol
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Legend:
River Clun Catchment
WFD River Water Bodies
Clun Wetlands
Client:
Shropshire Council
Project:
River Clun SAC Mitigation Measures
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Co-ordinate system: British National Grid
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