HYDROGEO
Groundwater and Environment

Surface Water Quality Management

Willey Cottage Farm, Presteigne

On Behalf of

Tim Hodnett

Quality Management

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1 Introduction

1.1 Background

This Technical Appendix has been prepared by Hydrogeo Ltd. (Hydrogeo) to support a planning application for proposed poultry farming facilities at Willey Cottage Farm, Presteigne, Herefordshire LD8 2LY (the Planning Site). The Planning Site includes areas of proposed and existing buildings associated with poultry farming, along with areas of undeveloped greenfield land (agricultural fields).

A Flood Risk Assessment (FRA) for the Planning Site has been submitted by Hydrogeo under separate cover. The FRA also includes an assessment of the existing and proposed surface water drainage for the proposed development; the drainage assessment only covers the proposed construction at the Planning Site and therefore this area will be referred to as the Drainage Site. The Drainage Site falls entirely within the Planning Site. The location of the Planning and the Drainage Site is discussed in Section 1.1.

This Technical Appendix covers the proposed surface water quality control measures to be used to mitigate and potentially improve runoff discharges to local surface water features as a result of poultry farming activities at the Planning Site. The report will discuss the way in which the Sustainable Drainage System (SuDS) features proposed at the Drainage Site can be used to reduce phosphate input to local surface water features following research-based guidance.

1.2 Regulatory Position Statements

The Site lies within the River Lugg catchment, is designated as a Special Area of Conservation (SAC) sub-catchment of the wider River Wye SAC.

The current (March 2020) position statement from Herefordshire Council for the River Lugg advises that there is a Nutrient Management Plan (NMP) in place for the River Wye SAC to reduce the phosphate levels to below the set limit by 2027. This involves reducing the average phosphate concentration in both rivers to less than 0.05mg/l.

Common sources for increased phosphate concentration in the River Lugg include waste water treatment and runoff from agriculture. It is a requirement that planning applications which may have an impact on phosphate concentrations in the River Lugg are assessed by the Local Authority.

The current approach taken by the Local Authority in granting planning applications is set out as follows:

"There remains potential for a positive appropriate assessment to enable development to proceed, on Natural England's advice, where it can be demonstrated that development is nutrient neutral (where avoidance / mitigation measures included in the plan or project counterbalance any phosphate increase from the plan or project) or would lead to 'betterment'. Proposals will need to provide appropriate evidence of this."

The Herefordshire Council position statement has been attached at Appendix A.

1.3 Site Location

The Planning Site is located at Willey Cottage Farm, Presteigne, Herefordshire LD8 2LY. The location of the Planning Site has been shown in Figure 1-1. The boundaries of the Planning Site and the Drainage Site have been shown in Figure 1-2.

The National Grid Reference for the centre of the Drainage Site is 332412, 268412.

Figure 1-1 Site location

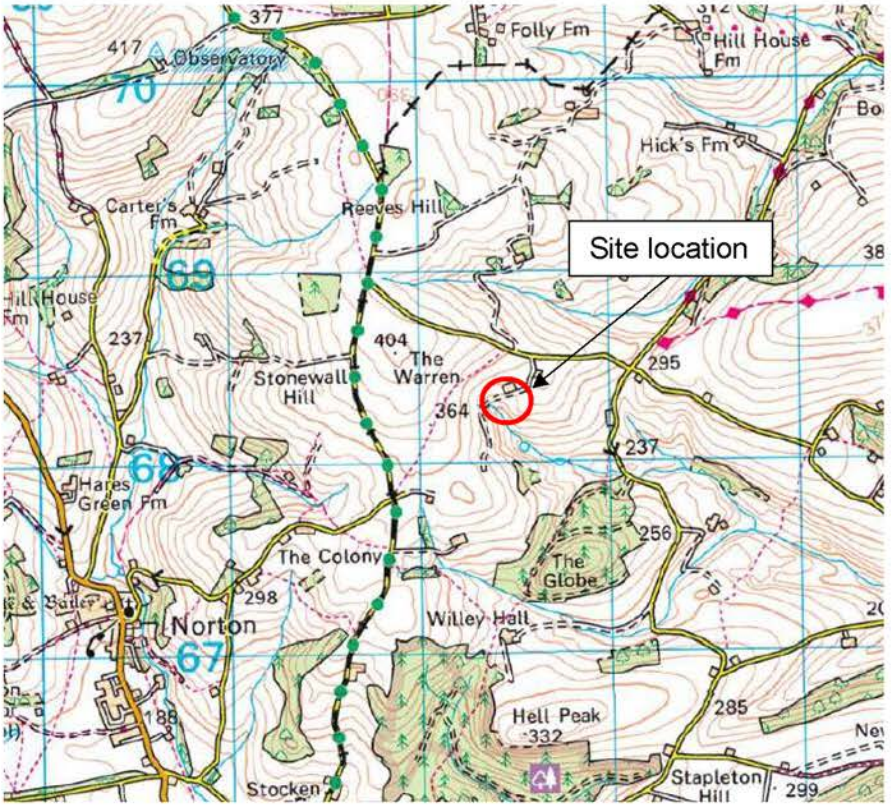
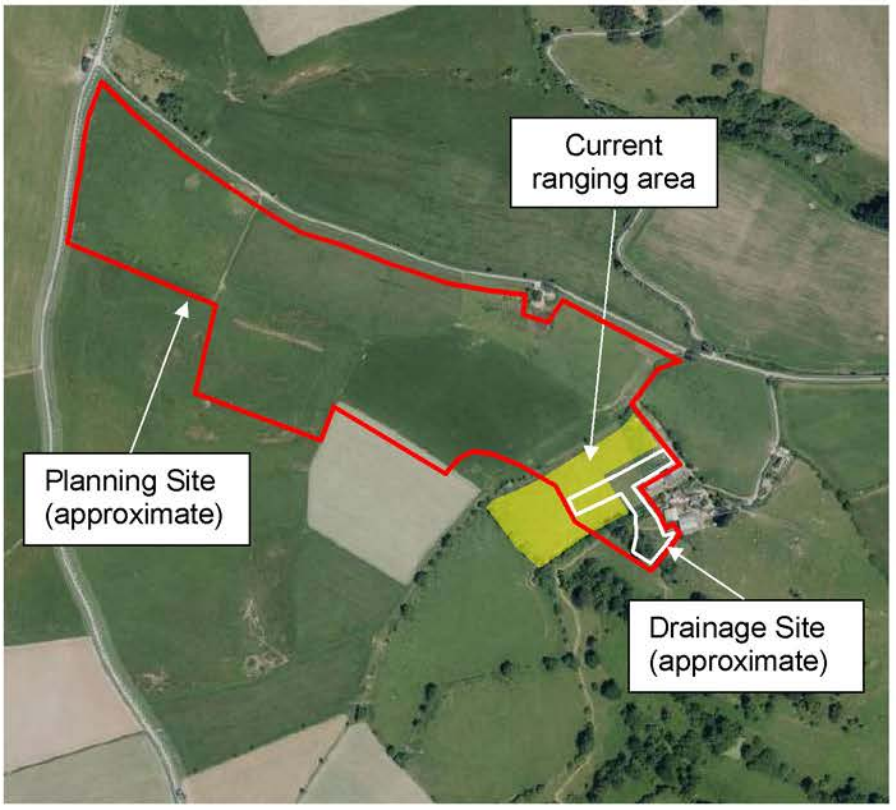


Figure 1-2 Site boundary



1.4 Existing Development

The Planning Site currently comprises agricultural fields, one of which is used for free-range poultry ranging, along with an existing poultry shed and associated processing buildings and parking/loading areas. It is understood that the existing poultry shed and associated processing areas were constructed within the last 2 years.

The Planning Site is bounded on all sides by agricultural land, including farm buildings immediately to the east.

1.5 Proposed Development

It is proposed to construct a new poultry shed immediately to the west of the existing poultry shed, along with a new muck store adjacent to the original farm buildings. The proposal includes the extension of the poultry ranging area to include a number of other fields, and the reduction in size of the existing ranging area.

A plan of the proposed development and wider Planning Site has been shown in Drawing 1.

1.6 Ground Levels

The Planning Site slopes generally from north west to south east. At the central area the maximum elevation is approximately 405m above ordnance datum (mAOD), and at the eastern boundary adjacent to the Drainage Site the elevation is approximately 318mAOD. The far north west corner of the Planning Site falls gently towards the north.

1.7 Catchment Hydrology and Existing Drainage

A spring emerges approximately 130m to the south of the raging area: this is the source of Lime Brook which flows through the valley to the south east of the Planning Site.

At its closest point Lime Brook is located approximately 80m south west of the Drainage Site. Lime Brook confluences with the River Lugg approximately 6.3km south east of the Planning Site.

The source of a separate unnamed stream is located approximately 30m north of the ranging area at the far north west corner. A pond is located approximately 30m south of the Planning Site in one of the ranging fields.

There are no public surface water sewers located within the vicinity of the Planning Site.

The surface water from the existing poultry shed and associated processing areas is collected in traditional sub-surface drainage network and discharged to land within 50m south of the poultry shed.

1.8 Proposed Surface Water Drainage

The proposals for the surface water drainage at the Drainage Site are detailed within the Hydrogeo FRA Report (March 2021). It is recommended that the FRA report is read in conjunction with this Technical Appendix.

A summary of the proposed surface water drainage has been included below:

- Runoff from impermeable roof and hardstanding areas will be collected by guttering and sub-surface pipework;
- Water will be conveyed to a vegetated detention basin;
- The basin will provide storage for a 1 in 100 year rainfall event, and will provide water treatment benefits;
- Water will be discharged from the basin at rate restricted to greenfield runoff via an orifice plate flow control device;
- Water will be finally discharged via reed beds to Lime Brook to the South of the Drainage Site via a sub-surface pipe.

Additional source and pathways surface water quality control measures are proposed to be included as discussed in Section 3.4.

2 Surface Water Management - Existing

2.1 Site Areas

The Planning Site mainly comprises a ranging area for poultry. The proposed ranging area has been shown on Drawing 1 and includes 6 no. individual undeveloped grassy agricultural fields labelled Field 1 to Field 6. Currently only Field 1 is used for poultry ranging. The internal field boundaries and labels are solely for the purpose of identification in this report. It is noted that internal boundaries within the ranging area may change and none will have formal designations in the planning application.

The ranging area includes land with variation in topography and slope direction, as well as proximity to surface water features.

The intensity of use for the ranging area is not expected to be equal; with a higher use expected close to the poultry sheds and lower use expected at distant areas.

Additionally, the area immediately surrounding the poultry sheds is expected to receive relatively elevated concentrations of phosphates from poultry manure when compared with the ranging area. The poultry sheds fall within the Drainage Site; the surface water from the sheds will be collected, stored and discharged separately to that of the ranging area.

These factors imply that the phosphate mitigation measures will vary across the ranging area, and also vary between the ranging area and the Drainage Site in response to the level of risk.

A number of areas at the Planning Site are considered to be more sensitive, with the rationale for the definition of these areas described in Section 2.2.

Drawing 1 also includes a number of surface and groundwater locations around the ranging area which are likely to be at risk of phosphate contamination. These locations were selected for background water quality testing undertaken by Hydrogeo in February 2021, as discussed in Section 3. **Error! Reference source not found.**

2.2 Phosphate Sensitive Areas

Drainage Site

The Drainage Site area is considered to represent the highest risk for phosphate runoff from the Planning Site. This relates to the area immediately surrounding the poultry sheds: the pop holes where poultry enters and exits.

The provision of phosphate mitigation measures at the pop holes has an impact on the proposed surface water runoff drainage scheme outlined in the Hydrogeo FRA (March 2021). Recommended additions to the surface water runoff scheme at the Drainage Site have been discussed in Section 3.4.

Ranging Area

A number of higher sensitivity areas are present around ranging area based on the proximity to the poultry sheds and existing surface water features.

Higher Sensitivity Fields

The closest ranging field to the sheds, Field 1, is expected to be used most commonly. This field falls towards the south east and currently contains 2 no. distinct natural linear depressions in the hillside where it is expected that surface water would be channelled during heavier incident rainfall. The proposed ranging area boundary includes a reduction in size of this field which would exclude these 2 no. liner depressions.

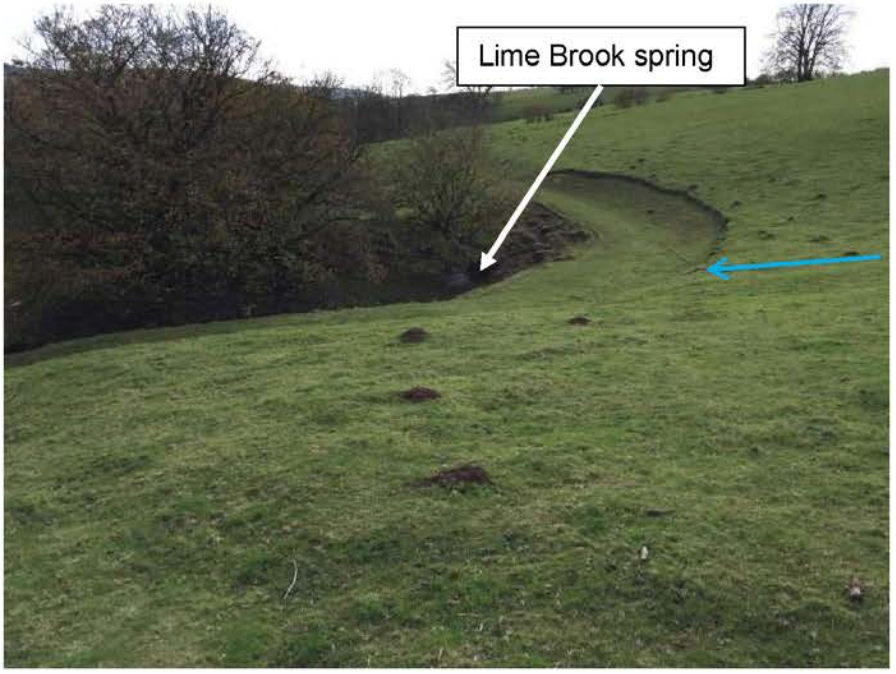
These depressions have been shown in Figure 2-1 and Figure 2-2.

Figure 2-1 Field 1 current runoff route - looking north east

Figure 2-2 Field 1 current runoff route - looking west

The spring source for Lime Brook is present to the south of Field 1. This feature is sensitive to increased phosphate concentration from surface water runoff and has been shown in Figure 2-3.

Figure 2-3 Natural runoff route south of Field 1 - looking south



The source of an unnamed stream is located just outside the north west corner of the ranging area at Field 6 is also considered to be sensitive to phosphates. The natural drainage at this location of Filed 6 is poor and the ground was waterlogged during a Hydrogeo site visit in February 2021.

Recent drainage work has been undertaken on the small lane immediately to the north of Field 6, with a new drainage ditch and culvert now present. The culvert conveys water north towards the source location and contributes to this water feature.

Congregation of poultry at this corner of the field may increase the phosphate concentration in the natural runoff from the field where the ground is waterlogged, to be conveyed to the stream source off-site by the new culvert below the road. These features have been shown in Figure 2-4 and Figure 2-5.

Figure 2-4 Field 6 waterlogged area - looking north

Figure 2-5 Highways drainage to north of Field 6 - looking north east

Standing water is also present at the south west corner of Field 6. This area falls gently towards the west and is the only part of the ranging area which may contribute to a separate set of valleys draining to the west of the Planning Site. However due to an earth and rock embankment at the western boundary of the field the likelihood of significant runoff to the west is considered to be lower than at the north west corner as described above.

Figure 2-6 Field 6 standing water - looking west

Lower Sensitivity Fields

All other fields at the ranging area are considered to be less sensitive to phosphate-rich runoff reaching surface water features. Mitigation measures are still proposed in some cases for other fields, as discussed in Section 3.1.

2.3 Historic Water Quality (Environment Agency)

EA freshwater sampling data is available for a Lime Brook at a location downstream of the Planning Site. This is described as 'The Priory' and has a national grid reference of 337400, 266115. A total of 64 no. water samples have been collected between 2007 and 2021. The dataset has been shown in Figure 2-7 and summarised below.

The most recent EA data was collected between the 8th November 2019 and the 3rd March 2021. The concentration of phosphate in Lime Brook across 10 no. samples collected between these dates ranges between 0.013mg/l on 03/03/2021 and 0.44mg/l on 04/12/2020.

The result of 0.44mg/l (04/12/2020) is the highest of all 64 no. collected by the EA between 2007 and 2021.

Interpretation

The data indicate fluctuating phosphate concentration In Lime Brook over time. Concentrations are generally below 0.05mg/l between 2007 and 2014. From 2014 onwards the fluctuation in concentration is greater, with several results recorded between 0.1mg/l and 0.3mg/l.

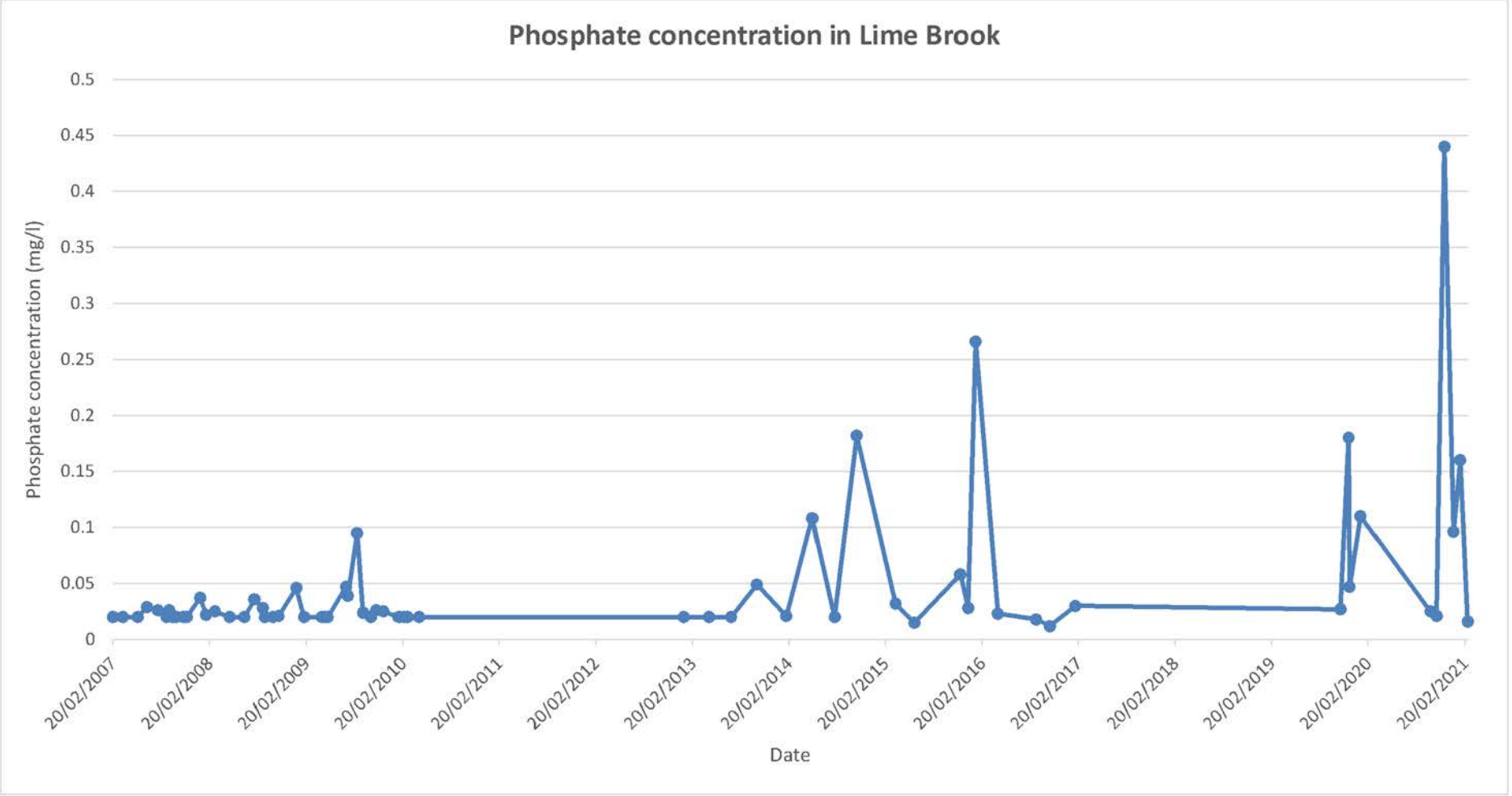
The single result of 0.44mg/l on 04/12/2020 is not considered to be reflective of the overall trend or of any recent upward trend. The 3 no. subsequent results for January, February and March 2021 are more in line with the general concentrations recorded since 2019.

The poultry farming activities at the Planning Site have been operational for approximately 2 years. Aside from the single result of 0.44mg/l in December 2020 the grouping of results between 2019 and 2021 is generally in line with the grouping of results between 2013 and

2017. This suggests that the construction of the existing poultry development at the Planning Site has not had a discernible impact on Phosphate concentrations in Lime Brook.

Despite the recorded phosphate concentrations in Lime Brook following poultry farming development over the last 2 no. years being generally in line with those recorded prior to development, it is considered that mitigation proposed within this Technical Appendix is prudent and would bring further water quality benefits to Lime Brook.

Figure 2-7 Historic phosphate concentrations - Lime Brook



EA data collected between 20th February 2007 and 3rd March 2021. Sampling location ID: MD-50836. NGR: 337400, 266115.

3 Surface Water Management - Proposed

3.1 Guidance

The June 2012 Environment Agency (EA) document Rural Sustainable Drainage Systems (RSuDS) has been used to determine the suitability of a number of mitigation options for the different parts of the ranging area.

The cost effectiveness and efficacy at reducing phosphate runoff has been the focus of the measures selected. These are based on the descriptions of each option in Section 6 and the summary shown in Table 6.1 of the EA document.

Further sources of information have been consulted including the April 2014 Woodland Trust guidance 'Tree planting for free range poultry', and literature sources and case studies where the measures have been successfully implemented.

Mitigation proposals for the Planning Site have been discussed in Section 3.3 and Section 3.4 of the report and fall into the following categories:

- Source control - canopy cover at the proposed poultry shed;
- Pathway control - buffer zones for runoff control, detention basin for settlement, and reed beds for phosphate removal.

3.2 Efficacy of Mitigation Features

At a number of sensitive locations across the ranging area buffer strips are proposed in order to slow runoff, reduce suspended solids and reduce phosphates entering surface water features. These features include grassy strips, dry riparian buffer strip and wet riparian buffer strips.

Riparian buffer strips are wide (up to 50m) bands of natural or naturalised vegetation situated alongside water features. In this case surface water features would include springs and ponds found at the ranging area. The riparian buffer strips ensure that machinery operations and poultry are kept away from these water features which reduces the risk of direct pollution.

Studies have been undertaken to assess the efficacy of buffer strips of various types, including a DEFRA project PE0205; 'The strategic placement and design of buffering features for sediment and phosphorus in the landscape' (cost benefit analysis attached at Appendix B). The study was undertaken between 2003 and 2006 by the National Soil Resources Institute at Cranfield University.

The cost-benefit analysis for the project concluded that for silty clay and silty clay loam soils the ground cover planting had the greatest impact on reduction of phosphates in runoff.

The report confirms that *"On all medium and heavy soils phosphorus retention increased by between 18-48% as ground cover increased, regardless of buffer width."* Slope angle and stem diameter were shown to have little effect.

3.3 Ranging Areas

Proposed Drainage Features

The proposed mitigation measures for the ranging area have been shown on Drawing 2.

Pathway and Runoff Control Measures

- The ranging area at Field 1 has been reduced in size to maintain a minimum 30m distance to the spring for Lime Brook, and to avoid the 2 no. linear depressions in the field which may act to concentrate runoff down-slope. The distance from the closest point of the revised Field 1 ranging area to the spring is approximately 130m and the closest point to Lime Brook itself is approximately 113m.

- The alteration of the ranging area boundary at Field 1 is considered to afford sufficient protection from phosphates for Lime Brook spring and the upper reaches of Lime Brook itself.

- The ranging area at Field 3 has been designed so that a distance of 30m is maintained to a pond located along the southern field boundary, as shown in Drawing 2. It is proposed that the 30m wide zone between the boundary and the pond is installed as a riparian buffer in order to protect this water feature. It should be noted that there is no direct connection between this pond and any flowing water features surrounding the Planning Site, therefore the risk to the wider river catchment is considered to be negligible.

- It is proposed that 30m riparian buffer strips are installed at 2 no. locations at the western corners of the ranging area in Field 6, where waterlogged ground is present. At the north west corner of Field 6 the source of an unnamed stream is located on the opposite side of a small road. A surface drain and culvert provides a preferential pathways for runoff to reach the stream at this location. At the south west corner of Field 6 an area of waterlogged ground is present including a small possibly ephemeral pond.

- It should be noted that the frequency that poultry is expected to travel to the western most ranging field (Field 6) is likely to be low, therefore the risk to the unnamed stream to the north of Field 6 is considered to be low.

- A 10m wide buffer is proposed to be installed to the north and parallel to the poultry sheds in Field 1. This field slopes towards the sheds and is likely to be where poultry spends the most time. Due to space and access constraints, it is proposed that this is installed as a grassy buffer strip only.

Details of the recommended planting for the riparian buffer strips has been discussed in Section 3.5.

3.4 Drainage Site

The proposed mitigation measures for the Drainage Site have been shown on Drawing 2.

Source Control Measures

- The pop holes at the northern side of the existing (Figure 3-1) and the proposed poultry sheds are considered to represent the most significant potential source of phosphates at the Planning Site. Under the current design this area is stoned up and cannot be effectively cleaned. Poultry manure in this area may potentially be washed into drainage channels alongside the sheds by incident rainfall, and into the surface water drainage system proposed in the Hydrogeo FRA Report.

Figure 3-1 Existing poultry shed - looking east

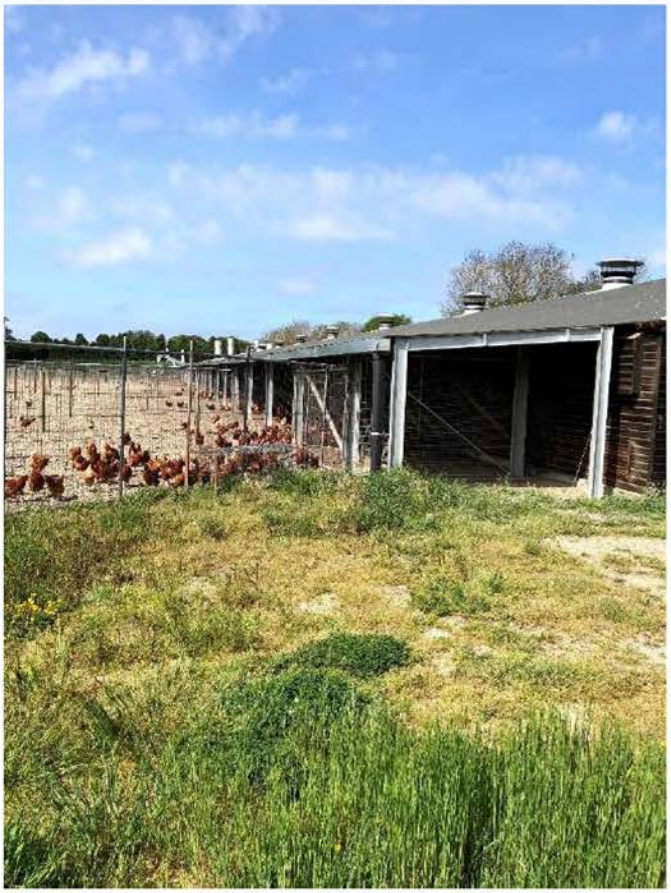
Pathway and Runoff Control Measures

- Under the proposals in the FRA Report, the surface water runoff from developed areas in the Drainage Site would be conveyed to a vegetated detention basin down-slope to the south, where storage and a treatment would be provided. The basin has been designed to accommodate the runoff resulting from a 1 in 100 year rainfall event, plus a 40% increase in rainfall intensity due to climate change and a 10% increase of impermeable surface area due to surface creep.

- The surface water drainage layout schematic developed as part of the Hydrogeo FRA Report has now been revised in order to mitigate the specific risk of increased phosphate concentration in poultry manure at the pop holes.

- The revised schematic takes into account a 2m wide canopy which will be installed at the northern edge of the proposed poultry shed in order to reduce incident rainfall at the pop holes. An example of a canopy for poultry shed pop holes has been shown in Figure 3-2. Surface water runoff from the canopy will be conveyed to the detention basin as with runoff from other roof areas.

Figure 3-2 Poultry shed canopy example



- The surface below the canopy will be concrete allowing effective poultry manure collection, reducing the risk of mobilisation into surface water runoff.

- Despite the canopy for the pop holes at the proposed poultry shed, it is considered prudent to provide additional treatment for the surface water runoff conveyed to the vegetated detention basin. It is proposed to install a reed bed following the outfall from the basin and the flow control device. The reed bed will provide an additional degree of treatment for phosphates and will not be required to provide attenuation storage.

- A permeable berm is proposed to be installed within the basin, creating a sediment forebay. This will provide further treatment by allowing fines to settle prior to entering the rest of the basin and then the reed bed.

- The canopy increases the impermeable surface of the Drainage Site by 145m^2 and therefore the water storage volume of the detention basin has been calculated to be 259m^3.

The reed bed and sediment forebay have been depicted on the drainage schematic drawing for the Hydrogeo FRA Report, with the final layout and design detail subject to a landscape plan as part of the planning application.

3.5 Planting Proposals

Planting in the riparian buffer strips should comprise a mixture of shrubs and trees, which will encourage poultry foraging and more distant use of the ranging areas. Tree and shrub species selected should reflect the existing species around the Planning Site in order to have best chance of success, with native species prioritised wherever possible.

The Woodland Trust guidance document 'Tree planting for free range poultry' (Appendix C) recommends a list of tree and shrub species:

3.6 Proposed Mitigation Summary

The qualitative summary shown in Table 6.1 of the June 2012 EA RsUDS guidance document has been shown in Figure 3-3.

The table categorises the benefits of various RSuDS methods in the following manner:

- Green = High
- Orange = Medium
- Red = Low

Figure 3-3 EA RSuDS qualitative summary table

Rural SuDS Component (results for basic version of system)	Multiple Benefits				Performance						Costs				
	Flow	Water Quality	Biodiversity	Amenity	Flow	Suspended solids	Total Phosphorus	Total Nitrogen	Pathogens	Pesticides	Set up	Running	Cost effectiveness	Lifespan	Site suitability/ limitations
In-ditch options															
Swales										E					
Infiltration trench					E					E					
Filter/French drains					E										
Barriers & traps (basic)					E	E	E	E	E	E					
Wetland					E				E	E					
Ponds[3]															
Detention															
Infiltraion									E	E					
Retention									E						
Woodland/Forestry															
Woodland shelter belts															
Buffer strip/headland technology															
New hedges/dry stone dyke					E	E	E	E	E	E					
Dry grass filter strips					E										
Buffer strip (dry)					E										
Buffer strip (wet)[1]					E				E	E					
Contour bund					E	E	E	E	E	E					
Filter Berm					E	E	E	E	E	E					
Wetland															
Artificial/restored wetland										E					
Biobeds															
Farm buildings															
Rainwater harvesting					E										
Cross-drains					E										
Green roofs															
Other															
Sediment trap															
Pervious surfaces									E	E					
Sedimentation boxes						E	E	E	E	E					
Soak away							E			E					
Grip (gully) blocking										E					

Environment Agency 2012. '*Rural Sustainable Drainage Systems*'

Figure 3-3 shows that dry buffer strips score highly for water quality, biodiversity, and amenity. In particular the phosphate reduction benefit is graded as 'High'. Other important factors include setup and running costs, and lifespan. On these aspects buffer strips also score highly.

Detention basins score highly for flow and sediment control, as well and longevity. The primary objective of the detention basin proposed within the Hydrogeo FRA Report is to provide water storage for a 1 in 100 year rainfall event from the positively drained areas of the Drainage Site. The addition of a permeable berm and sediment forebay, along with a reed bed will provide cumulative water quality benefits for the entire site in the future.

It is therefore considered that the proposed mitigation at the Planning Site will be effective and suitable for the intended development.

4 Summary and Conclusions

4.1 Summary

This Technical Appendix presents summary of the proposals to mitigate potential water quality impacts (specifically phosphates) on the River Lugg catchment from the proposed poultry farming development at Willey Cottage Farm, Presteigne, Herefordshire.

Historic surface water monitoring undertaken by the EA between 2007 and 2021 indicate that the concentration of phosphates in Lime Brook has fluctuated over time. Recent results over the last 2 no. years since the poultry development at the Planning Site has been operational are broadly in line with historic fluctuations between 2013 and 2017.

The provision of recognised water quality mitigation features for the proposed development at the Planning Site, and the existing site are recommended in order to protect the future water quality in Lime Brook.

At the northern side of the proposed poultry shed a 2m wide canopy is proposed to form part of the development. This canopy will provide protection for the pop holes at this shed and reduce the risk of incident rainfall and runoff from washing poultry manure into the drainage system at this location where manure loading is always at its highest. A concrete surface will be installed allowing effective poultry manure collection without affecting the formal drainage runoff. Roof water from the canopy will be discharged to the proposed sustainable drainage system components as described in the Hydrogeo FRA Report.

Revised hydraulic calculations have been undertaken for the additional impermeable surface area at the proposed poultry shed and additional water treatment has been proposed. This will take the form of a permeable berm within the basin, creating a sediment forebay, and the addition of a reed bed system. The reed bed feature is proposed to be installed following surface water discharge from the detention basin located in the south of the Drainage Site.

Across the ranging area a number of more sensitive areas have been identified adjacent to surface water features such as springs and ponds. It is proposed that these areas are fenced off and riparian buffer strips are installed in order to reduce the likelihood of poultry manure from reaching the features.

The efficacy of riparian buffer strips for protecting surface water features from runoff has been demonstrated in EA guidance and referenced in this Technical Appendix. It is proposed that the buffer strips are planted with a selection of native trees and shrubs following Woodland Trust guidance.

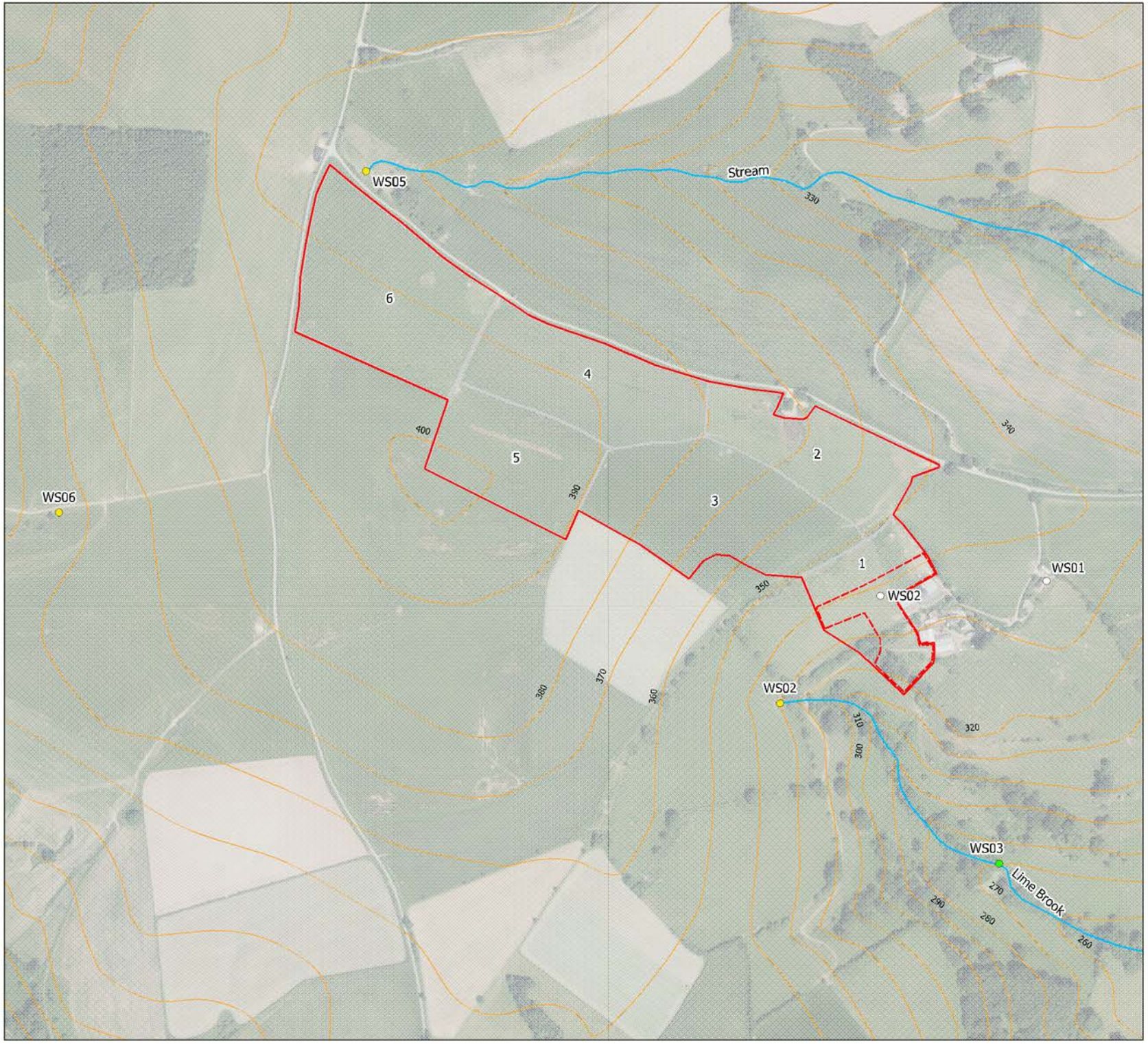
4.2 Conclusion

In conclusion, the surface water runoff quality management measures at the Planning Site (from catchment to discharge) will provide significant cumulative protection to the surrounding water features and to the wider River Lugg catchment.

Drawings

Drawing 1

Site layout



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HYG820 Willey Cottage Farm

DRAWING 1

Site layout

KEY

- Planning Site boundary (approximate)
- Drainage Site boundary (approximate)
- Individual ranging field
- Elevation contour (mAOD)
- Surface watercourse

Water sampling locations

- Surface water sample
- Groundwater sample
- Spring sample

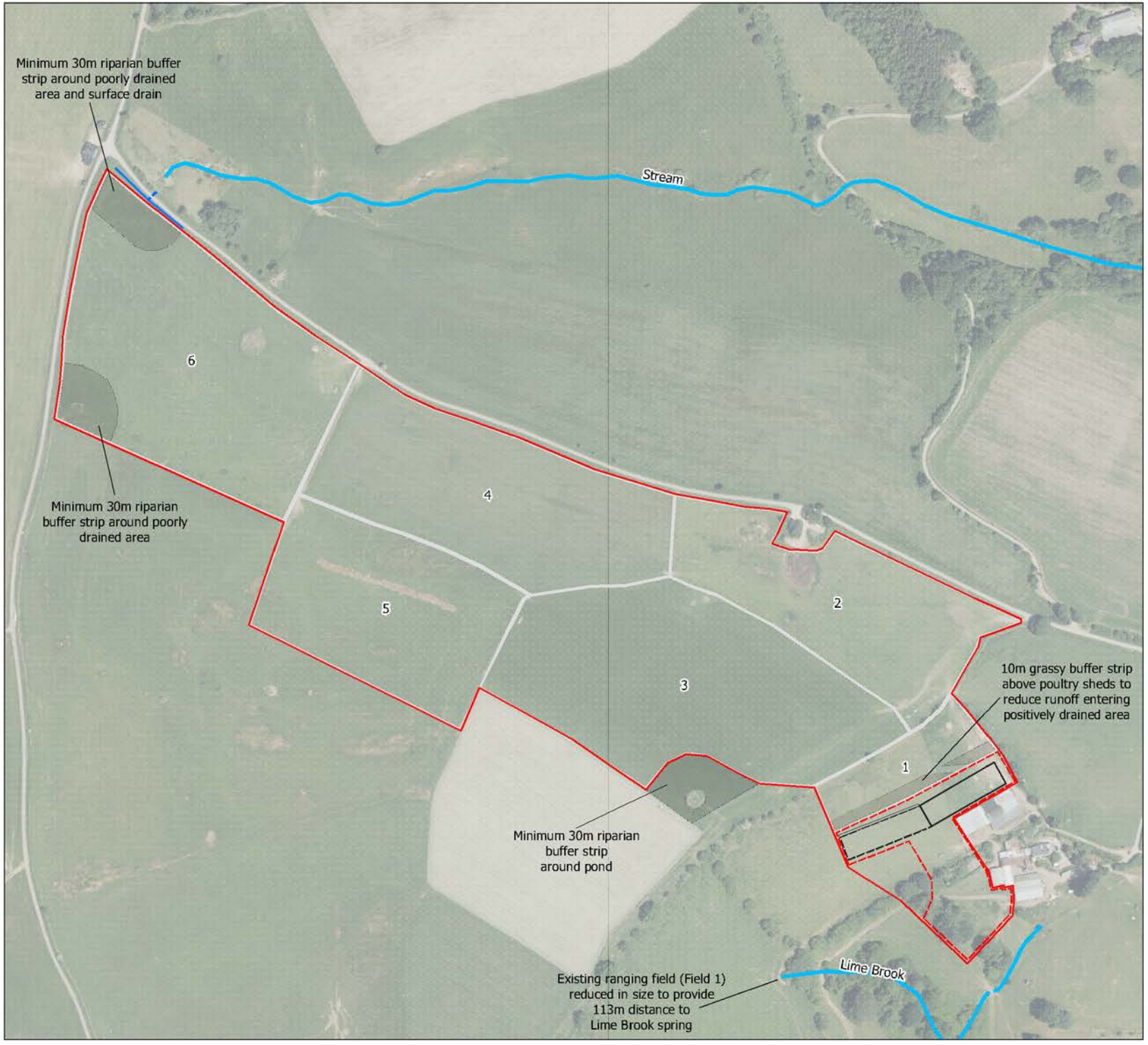
50 0 50 100 m

N

Date	By	Paper	Scale	Rev
03 2021	TP	A3	1:4,500	1

Drawing 2

Proposed mitigation measures



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HYG820 Willey Cottage Farm

DRAWING 2

Proposed mitigation areas

KEY

- Planning Site boundary (approximate)
- Drainage Site boundary (approximate)
- Existing poultry shed
- Proposed poultry shed
- Poultry shed canopy
- Individual ranging field
- Buffer strip
- Surface watercourse
- Surface drain
- Culvert

50 0 50 100 m

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Date	By	Paper	Scale	Rev
04 2021	TP	A3	1:3,000	2

Appendices

Appendix A

Herefordshire Council position statement - River Lugg

Herefordshire Council

Position Statement - Development in the River Lugg Catchment Area
March 2020

Background

Herefordshire is an area rich in its natural features of special value; its landscape, wildlife, recreation and health benefits, as well as its local economy. The River Wye and its tributaries are recognised as being of international importance for their unique character and wildlife, requiring the highest level of protection, management, enhancement and where appropriate; restoration.

Habitat Regulations Assessment

Herefordshire Council as the 'competent authority' under the Habitats Regulations, (The Conservation of Habitats and Species Regulations 2017) is legally required to assess the potential impacts of projects and plans, on internationally important sites which include the River Wye SAC (Special Area of Conservation).

In its role as competent authority, the council must carry out a 'Habitat Regulations Assessment' on any relevant planning application that falls within the red and purple areas shown on the plan. Where there is a 'Likely Significant Effect', the council must carry out an 'Appropriate Assessment' in order to determine, with scientific certainty, that there would be no 'Adverse Effect on Integrity' on the designated site from the plan or project, either alone or in combination with other plans and projects. The council takes this into account when considering whether planning permission can be granted. If it cannot be proven that there would not be an adverse effect on integrity, then planning permission cannot be granted without further stringent consideration under the Habitats Regulations.

Natural England (NE) is a statutory consultee on appropriate assessments and provides advice to competent authorities in relation to sites designated as SACs. Local Planning Authorities must have regard to the advice given by NE when making planning decisions (for both individual developments and local plans). NE's advice should be given considerable weight, but competent authorities are entitled to depart from it where they can give cogent reasons for doing so.

The Nutrient Management Plan

The NMP is a partnership plan developed to reduce phosphate levels in the River Wye SAC to below the set limit by 2027 - in line with the final date for achieving good ecological status set by the Water Framework Directive. The NMP is managed by the Nutrient Management Board (NMB), comprising; Herefordshire Council, Powys Council, Natural England, Natural Resources Wales, the Environment Agency, Dwr Cymru Welsh Water, Wye and Usk Foundation, National Farmers' Union, Farm Herefordshire and the County Land and Business Association.

The work that went into producing the NMP established that target phosphate levels were achievable, including when considering growth plans across the catchment. The NMP established that a combination of discharge reductions from waste water treatment works, land use change and changes to agricultural practice would be required to meet the target. Improvements to waste water treatment works were to be included in Welsh Water's work plans, whilst land use changes and changes to agricultural practice were to be progressed on a voluntary basis with support from schemes such as Catchment Sensitive Farming. At the time, this was adequate to allow the council to adopt its Core Strategy and to allow development proposals to proceed, however this is no longer the case.

Approach to proposals in the River Lugg catchment

The River Lugg is a tributary of the River Wye SAC, and forms part of the SAC from Hope under Dinmore. The River Lugg catchment covers predominantly the north of the Herefordshire administrative area (refer to plan). The River Lugg is currently exceeding its limits for phosphates, as a result of water pollution from both 'point' source (in particular sewage outlets) and 'diffuse' source (in particular agricultural run-off).

The approach taken by Herefordshire Council to date has been to permit development in the River Lugg catchment even when it would add to the existing phosphate levels in the river, because they were in the context of an agreed plan (the NMP) to reduce phosphate levels down to target. However, recent European case law means that this approach can no longer be taken. *For further information: on the Nutrient Management Plan; The Wye and Lugg Monitoring Dashboard web:*
https://www.herefordshire.gov.uk/directory_record/2097/nutrient_management_plan

Recent developments

Following the judgment in the case of *Cooperatie Mobilisation* handed down in November 2018 by the Court of Justice of the European Union (Joined Cases C-293/17 and C-294/17) (known as the Dutch Case), the approach to allowing proposals that would increase phosphate levels in the Lugg catchment has been reviewed.

Natural England provided initial advice to Herefordshire Council on 22nd July 2019 and further advice on 30th August 2019. Subsequent to this, Herefordshire Council has sought its own legal advice on the issue.

In the light of the Dutch judgment, where a site is failing its water quality objectives and is therefore classed as being in unfavourable condition, there is limited scope for the approval of planning applications that give rise to additional damaging effects. Furthermore, the future benefit of mitigation measures cannot be relied upon in an appropriate assessment, where those benefits are uncertain at the time of the assessment.

Natural England has advised that for any plans or projects in the River Lugg catchment which require an appropriate assessment, the effects are currently uncertain. This is because there is reasonable scientific doubt as to whether the NMP provides adequate mitigation and can be relied upon to underpin a conclusion of no adverse effects on integrity.

Herefordshire Council has sought its own legal advice on how to proceed and is liaising with Natural England and other partners to find an effective solution as soon as possible. This includes discussions with the NMB. It is likely that the NMP will need to be reviewed, in order to provide an increased level of certainty and allow it to be relied upon as mitigation in an appropriate assessment again.

An interim approach

There remains potential for a positive appropriate assessment to enable development to proceed, on Natural England's advice, where it can be demonstrated that development is **nutrient neutral** (where avoidance / mitigation measures included in the plan or project counterbalance any phosphate increase from the plan or project) or would lead to **'betterment'**. Proposals will need to provide appropriate evidence of this.

In relation to discharges to drainage fields in the red zone, Natural England have indicated that if the following criteria are in place then phosphates would be unlikely to reach the river as there is therefore no pathway for impacts. With no pathway for impacts there is no need for further Habitat Regulations Assessment:

- The drainage field is more than 50m from the designated site boundary or sensitive interest feature **and**;
- The drainage field is more than 50m from any surface water feature e.g. ditch, drain, watercourse, **and**;
- The drainage field is in an area with a slope no greater than 15%, **and**;
- The drainage field is in an area where the high water table groundwater depth is at least 2m below the surface at all times **and**;
- There are no other hydrological pathways which would expedite the transport of phosphorous e.g. fissured geology, flooding or shallow soil.

Appendix B

DEFRA project PE0205 - Cost benefit analysis

Appendix I – Cost Benefit Analysis

Introduction

Driven by polices such as the Water Framework Directive (2000/60/EC) and the need to put in place River Basin Management Plans for managing the water environment, considerable attention has been focused on how best to reduce diffuse pollution from agricultural sources. In recent years research has included calculation of cost and effectiveness of methods of pollution control, including the development of cost-curves for nitrate, phosphorus and other pollutants (Defra projects PE0203; NT2511; ES0121). The cost benefit analysis presented herein focuses on buffer designs and environments examined as part of this project, at the field scale.

For the purpose of this project the costs and benefits of installing grass buffer strips were divided into two primary components: financial and environmental. Table CB1 shows the components considered under these two categories and whether they represent a real or potential loss or gain of income to a farm.
Costs and benefits can be broken down into definable economic costs/gains and subjective cost/gains. Subjective costs/gains are inevitably harder to quantify in monetary terms but their significance to the landowner/farmer should not be underestimated by advisors.

Table CB1: The financial and environmental implications of installing buffer features in an agricultural landscape.

	Negative effect to land owner (Cost)	**Positive effect to land owner (Benefit)**
Financial	• Loss of productive land • Investment cost • Maintenance cost	• Subsidy for implementing • Reduce risk of fine for pollution, sediment on road or damage to third party property • Potential for reduction in pesticide application because of increase in biological predators • Increased crop yields
Environmental	• Loss of previous land use • May hinder farming operations	• Reduce nuisance of sediment on the road or blocked drains • Increase aesthetic value • Increase wildlife habitat, corridors and biodiversity • Minimising phosphorus and sediment forms of diffuse pollution

Costs

Loss of productive land

Loss of productive land depends on the size of the field and the placement of buffer feature in the landscape. Of the field sites examined, percentage loss of productive land varied from 1 to 7% of field area. The financial loss of production this represents is illustrated in Table CB2. The values in Table CB2 are calculated for a field 100 m by 100 m (1 ha), and for buffer widths of 2, 4, 6, 10 and 24 m. The crops selected for illustration purposes (wheat, barley, potatoes and oilseed rape) are those recorded in the Parrett catchment.

Table CB2: Calculation of loss of yield per unit area of buffer in a field. Crop value based on average best price 2003 market value.

Crop	Area (ha)*	Yield (t/ha 2003)	Yield loss (t)	Cost per t (2003 £)+	Lost revenue (based on 2003 £)
Wheat	0.02	7.8	0.16	85	13
	0.04	7.8	0.31	85	27
	0.06	7.8	0.47	85	40
	0.10	7.8	0.78	85	66
	0.24	7.8	1.87	85	159
Barley	0.02	5.9	0.12	83	10
	0.04	5.9	0.24	83	19
	0.06	5.9	0.35	83	29
	0.10	5.9	0.59	83	49
	0.24	5.9	1.42	83	117
Potatoes	0.02	40.7	0.81	97	79
	0.04	40.7	1.63	97	158
	0.06	40.7	2.44.	97	238
	0.10	40.7	4.07	97	396
	0.24	40.7	9.77	97	950
Oilseed rape	0.02	3.3	0.07	165	11
	0.04	3.3	0.13	165	22
	0.06	3.3	0.20	165	33
	0.10	3.3	0.33	165	55
	0.24	3.3	0.79	165	131

*Area assumes a 100 m field margin with a 2, 4, 6, 10 or 25 m buffer

+Based on best price (i.e. milling price for grain; National Statistics Online)

The placement of a buffer feature needs to be considered carefully because loss in productivity associated with change in land use will vary from field to field, as well as within a field. For example, buffer strips might occupy more productive land while riparian buffers occupy less productive land. However, this is not always the case; land at the bottom of a slope can be deeper and more fertile than in mid-slope positions due to down slope transfer of sediment and organic material.

Investment cost

Identified investment costs include preparing a Soil Protection Review (SPR)[1] to identify potential erosion problems on a farm and to develop a management plan to effectively deal with problem areas. Defra, in 2004, as part of its Regulatory Impact Assessment estimated the cost of developing a SPR on a medium sized farm of 130 ha to be £2/ha.

Land will need to be worked (ploughed, pressed, cultivated, drilled and rolled) in preparation for sowing grass seed (broadcast and rolled) at an estimated cost of £115/ha (HGCA, 2005). Various grass

[1] To be eligible for the Single Payment Scheme (SPS) agricultural land must be in Good Agricultural and Environmental Condition (GAEC) and comply with Statutory Management Requirements (SMRs; Defra, 2003). Entry Level Stewardship (ELS) goes beyond SPS to maintain land in GAEC. Completing a soil protection review is a new requirement introduced with cross compliance (Farmer, 2007).

seed mixes are marketed for buffer strips including wild bird seed mix, and pollen and nectar mix that could earn additional points under the Entry Level Stewardship (ELS). However, a basic seed mix would cost in the order of £2.45 to £3.13 per kg (based on 2007 prices) and should be applied at between 20-25 kg/ha. Table CB3 illustrates the cost of seed for different buffer widths.

Table CB3: Cost of seed required for sowing a 100 m buffer of various widths.

Buffer width (m)	**Seed price (£)***
2	1.15
4	2.29
6	3.44
10	5.73
24	13.75

*Price of seed based on average price of four commercially available seed mixes.

Maintenance cost

Under ELS, in the first twelve months of establishing a grass strip the buffer may need cutting regularly to control annual weeds and promote good grass tiller (Defra, 2003). Twelve months after establishing a buffer strip, 2 m and 4 m grass buffers require cutting to control woody growth. After this these buffers should be cut again no more than once in five years. With a 6 m buffer the 3 m next to the crop must be cut annually. The rest is cut as for a 2 or 4 m buffer. The estimated cost of cutting the grass strip is £13 per ha (HGCA, 2005).

It is unlikely that the grass buffer will need reseeding as it should be self maintaining through natural regeneration. However, the buffer will require spot treatment for invasive weed species.

Loss of previous land use

The establishment of a buffer strip will directly take land out of crop production. In addition to the loss of productivity (Table CB2) there is an associated perceived loss in value where land managers could potentially view grass buffer strips as problem areas giving weeds more opportunity to invade and incurring a cost for herbicide and the time required to spot treat weed patches.

May hinder farming operations

Under Entry Level Stewardship GAEC (Good Agricultural and Environmental Condition) regulations, it is not permitted to use grass buffer strips for regular access, turning or storage. Therefore, additional land, needed for access and storage, may be lost to production resulting in a proportional loss of income as defined in Table CB2.

Benefits

Subsidy for implementing

To qualify for ELS a farm requires 30 points per hectare for all eligible land (Defra, 2003). If this target is achieved a basic payment of £30 per ha per year will be received. A 2 m buffer attracts 200 points per ha while 4 and 6 m buffers attract 400 points per ha. This equates to 4 points for a 2 m buffer and 16 points for 4 and 6 m buffers across a field of width 100 m.

Breach of ELS agreement including non-compliance with GAEC can lead to loss of, or reduction in, payment. A first offence leads to a 3% cut, while multiple offences leads to a 5% cut, and persistent offences leads to a 15% cut or even total loss of subsidy (Entry Level Handbook; Defra, 2003).

Reduce risk of fine for pollution, sediment on road or damage to third party property

Loss of sediment from a field onto a public highway (road, verges or footpath) can have severe economic consequences. Such an event would be considered a breach of GAEC and could lead to loss of ELS subsidy. The land owner could also be liable for the cost incurred by a council for clearing the highway and any cost of rectifying damage caused to other individual's property. The movement of sediment onto a public highway also provides a potential pathway for pollutants to rapidly enter stream ways, which could lead to prosecution from the Environment Agency.

Potential for reduction in pesticide because of increase in biological predators

Grassy field margins help prevent invasion of the crops by docks and thistles. These wild margins also act as reservoirs of predators that help to keep pest insects controlled. As the number of predators increases the need for chemical pesticides should reduce.

Increased yields

By reducing runoff and erosion, soil productivity can be increased. Much depends on the purpose and therefore spacing of the buffers. For this effect to occur the buffers need to be spaced so as to prevent runoff from exceeding the critical erosion velocity for the soil and slope condition. Such spacings are likely to be more frequent than those where the objective is merely to trap eroded sediment instead of preventing erosion from occurring in the first place. Riparian barriers may merely trap sediment whereas to prevent erosion the barriers will need to be placed further upslope in the landscape. Erosion of valuable topsoil, containing plant-available nutrients, reduces fertility of the land and requires addition of fertiliser to maintain productivity. By reducing soil loss through surface runoff, fewer nutrients are lost and the quality of the soil is maintained, and potentially less fertilizer is required to maintain productivity.

Soil erosion can also lead to washing out of the crop and to crop damage through inundation and subsequently deposited sediment. The amount of damage caused is dependent on the magnitude of the erosion event, and on the stage of plant development – younger, smaller plants being more vulnerable. Preventing erosion in the first instance could therefore prevent loss in productivity.

Reduce nuisance of sediment on the road or blocked drains

As well as the financial cost of allowing sediment to runoff onto public highways (as stated above) such an event can cause a public nuisance, endanger life, lead to flooding due to storm drains becoming blocked and can lead to prosecution of the land owner. Sediment on roads, in wet conditions, can make driving conditions hazardous as well as being unsightly. The sediment deposited may inconvenience people by blocking small country lanes requiring a lengthy diversion of traffic. Once on the road the sediment can run into drainage ditches causing them to block and overflow. The subsequent flooding can affect crop production and wildlife habitats, as well as causing damage to property.

Increase aesthetic value

The reintroduction of hedges and grass margins arguably increases the aesthetic value of the agricultural landscape. The aesthetic value is difficult to quantify in terms of financial gain although it may well have an impact on tourist visitor numbers to an area and therefore on the amount of money spent in the region. Thus, while such a value may be difficult to assess and calculate, its overall importance on the local economy may be very significant.

Increase wildlife habitat, corridors and biodiversity

The introduction of buffer strips will benefit biodiversity by reduced pesticide and fertiliser drift, and from the reduced possibility of hedgerows being damaged by machinery. Increased biodiversity brings benefits of natural pest control as mentioned above and conservation of endangered species. Increasing the area of natural vegetation will help extend the network of green corridors, which enable species to migrate and maintain genetic diversity.

Minimising phosphorus and sediment forms of diffuse pollution

Every year £250 million of public money is spent on cleaning-up diffuse pollution across the UK (RSPB www.rspb.org.uk; Environment Agency, 2002).

The diffuse loss of phosphorus has cost implications for water supplies, fisheries, recreation and conservation. The water industry incurs increased treatment costs to meet drinking water standards as a result of algal blooms (eutrophication) linked to elevated levels of phosphorus in river water. The estimated cost of treating water to remove pesticides and nutrients from drinking water is £7 per year for every water consumer (Defra, 2005). Algal blooms can also deplete dissolved oxygen and affect commercial and natural fisheries. Pretty *et al.* (2001) estimated the national cost in the UK of freshwater eutrophication attributable to agriculture as being £19 million annually.

Other consequences of increased phosphorus concentrations in stream water include displacement and potential loss of sensitive species of high conservation value. The importance of losing plant and animal species from a food chain can be hard to predict. While difficult to place an economic value on the loss of a species, there are quantifiable costs associated with trying to maintain biodiversity and reduce phosphorus concentrations, as defined above.

Algal blooms caused by excessive phosphorus concentration in water can be toxic. Animal stock drinking from the water can become ill and require veterinary treatment or may even perish. Toxic water can even impact on public heath where the water is used for recreation. This can lead to loss in productivity in the wider community and also loss in recreational/tourism money in an area if access is prohibited or people's perception of an area is tarnished.

Fine sediment particles, such as clay, silt and fine sands, can damage fish spawning grounds and affect biodiversity of a river by covering invertebrates and affecting plant growth. The cost of damages and dredging stream channels attributable to agriculture is estimated to cost £7.8 million annually (Evans, 1996; EA 2002). The cost of poor biological water quality attributed to agriculture has been estimated to be approximately £27.9 million annually (EA, 2002).

An example of the amount of phosphorus and sediment that may be retained by grass buffer strips is given below. The example is based on field data collected in the Parrett catchment as part of this project and predictions using the Buffer Model. While this data is specific to the Parrett catchment it provides a good illustration of sediment and phosphorus loads that may be retained by grass buffers in areas sharing similar characteristic.

Estimation of the amount of P prevented from reaching a watercourse

The main objective of this report has been to use buffer model simulations to provide quantitative information on the effectiveness of buffer features in retaining sediment and sediment-associated phosphorus in grass buffer strips. Various different buffer features and field combinations were considered (as defined in the DSS), including:

- two vegetation cover densities (10% and 90% cover);
- six soil types (C, ZC, ZCL, SCL, ZL and SL);
- three slope angles (gentle = 0 to 2°; moderate = 3 to 6°; steep = 7 to 12°);
- five buffer lengths (2, 4, 6, 10 and 24 m); and
- two stem diameters (high = upper quartile; low = lower quartile).

The estimation of phosphorus retention within the buffer took into account the particle size of the sediment exported from the field unit (i.e. slope and buffer). The DSS-model gave a percentage sand, silt and clay exported, this particle size distribution was converted to specific surface area (SSA) using a lookup table provided in Horowitz (1991). Particle size from the DSS-model results were then used to

estimate total phosphorus (TP) using the empirical relationship put forward by Owens and Walling (2002) that relates TP content of sediment to specific surface area:

$$TP = 1214.8Ln(SSA) + 2924.9 \ (r^2 = 0.98) \quad (1)$$

This was used to provide an estimate of the proportion of phosphorus that could be associated with each size class i.e. sand (negligible), silt (20% TP) and clay (80% TP). This weights the phosphorus loss from the field unit and the phosphorus retention in the buffers according to the amount of silt and clay. To calculate a meaningful value of phosphorus in the Parrett catchment the average total phosphorus content (680 mg/kg) of sediment samples <1 mm collected in the Parrett catchment was used to calculate a phosphorus load based on the particle size distribution.

The effects of ground cover, stem diameter, slope, buffer width and soil type on phosphorus and sediment retention are illustrated in Tables CB4 and CB5, respectively. Both tables show the increase in phosphorus or sediment retained by a specific buffer as ground cover is increased from 10% to 90%. The term "percentage retained" used in both tables refers to the percentage increase in sediment intercepted by the maximum ground coverage (90% cover) compared to the minimum considered ground coverage (10% cover). Both tables show the minimum and maximum values of change in retention and how this relates to soil type and buffer width as an illustration of effectiveness of buffer design in different environments.

The smallest effect of ground cover variation, on phosphorus retention, was observed on the sandy loam (SL) soils; in any case, the higher sand content would have low levels of phosphorus associated with it. While a 24 m buffer strip showed the least difference with increased ground cover, none of the different buffer widths options was greatly affected by differences in ground cover composition. Slope and stem diameter also had minimal impact on the efficacy of buffer retention of phosphorus on the sandy loams.

Conversely, ground cover had the greatest impact on silty clay (ZC) and silty clay loam (ZCL) soils. The general trend was that the effect of ground cover variation on phosphorus retention tended to decrease on lighter textured soils. On all medium and heavy soils phosphorus retention increased by between 18-48% as ground cover increased, regardless of buffer width. Again slope angle and stem diameter showed little effect.

Table CB4: Expected variation in the effectiveness of buffers in retaining phosphorus, in relation to slope and ground cover fraction.

Slope	Stem diameter (mm)	Least change with land cover			Most change with land cover		
		% Retained[+]	Soil type[*]	Buffer width (m)	% Retained[+]	Soil type[*]	Buffer width (m)
Gentle (0 to 2°)	14	9	SL	24	45	ZC, ZCL	2
	1	10	SL	24	48	ZC, ZCL	2
Moderate (3 to 6°)	14	9	SL	24	44	ZC, ZCL	2
	1	9	SL	24	47	ZC, ZCL	2
Steep (7 to 12°)	14	8	SL	24	44	ZC, ZCL	2
	1	9	SL	24	47	ZCL	2

[+] % retained by 90 % cover minus % retained by 10 % cover

[*]Soil type: SL = Sandy loam; ZC = Silty clay; ZCL = Silty clay loam

Increasing ground cover had little affect on the proportion of sediment retained for sandy loam (SL) soil. While SL soil showed the least difference, sandy clay loam (SCL) also showed only a small difference in sediment retention with increasing cover (6 to 8% increase). However, on further examination of the data the small difference in retention, with increasing ground coverage, may be due to the weight of sediment (t/ha) deposited being considerable even for the minimum 10% coverage (SL = 30-61t/ha; SCL = 24-43t/ha). Even a sparse vegetation cover can be sufficient to disrupt flow sufficiently for sand sized sediment to be deposited in the buffer.

The soils that showed the biggest change in sediment retention by increasing ground cover were the silty clay (ZC = 38-47% increase), silty clay loam (ZCL = 38-48% increase) and silty loam (ZL = 38-47% increase), although, clay (C = 37-42% increase) soils also showed a similar increase with ground cover. The data again suggested little effect of slope or stem diameter on sediment retention.

Table CB5 Expected variation in the effectiveness of buffers in retaining sediment, in relation to slope and ground cover fraction.

Slope	Stem diameter (mm)	Least change with land cover			Most change with land cover		
		% Retained[+]	Soil type[*]	Buffer width (m)	% Retained[+]	Soil type[*]	Buffer width (m)
Gentle (0 to 2°)	14	2	SL	2, 4, 6, 10, 24	45	ZC,ZCL, ZL	2
	1	2	SL	2, 4, 6, 10	48	ZC, ZCL,ZL	2
Moderate (3 to 6°)	14	2	SL	2, 4, 6, 10, 24	44	ZC,CL, ZL	2
	1	2	SL	2, 4, 6, 10, 24	47	ZCL,ZL	2
Steep (7 to 12°)	14	2	SL	2, 4, 6, 10, 24	44	ZC, CL, ZL	2
	1	2	SL	2, 4, 6, 10, 24	47	ZL	2

[+] % retained by 90 % cover minus % retained by 10 % cover

[*]Soil type: SL = Sandy loam; ZC = Silty clay; ZCL = Silty clay loam; Silty loam = ZL

The model data suggests that for medium to heavy textured soils increasing ground coverage would both reduce sediment-associated phosphorus and sediment loss from the field by 18 to 48 % and 37 to 48% respectively. In this example, this equates to between 1 and 4 kg/ha of phosphorus and 3 to 7 t/ha of sediment retained by increasing ground cover. Even for the lighter soils that showed little difference with retention and ground cover, an additional 1 kg/ha of phosphorus and 1 t/ha of sediment would be retained by increasing ground coverage. An ability to trap this extra amount of sediment is important. Areas of England where erosion is considered high may have annual erosion rates of only 1.4-7.0 t/ha with a 10-year return period (Wood et al., 2006) and annual sediment delivery to water courses in high risk areas may be only 0.19 t/ha (Evans, 2006). Further events of such moderate magnitude may be more important in transporting P than high magnitude events with longer return periods when the higher volumes of runoff mean that the P content is diluted (Quinton et al., 2001). Thus buffers may be sufficient to deal with all but infrequent, high magnitude events in the UK.

Table CB6 summarises the costs, as detailed above, associated with establishing grass buffer strips in a one hectare field producing wheat. Total cost represents outlay for first year. In subsequent years costs associated with preparation and grass seed will not apply.

Table CB6 Cost of implementing buffers of different widths.

Buffer width (m)	Loss of production – Wheat (£/ha)	SPR[+] (£)	Preparation cost (£/ha)	Grass seed (£/ha)	Maintenance (£/ha)	Additional land for trafficking and storage (£/ha)[*]	Total cost[◊]
2	13	2	2.3	1.15	0.26	13	31.7
4	27	2	4.6	2.29	0.52	13	49.4
6	40	2	6.9	3.44	0.78	13	66.1
10	66	2	11.5	5.73	1.3	13	99.5
24	159	2	27.6	13.75	3.12	13	218.5

[+]Soil Protection Review (SPR)
[*]Assumes no more than the area equivalent to a 2 m buffer across the field edge would be needed.
[◊]Assuming a 100m by 100m (1ha) field.

Conclusion

While there are initial and ongoing capital costs involved with establishing a buffer feature, which are relatively easy to quantify, for example by implementing a 2, 4, 6, 10 and 24 m wide buffer strip in a 1 ha field under wheat the capital cost in the first year would be in the region of £32, £49, £66, £100 and £219 respectively. While in subsequent years (assuming no changes in market price) the cost would be in the region of £27, £40, £54, £81 and £176. Capital gains from establishing a buffer feature are not always easy to estimate. However, if by establishing buffer features on a farm, along with other eligible features, the farm qualifies for ELS subsidy then the 1 ha parcel of land would gain from a £30 payment. This raises the question of whether the 'national' costs of diffuse pollution through P could be reduced economically by increasing the benefit to the farmer of establishing buffers from, for example, £30 to £60/ha. Other cost savings, external to the farm, may include costs of cleaning up diffuse pollution. If as predicted between 20 to 40 % of phosphorus and sediment are retained in the field instead of being lost to the water course then potentially the £19 million pounds spent on cleaning up diffuse pollution may be reduced proportionally to between £11and £15 million. However, the reduction in cost of cleaning up diffuse pollution assumes no threshold level. It may be that a 20 to 40 % reduction in phosphorus and sediment load may not bring the levels of these pollutants to below a future defined quality threshold in which case there would be no reduction in cleanup cost.

Based on the evidence presented above 2 m grass buffer features would appear to be a cost effective way to reduce diffuse pollution and enhance environmental quality within the landscape. Grass buffer strips with grater widths may provide more environmental benefits, however, cost to farmers may deter there use unless subsidies are increased.

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Appendix C

Woodland trust - Tree planting for free range poultry

A Woodland Trust guide to

Tree planting for free range poultry

April 2014

WOODLAND TRUST

About this guide

This Woodland Trust guide to tree planting for free range poultry provides advice on tree planting design, woodland establishment and maintenance for all woodland poultry producers, and meets the Woodland Standard for poultry products (See *Meeting the Woodland Standard* box on page 5).

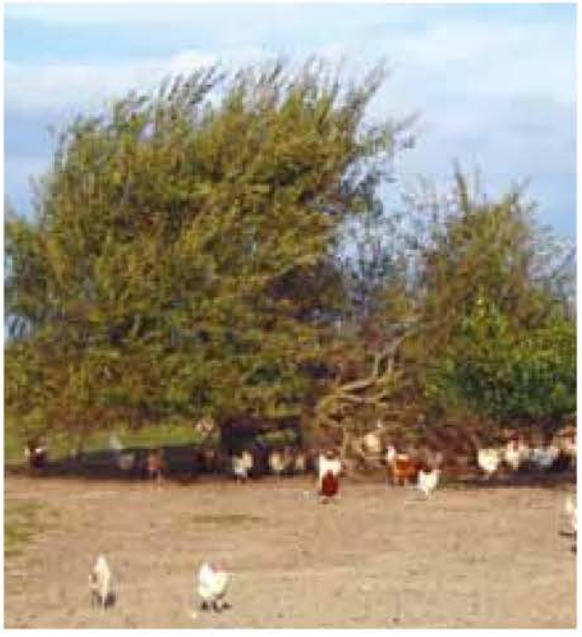
Tree planting for free range poultry

The ancestors of domesticated chickens were forest birds and many of their behavioural traits persist in modern hens. It is therefore not surprising that providing tree cover for free range chickens is beneficial to both the welfare of the birds and their performance.

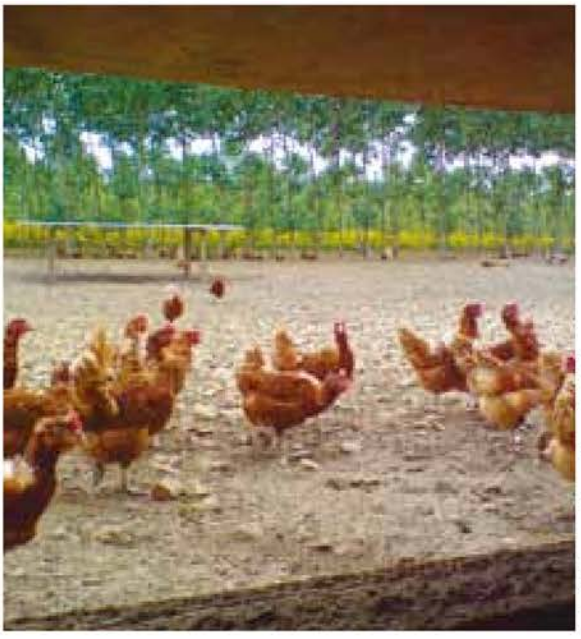
Encouraging ranging is crucial if the potential welfare benefits of the free-range system are to be realised. In commercial free-range systems it is quite usual for only a small proportion of the hens to use the outdoor range, with those that do remaining close to the house. Poor range use is associated with an increased risk of injurious feather pecking (IFP) which causes pain, leads to plumage loss and can result in cannibalism and increased mortality in affected flocks. Hens with poor feather cover also have less thermal insulation and therefore need to consume more feed to maintain their body temperature. This can have significant economic consequences for the farmer.

Properly undertaken, tree planting around hen housing can encourage the ranging of hens which promotes natural behaviours that are good for their welfare. Studies have demonstrated that on laying hen ranges with tree cover, a higher proportion of the flock uses the range and roam further than hens kept on ranges without tree cover. Tree cover can also help reduce nutrient load, parasitic contamination and poaching in the area close to the house by drawing the birds away from the building.

Trees close to housing units capture part of the atmospheric emissions of ammonia and reduce the impact on the surrounding environment.



Even just one established tree offers a huge amount of shade and shelter close to the shed



Trees provide an attractive view from the pop-holes and encourage birds outside by providing foraging under natural shelter, away from wind and predation

John Widdowson; Emma Mayo; Jon Walton

Check that the land can be planted

If the land to be planted is ecologically valuable or has archaeological features such as ridge and furrow or earthworks, you will need to check with the relevant authority. As a general rule, trees should only be planted on former arable land or improved grassland. If your land is unimproved then check first to ensure that you will not be damaging any ecological interest. Also, if it is under an existing agri-environment scheme, check that your planting falls within the conditions of the scheme.

Check if you are eligible for a tree planting grant

There may be incentive schemes to help fund your tree planting. If you are planting over 500 trees, the Woodland Trust may be able to help. Telephone **0845 293 5689** or email **woodlandcreation@woodlandtrust.org.uk**

Mike Townsend (x2); Emma Mayo

Hens will range without cover, but the majority are likely to stay inside

Groups of trees close to the shed offer easily accessible shelter

Trees planted on the perimeter a long distance from the shed provides screening and shelter, but may discourage ranging

Site layout

Often the siting and design of the new wood is constrained by other factors such as the location of sheds, availability of land and field shape. There are still ways of maximising the tree planting in a manner that suits both your site and the hens.

The 'design ideas' section on page 8 provides some suggested site layouts.

Tree spacing

Tree spacing can vary, but a minimum requirement of 20% tree cover is needed to qualify as woodland. If you would like regular, easy to manage lines, then plant at regular 2m, 2.5m or 3m spacing, with ideally 2-3m between rows. Planting at this density will require future thinning when the canopy closes but will become 'woodland' faster and could provide an early source of firewood.

Alternatively, you could plant small groups of trees at irregular spacing of 2-3m leaving larger spaces between the groups for the birds to roam through.

You may want to control the weeds in the tree-planted areas or mow the grass between rows, so make sure the planting allows you to do this. Depending on the width of your tractor and topper/mower, allow sufficient space between rows with room at the end of rows for tractor turning.

Planting at wider spacing of say 4-5m will allow for tractor mowing between the rows. Trees can then be spaced 2-3m apart in the rows. Provided trees are well maintained they should still achieve canopy closure within about five years.

If you do want to plant in rows to make management with tractor-mounted machinery possible, try to make those rows a bit wavy and avoid planting in a grid as this looks unnatural.

Graduating species

Planting shrub species on the edges of the planting areas will create a graded woodland edge and encourage the birds to explore. It will also act as a wind break, making the area warmer, and providing better screening of the sheds. However, try to avoid the lower branches of the shrubs being in contact with ground vegetation such as grasses, as this degree of cover can encourage hens to lay outside in the enclosed areas under shrubs.

The trees closest to the sheds will be difficult to establish but they are the most important as they encourage the hens to range, provide screening and soak up ammonia. They will need to be thinned once the canopies have started to close

With no trees or cover nearby, only a few of the bravest hens are venturing out into the range, and all are staying close to the shed

This range contains a mix of planted native species including fast growing willows, and an established tree belt. If there are particularly sensitive areas, such as the bases of ancient hedgerows, it may be worth fencing these out

Mike Townsend (x2); Emma Mayo

Encouraging ranging – planting close to sheds

The trees closest to the sheds will be exposed to the greatest pressure from the birds and may be difficult to establish. However, it is important to persevere as these trees will encourage the chickens out of the sheds. Try planting at a higher initial density to make up for any losses, moving to a lower density of trees behind them so the birds have visibility and are encouraged to roam further.

It is important to plant as close to the shed as is practically possible but allowing for machinery access. For example, shrubs and trees at 10m from the shed will encourage a greater number of birds outside.

Studies show only a small proportion of hens in many large scale units use the range (possibly less than 10%) and of those around 70% will stay within 17m of the house. Well-designed tree planting can encourage use of the range and the hens to range further, which in turn reduces nutrient load from excretion and parasitic contamination close to the house.

The RSPCA Freedom Food guidance provides detailed advice and recommendations on welfare matters relating to the range: **rspca.org.uk/freedomfood**

Meeting the Woodland Standard

The aim of the Woodland Standard is to establish new native woodland, so wherever possible only native trees should be planted. The Woodland Trust recommends one hundred percent native tree planting, though the Woodland Standard does allow for a percentage of the planted area to include non-native poplar e.g. white or grey poplar, or hybrid varieties, in order to rapidly establish canopy cover. The fastest growing native species are birch, alder and willow.

Where poplars are planted they must be removed during subsequent thinning as the wood becomes established to allow the slower growing native species to dominate. This is likely to be after at least 15 years but could be sooner depending on growth rate and planting density.

Species choice

The best way to select tree species suitable for your site is to look at what is already growing well in the neighbourhood. This gives a good guide as to which species suit the local climate, character and wildlife of the area, ensuring a better chance of survival.

Top choices for native trees

You can find out more about the top native trees listed here, and other native species, at the Woodland Trust's 'British Trees' website **www.woodlandtrust.org.uk/learn/british-trees**. These species suit a wide range of soil types and weather conditions, and will also enhance the range for birds and wildlife.

Top native trees

Trees

Oak king of the trees, durable
Wild cherry good for wildlife, attractive
Birch fast growing, good for poor quality ground
Alder very fast growing, copes well with wet areas
Willow fast growing, also thrives in wet areas, nice and bushy
Hornbeam attractive and distinctive, good for firewood
Aspen beautiful and delicate tree, prefers clay and wet areas in lowlands
Rowan copes with exposed conditions
Field maple tolerates most conditions, pretty in the autumn, bushy

Shrubs

Hazel good for wildlife and thatching
Hawthorn prickly and hardy
Spindle prefers richer soils, attractive
Elder vigorous growth, bushy, can grow like a weed
Dogwood pretty in winter with brightly coloured bark

The young sapling will be protected from the birds with a plastic tube

Space the trees in a way that will suit your future management

Well planted trees will soon start to pop out of the tubes

WTPL/Christine Martin; WTPL; Charles Fry

What to plant

Small bare-rooted or cell-grown (i.e. in peat plug) trees of around 40-60 cm (2ft – 3ft) high are the best option as they are cheap to buy, easy to transport and plant, and will establish quickly. Generally, you don't need to spend money on large standard or pot-grown trees which are expensive, cumbersome and prone to die-back under stress. Invest your resources in good site preparation and good after-care instead.

Buy trees from a specialist tree nursery - there are a number of these around the country - and ask for UK-sourced and grown trees to avoid bringing in tree diseases.

Plant trees as soon after delivery as possible.

Don't store trees outside and do keep them in bags until planted, provided you are going to plant within a week of delivery.

If you can't plant your trees within a week of delivery, they will need to be 'heeled-in'. Dig a trench, laying the roots of the trees into the trench, and then cover the roots with soil. Trees can be stored like this for a few months but will need to be planted before spring or they will start to grow in the trench.

When planting make sure the hole you dig is big enough for the roots of the tree to spread.

Firm in the soil around the roots by pressing hard with your boot.

Make sure all the roots are covered by soil.

When to plant

Aim to plant your trees in the dormant winter period, which for bare-rooted saplings is mid-November to March, and for cell-grown trees can be from as early as October. Don't leave it until the last minute to place your order as nurseries may run out of the planting stock you require, and planting early in the season gives the trees a far better start in life. If you have clay soils, it's far better to plant in November or December.

How to plant

Dig a hole big enough to encompass all the roots without squashing them. You don't need to put compost or bone meal in the hole as trees will grow well in most soils without any additional nutrients. Place the soil back around the roots and firm in with your boots. Ensure all the roots are covered up and the tree is reasonably upright.

To watch a video on how to plant a tree visit **youtube.com/woodlandtrust** and search for the Plant a Tree guide.

Guards

Trees must be protected with suitable guards. The best type is a solid tubular guard with ratchet ties for securing to a wooden stake. Don't use a cane as these are not strong enough to resist the attention of the birds. The stakes need to be knocked well into the ground - ideally a third of its length - with the top of the stake just below the top of the guard so the tree doesn't rub on the stake as it emerges.

Spiral tree guards are unsuitable as the hens can peck through the gaps in the spiral and kill the tree. Also avoid mesh and combined mesh/plastic type guards as again the hens can peck through these.

The height of the guards is critical as they need to be tall enough so the birds can't jump on to them and peck the tree inside. The best height is a minimum of 75cm, but if you also have deer, use 1.2m tubes.

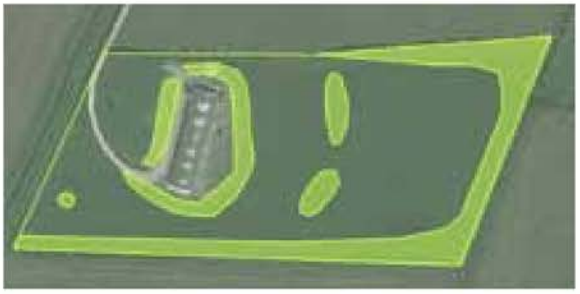
If the ground allows it, push the guard about a centimetre down into the soil to ensure mice or voles can't get inside and chew the bark.

If livestock are located close to planting areas, they will need to be fenced off from the young trees with post and wire fencing to prevent them from eating the trees.

Design ideas

There are several design options to consider depending on your preferred management practices. All of these designs should encourage the birds to roam as they have trees and shrubs within a close distance of the shed.

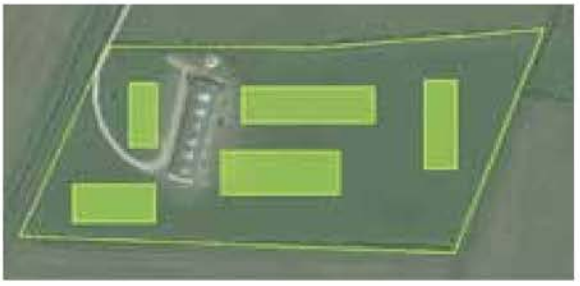
Design 1: Plant close around the shed with a clear view of tree cover from pop-holes to encourage birds outside and onto the range



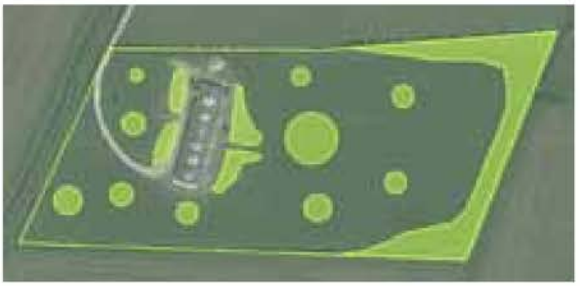
Design 2: Plant lots of groups of 15-30 trees at 2m spacing, with the bulk of trees on the edge at 3m spacing to create shelter

Design 3: Plant large lozenges of trees at 2m spacing and start thinning at 5-10 years

Design 4: Plant in blocks of straight lines at 2m spacing for easier mowing between rows and thin after 5 years



Design 5: Encourage hens outside by leaving corridors between belts of woodland which may take them further out into the range. Plant trees at 2m spacing and start thinning trees at 5-10 years



Introduction to site preparation, marking your site, storage

Start by marking out the planting positions for your trees using stones, spray paint or the stakes when they arrive.

Keep trees in their bags on the planting day so the roots don't dry out in the wind. If they do dry out, soak them in a bucket of water prior to planting.

Some sites may require 'topping' if overgrown with tall weeds. This involves cutting everything down to a certain height to make planting easier.

Pit planting

Pit planting is the most thorough method and is suitable for all ground types, though it can be difficult in areas with stony soils and is quite time-consuming. It is the recommended planting method for areas that are susceptible to drought.

1. Each tree will require a pit to be dug with a spade. These pits need to be several centimetres wider and deeper than the tree's roots.

2. The grass you have dug up can be placed upside down in the bottom of the pit to provide the tree with extra nutrients.

3. Place the tree into the pit and check that all the roots will be below ground level.

4. Now carefully backfill the soil around the tree while holding it upright. Firm the top layer of soil around the tree with your heel.

5 & 6. Now push the stake into the ground next to the tree, making sure it is stable. If using a spiral guard, place this over both the tree and the stake. If using a tube, place it over the tree with the stake on the outside. The tube can then be fixed to the stake using the nylon ties. Press the shelter into the top of the soil. Deer tubes can be tied using nylon ties. **Note**: Photo shows a cane, but use a stake for planting for poultry.

Slit planting

Slit planting is a simple method that is suitable for bare soil and grass, and can be an easier method in stony soils than pit planting. We don't advise using this method if you are planting in an area susceptible to drought or with clay soils because in dry conditions the slit can re-open, exposing the tree roots.

1. First, fully insert a spade into the ground and push it forwards to create a slit. Ensure the slit is deep enough for the tree roots.

2. When the slit is open, insert the roots into the slit, keeping the roots straight and ensuring they're all below ground.

3. Then simply remove the spade and push the soil back firmly down around the tree.

T-notch planting

T-notch planting is another quick method suitable for grass covered ground but not bare soil. This method is an alternative to pit planting in areas susceptible to drought but again not recommended for sites with clay soils.

1. Push the spade fully into the ground.

2. At a right angle to the first cut, repeat step 1 to create an inverted T-shape.

3. Take the spade to the original cut and lever it upwards parting the turf.

4. Place the tree carefully in between the sections of turf.

5. Lever the spade back out and the turf will fall into place. Ensure all roots are taken into the hole.

6. Adjust the tree to ensure it is at ground level, and thoroughly firm down soil around the tree.

Maintenance of planted areas

Why weed?

It is essential that the base of all newly planted trees is weed free. This is to ensure that the young tree with its immature root system can access as much water as possible during the growing season.

When to weed and what to use

Weeding should be done as soon as the growing season starts which often is as early as March, but could be April or May. An approved herbicide can be applied with a knapsack sprayer once or twice a year for the first two or three years.

After two or three years the tree roots should be sufficiently well developed to render weeding unnecessary. Mulching is sometimes used but this is not recommended for free range units as the birds will scratch and remove it, and mulch mats are often pecked away by the birds within a year.

For organic farms, the options are screefing (removing grass or other vegetation around the base of a tree prior to planting) or mulch mats (but see above paragraph).

How to weed

A weed-free circle around the base of the tree can lead to scratching by hens right up to the tree stem, damaging surface roots. Creating a weed-free 'polo mint' shape – i.e. leaving a ring of vegetation approximately 10cm wide directly adjacent to the base of the tree - can help protect the roots from scratching by the hens. When using herbicide, this is easily achieved by tilting the lance of the knapsack.

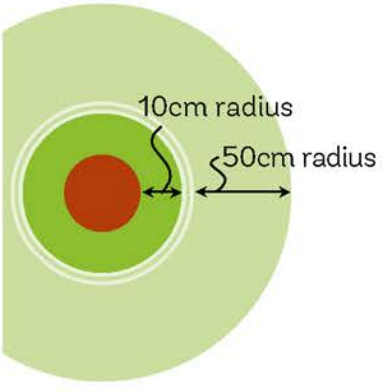
If some trees are still suffering from pecking around the roots, especially trees nearest to the shed, you could try fitting a square of plastic garden mesh around the tree to provide a more peck-resistant surface.

Mowing or topping between rows of trees deters birds from laying outside.

Is watering necessary?

Watering is not normally necessary provided the trees have effective weed control. However if the infrastructure is in place and water can be easily and cheaply applied, then it may be worth considering in periods of severe drought, particularly during the early part of the growing season following planting.

If a tree is not weeded the grass will compete and slow down the growth rate of the tree



Leave a 10cm ring of unsprayed vegetation directly around the tree

WTPL/Steven Kind; WTPL

A tree weeded in a 'polo mint' shape is less susceptible to pecking around the roots

Early maintenance and pruning – up to year 5

Monitor your trees

Keep an eye on your trees by inspecting them about once a month. Look out for trees which don't look healthy and investigate causes. Often it's obvious what it is and can be remedied there and then.

Issues to look out for:

Years 1 – 3

Tree losses

Despite your best efforts, it's likely that some trees will die, possibly 5-10%, and these should be replaced the next winter. If all the same species are dying then there may be conditions which make this species unsuitable. Consider replacing with a mix of other species. For any trees that have died, remove the guards and store for re-use next winter.

Check your guards

One of the most common issues to address is vegetation growing inside the tube. Don't be tempted to pull this out from the top as this will often pull the tree out as well. Lift the guard and pull out from the bottom. It's fiddly but more effective, and safer. Sometimes guards work loose, particularly on windy sites, and will need firming and straightening up.

If the trees are planted and weeded well there shouldn't be much other early maintenance to do.

Emma Mayo: WTPL

Some tubes here are falling over and need to be firmed up to ensure the trees' survival. There are also gaps where trees have failed and should be replaced

Using a pruning saw to make a clean cut as near as possible to the trunk

Making a clean cut reduces the chance of any disease entering the wound

Years 3 – 4 onwards

Pruning

If you decide to prune, start from the bottom and don't remove more than a quarter of the branches.

Pruning can be started once the tree is established - often after 3 or 4 years. Most native trees are best pruned in winter when dormant, except field maple, cherry and walnut which need pruning in summer to reduce risk of disease and sap bleeding. Pruning can reduce damage caused by birds trying to roost on lower branches which aren't strong enough to take their weight; and prevents ground vegetation growing into lower branches which may lead to hens laying outside.

Aim to make a clean cut as close to the main trunk of the tree as possible. Don't cut so close that you damage the bark but don't leave a stump of more than a couple of millimetres sticking out.

Pests and diseases

The majority of native trees are rarely prone to serious pest or disease problems. However, depending on the species planted, your trees may be affected by less serious conditions such as leaf curl, cankers, blights or mildew, but in the majority of cases these are not a cause for concern, as they will rarely kill young trees.

Remove the tree guards

Remove the guards once the stem of the trees are becoming too wide for the tubes and they have started to split, or the trees have grown to over 3m in height. If the tubes are still in good condition they can be recycled and used again. It's best to remove the guards in the spring and summer months as rabbits may eat the tender bark if the removal coincides with a hard frost.

Long term maintenance – year 10 onwards

Thinning

What is thinning and why is it necessary?

Thinning involves the removal of some of the planted trees to reduce the competition for light, water and nutrients. By giving the retained trees more 'room' they develop a better shape and are more wind-firm and less likely to blow over. Thinning also helps to retain some vegetation by allowing light to reach the ground.

When to thin

Timing of thinning depends on a number of factors such as initial planting density and how quickly the trees grow. Typically, the first thinning of a new broadleaved wood takes place between year 15 and year 25. However if you want to maintain the ground vegetation, you should thin as soon as you see the shade of the trees significantly reducing the ground cover which could be as early as year 10. About 50% canopy cover and 50% sunny areas is a good combination.

Thinning little and often is better than heavy and infrequent.

Fell when birds are not around and clear up quickly, leaving some felled material for the birds, but be aware that piles of branches can harbour vermin and hinder your future maintenance.

How to thin

To select the trees to be removed, walk through and familiarise yourself with the range of trees you have. There will be tall, straight, well-formed ones as well as small, spindly, poor quality ones. Vigorous growing species, such as poplar and willow, planted to provide quick early cover, should be thinned out in favour of more long-term but slower growing species such as oak. Shrubs don't usually need thinning. Once you have a feel for what you have, mark the trees which need to come out. Typically this won't be more than one in ten trees and if it's more than one in five you are probably selecting too many.

If your woodland is of any significant size and the tree trunks are thicker than a tin can, check with the Forestry Commission (free) to see if you need a felling licence: **forestry.gov.uk**

The cut stumps can be treated with a herbicide to prevent re-growth.

Making use of your felled trees

Firewood: Thinned trees can be used for firewood, with the smaller material either chipped or burnt. Poplar is considered a poorer species but will burn quickly when well-seasoned and makes good kindling. Ash, oak, hawthorn, hazel, beech, rowan and hornbeam are all good for firewood as long as they are well seasoned.

If you do make bonfires ensure these are completely extinguished before allowing the birds to roam again.

Dense woodland canopy – without thinning and management your woodland could become too dense and dark

This woodland is due to be thinned as the canopy has closed and it is very dark inside. Creating areas of light will allow the ground flora to return and the hens should roam further into the woodland area

This woodland is ready for thinning as the canopy has closed. The dappled shade and thick undergrowth around the trees has tempted hens to range up to 50m from the shed

WTPL/Lee Dudley; WTPL/John Tucker (x2)

Long term maintenance – year 10 onwards

Pollarding

What is pollarding?

Pollarding involves felling trees at a certain height, generally above which animals can browse the re-growth. You can then continue to cut the re-growth back to this point. Consider pollarding if you don't want to remove the tree through thinning but want to restrict the extent of the tree, as is often done with street trees.

Why is pollarding a good solution for Woodland farms?

- Keeps trees at a manageable height and scale for long term maintenance, while maintaining some cover
- Avoids complete canopy closure, allowing light to reach the floor to maintain vegetation cover
- Allows trees to re-grow out of reach of birds
- Provides useful raw materials for use on the farm (e.g. firewood).

How to create new pollards

- Think about pollarding once your tree has reached the desired height, which is likely to be after at least 10 years
- This should be when stems are broomstick or wrist thick, although they could be up to 20cm depending on tree species
- Bear in mind that growth will come from below the cut so cut a little higher than you want
- Once the tree has been cut, try to ensure that it is maintained by regular cutting on a 10-20 year cycle (appropriate for most situations)
- Do the cutting in the winter months.

If you are unsure about how to manage your trees once they are larger and need to be thinned, pruned or pollarded, then seek professional advice.

WTPL; Emma Mayo; John Tucker; Exe Valley Eggs

Use an extendable pruning saw to prune high branches on more well established trees

The hens will make good use of the shade cast by more mature trees

Within a few years, the young trees will start to provide shade and shelter

Further advice

Overall, a well-designed tree planting scheme which provides good canopy cover is the most practical and sustainable method to encourage hens outdoors and get them ranging further; and to provide opportunities for species-specific behaviours such as foraging.

For more information and recommendations on how to manage the range to improve hen welfare, download the RSPCA Freedom Food guidance: **rspca.org.uk/freedomfood** and FeatherWel advice guide on injurious pecking: **featherwel.org/**

The Woodland Trust woodland creation team is happy to provide advice to all woodland poultry producers on the design, establishment and maintenance of planting schemes, as well as possible funding support.

Call on **0845 293 5689** or email **woodlandcreation@woodlandtrust.org.uk**

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