Wolfcastle Mitigation Plan

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Summary

The Wolfcastle housing development is proposed for a minimum of 12 homes and is predicted to produce 12.2 kg of phosphorus per year. The implementation of nature-based solutions that remove phosphorus from the wider catchment area have the potential to mitigate all of the phosphorus produced by the proposed housing development. Within the water catchment area there is the most ecological opportunity for the creation of field buffers as a phosphorus mitigation measure.

Mitigation options

Following a literature review several nature-based mitigation options for phosphorus removal in Pembrokeshire were identified. These are field buffers, riparian buffer strips, floodplain woodlands and waste water treatment works (WWTW) constructed wetlands. These options can be implemented over a medium (1-5 years) or long-term (> 5 years) timescale and can provide phosphorus mitigation services for the medium (5-25 years) or long-term (> 25 years) if managed appropriately. In the short term to allow housing developments to proceed a phased approach may need to be considered whereby mitigation options that directly target agricultural practices are adopted in the first instance to allow mitigation to begin in a shorter-timescale while the proposed nature-based solutions have time to establish. A more detailed comparison of the nature-based solutions is shown in Table 1.

Table 1 Summary of nature-based solutions suitable for mitigating phosphorus pollution within the Wolfcastle water catchment

Solution	Development timescale	Duration timescale	Phosphorus removal efficiency	Habitat/site considerations	Associated management activities	References
Field buffer strips (e.g. hedgerows).	Medium	Medium	0.3 - 4.8 kg ha^{-1} yr^{-1}	Most effective when placed next to areas with high phosphorus input.	Sediment and vegetation removal (Cole et al. 2022)	Abu-Zreig et al 2003; Zabronsky 2016
Riparian buffer strips.	Medium	Medium	11-21 kg ha^{-1} yr^{-1}	Most effective when placed next to areas with high phosphorus input.	Sediment and vegetation removal (Cole et al. 2022).	Fortier et al 2015; Zabronsky 2016; Aguiar et al. 2015
Waste water treatment work (WWTW) constructed wetlands.	Long term	Long-term	Mean: 12kg ha^{-1} yr^{-1} Range: 5-50 kg ha^{-1} yr^{-1}	Should be placed downstream as close as possible to the waste water treatment works.	Sediment and vegetation removal (Cole et al. 2022)	Land et al. 2016; Weisner et al. 2020; Mitsch et al. 2000.

When examining the ecological suitability of nature-based phosphorus mitigation options, the creation of field buffers (e.g. hedgerows) was identified as the most suitable mitigation solution for the Wolfcatle water catchment area based on the ecology and existing land uses of the site.

An in-field buffer is a vegetated strip of land, located along the land contour, on upper slopes or in valley bottoms. The strips act as a natural buffer to reduce the transfer of diffuse pollutants in surface run-off from agricultural land to water. The buffer strips reduce the length of the slopes, can act as a sediment trap, and help to reduce nutrient and pesticide losses in run-off (Schoumans et al. 2014). Grass buffers between 3-20 m in width have been reported to remove 39-90 % of phosphorus from agricultural run-off in silt, clay, and loam soils (Zabronsky 2016). Similarly, a study comparing the efficiency of grass versus vegetated (scrub, hardwood trees, wild hay and flower) buffers reported buffer strips as effective mitigation solutions in retaining phosphorus with a mean loss of total phosphorus reported as 0.3 and 0.2 ha ha^{-1} yr^{-1}, respectively in grass and vegetated buffers compared to a non-buffer zone that lost 0.6 kg ha^{-1} yr^{-1} (Uusi-Kamppa et al 2000). The width of the buffer, type of vegetation planted, slope of surrounding land and substrate type are all factors that will influence the phosphorus removing capacity of buffer strips, and should be carefully considered when Implementing mitigation options.

For the identification of opportunity areas for field buffers This report focuses on the establishment of hedgerows as field buffers. Two existing data layers were mapped that identify (1) opportunity areas suitable for hedgerow planting and (2) opportunity areas suitable for hedgerow planting in areas prone to flooding. Both may be considered suitable for the creation of field buffers, but the species composition will vary depending on hedgerow species ecological requirements (e.g tolerance of wetter conditions).

Calculation of phosphorus removal potential

Using the total area identified for mitigation opportunities within the catchment area the phosphorus removal efficiency reported from previous literature was applied to estimate the amount of phosphorus that could potentially be removed by the proposed nature-based solutions. However, it should be noted that these previously reported phosphorus mitigation efficiency values have been sourced from a range of different field scenarios; which will be based on environments that have different climates, soil types, slopes, agricultural processes and intensity (Gruau et al 2017). For example, previous scientific studies have reported phosphorus removal efficiencies of field buffers ranging from 0.3 - 4.8 kg ha^{-1} yr^{-1}. This range in values can be attributed to studies focusing on buffers of different widths (ranging from 2.5 - 30 m), with different species compositions and species present (e.g. grass, herbaceous or tree) that were located on a variety of soil, slope and agricultural types. Every site will be different and the most important factors that influence phosphorus removal capacity will need to be investigated on a site-by-site basis to better inform the

areas selected for mitigation solutions and to develop recommendations for best practice implementation. As a precautionary principle we have applied the minimum phosphorus removal values reported in the literature per hectare of identified opportunity area for each of the proposed nature-based solutions.

Results of opportunity mapping for this water catchment area reveal that 23.7 ha of hedgerow buffer planted within the identified opportunity areas could sufficiently mitigate phosphorus from the proposed housing development (Table 2, Map 1).

Table 2. Areas of opportunity (ha) within the Wolfcastle water catchment for the creation of nature-based solutions and the estimated amount of phosphorous that will be removed from this water catchment if all opportunity areas are used. When all potential opportunity areas for each of the solutions are combined then up to 23.7 kg yr^{-1} of phosphorus can be removed from the water catchment, this is significantly more than the required 12.2 kg yr^{-1} of phosphorus estimated to be produced annually by the proposed housing development. However, in reality, adoption of potential opportunity areas by land managers is likely to be limited.

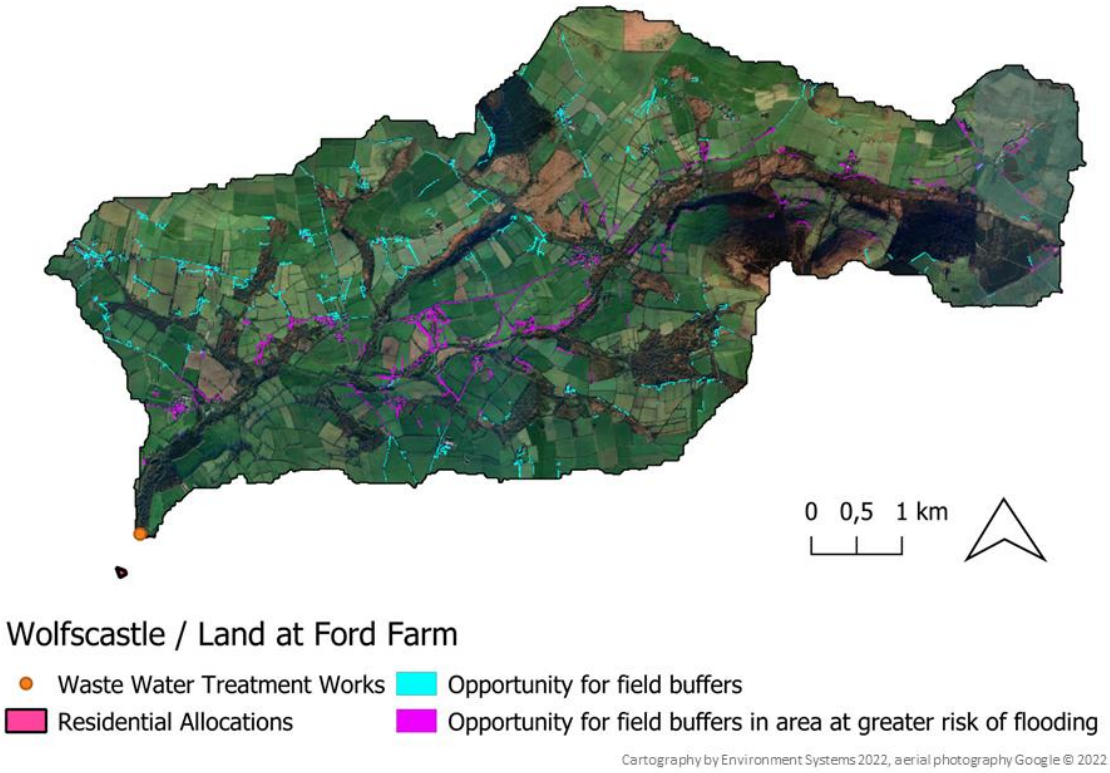
	Riparian buffer strips	Floodplain woodland	Field buffers	Field buffers in areas of greater flood risk	Artificial wetland associated with WWTW	Total
Areas of opportunity for mitigation (ha).	0	0	43.9	35.1	0	79
Estimated phosphorus removal efficiency (kg yr^{-1}).	0	0	13.2	10.5	0	23.7

Considerations for placement and development of solutions

The opportunity maps created for each mitigation solution highlight all ecologically-suitable areas where each nature-based solution could be implemented. However, we understand that the entire extent of these areas may not be suitable based on various site-specific factors such as landowner support and their business objectives and additional or alternative opportunities these areas might deliver for the landowner. In addition, the potential sensitivities of the sites, such as historic, cultural and biodiversity values, and also how the proposed measures fit with any local nature recovery plans/partnerships should be considered.

Before planning permission is granted for the housing development to proceed the next phase of this work will require further definition and prioritisation of areas for the implementation of the proposed mitigation solutions. This next phase will require more in-depth stakeholder consultation and site visits to allow the most acceptable

and effective mitigation solutions to be designed and implemented. In addition, site-specific monitoring and management plans should be established to monitor and evaluate local phosphorus removal efficiencies that will help to inform future management and ensure that phosphorus mitigation requirements are being met into the future. The costs and timeframe for the next stage of this process should be agreed between interested stakeholders.



Map 1. Location of opportunity areas for field buffers within the Wolfcastle water catchment.

There are various sources available that can be used to help Inform the best-practice implementation of hedgerow buffers such as those detailed in the Glastir Management Verifiable Standards (2016). In the case of field and riparian buffers the width of the buffer and species composition should be carefully considered following site visits and consultation with local stakeholders, and would be best guided by national guidelines as mentioned above.

References

Abu-Zreig, M., Rudra, R.P., Whiteley, H.R., Lalonde, M.N. & Kaushik, K. (2003). Phosphorus removal in vegetated filter strips. Journal of Environmental Quality. 32, 613-619. DOI: 10.2134/jeq2003.6130

Aguiar T.R., Rasera, K., Parron, L.M., Brito, A.G., Ferreira, M.T. (2015). Nutrient removal effectiveness by riparian buffer zones in rural temperate watersheds: The impact of no-till crops practices. Agricultural Water Management; 149: 74-80. https://doi.org/10.1016/j.agwat.2014.10.031

Bowers, O. (2020). Somerset Levels and Moors Phosphate Mitigation Solutions. Report for Combined Somerset Authorities. RoyalHaskoningDHV. Exeter, UK https://www.somersetwestandtaunton.gov.uk/media/3232/solutions-report.pdf

Cole, L.J., Stockan, J, and Helliwell, R. (2020). Managing riparian buffer strips to optimise ecosystem services: A Review. Agriculture, Ecosystems and Environment. 295. https://doi.org/10.1016/j.agee.2020.106891

Cuttle, S.P., MacLeod, D.R., Chadwick, D., Scholefield, D., Newell-Price, D., Chambers, B.J., Humphrey, R. (ADAS. (2007). An Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA) USER MANUAL. Prepared as part of Defra Project ES0203

Da Ros, L., Soolanayakanahally, R., Guy, R., Mansfield, S.D. (2018). Phosphorus storage and resorption in riparian tree species: Environmental applications of poplar and willow. Environmental and Experimental Botany. 149:1-8. https://doi.org/10.1016/j.envexpbot.2018.01.016.

Djodjic, F., Geranmayeh, P. and Markensten, H. (2020). Optimizing placement of constructed wetlands at landscape scale in order to reduce phosphorus losses. Ambio 49, 1797–180. https://doi.org/10.1007/s13280-020-01349-1

Fortier, Julien & Truax, Benoit & Gagnon, Daniel & Lambert, France. (2015). Biomass carbon, nitrogen and phosphorus stocks in hybrid poplar buffers, herbaceous buffers and natural woodlots in the riparian zone on agricultural land. Journal of environmental management. 154: 333-345. https://doi.org/10.1016/j.jenvman.2015.02.039

Gruau, G., Gu., Dupas, R., Gascuel-Odoux, C.I Rumpel, C. & Petitjean, P. (2017). Release of dissolved phosphorus from riparian vegetated buffer strips: a field assessment of mechanisms and risks. 10.13140/RG.2.2.24289.10082.

Hoffmann, C., Kjaergaard, C., Uusi-Kamppa, J., Hansen, H. and Kronvang, B. (2009) Phosphorous Retention in Riparian Buffers: Review of Their Efficiency. Journal of Environmental Quality: 38, 1942-1955. DOI: 10.2134/jeq2008.0087

Isebrands, J.G., et al. (2014). Environmental applications of poplars and willows. In book: Poplars and Willows; trees for society and the environment. Chapter 6. CABI and FAO. DOI: 10.1079/9781780641089.0258.

Johnston, C.A., Bubenzer, G.D., Lee, G.B., Madison, F.W. and Mc Henry, J.R. (1984), Nutrient Trapping by Sediment Deposition in a Seasonally Flooded Lakeside Wetland. Journal of Environmental Quality, 13: 283-290. https://doi.org/10.2134/jeq1984.00472425001300020022x#

Kronvang, Brian & Andersen, Inga & Hoffmann, Carl & Fejerskov, Morten & Ovesen, Niels & Andersen, H. (2007). Water Exchange and Deposition of Sediment and Phosphorus during Inundation of Natural and Restored Lowland Floodplains. Water, Air, and Soil Pollution. 181. 115-121. https://doi.org/10.1007/s11270-006-9283-y

Land, M., Graneli, W., Grimvall, A., Hoffman, C., Mitsch, W., Tonderski, K., Verhoeven, J. (2016). How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal? A systematic review. Environmental Evidence: 5:9. https://doi.org/10.1186/2047-2382-2-16

Letts et al (2020). 3D buffer strips- designed to deliver more for the environment. https://www.gov.uk/government/publications/3d-buffer-strips-designed-to-deliver-more-for-the-environment/3d-buffer-strips-designed-to-deliver-more-for-the-environment-summary

Luderitz, V., Eckert, E., Lange-Weber, M., Lange, A., Gersberg, R. (2001). Nutrient Removal Efficiency and Resource Economics of Vertical Flow and Horizontal Flow Constructed Wetlands. Ecological Engineering, 18(2):157-171.

NRWM (2013). Buffer Strips and Hedges. Report for the European Commission. http://nwrm.eu/sites/default/files/nwrm_ressources/a2_-_buffer_strips_and_hedges.pdf

Mackenzie, S.M. and McIlwraith, C.I. (2015) Constructed farm wetlands - treating agricultural water pollution and enhancing biodiversity (2nd edition). Available from: www.wwt.org.uk/farmwetlands

Maucieri, Carmelo & Salvato, Michela & Borin, Maurizio. (2020). Vegetation contribution on phosphorus removal in constructed wetlands. Ecological Engineering. 152. https://doi.org/10.1016/j.ecoleng.2020.105853

Mitsch WJ, Horne AJ, Nairn RW. (2000). Nitrogen and phosphorus retention in wetlands-ecological approaches to solving excess nutrient problems. Ecological Engineering. 14 (1–2):1–7

Newell Price, J., Harris, D., Taylor, M., Williams, J., Anthony, S., Deuthmann, D., Gooday, R., Lord, E., Cambers B., Chadwick, D., Misslebrook, T. (2011). An Inventory of Mitigation Methods and Guide to their Effects on Diffuse Water Pollution, Greenhouse Gas Emissions and Ammonia Emissions from Agriculture. Defra Project WQ0106.

Rural Payments Agency & Natural England (2015) SW11: Riparian management strip https://www.gov.uk/countryside-stewardship-grants/riparian-management-strip-sw11

Rural Payments Agency & Natural England (2015) SW11: BN11: Planting new hedges https://www.gov.uk/countryside-stewardship-grants/riparian-management-strip-sw11

Schoumans, O.F., Chardon, W.J., Bechmann, M.E., Gascuel-Odoux, C., Hoffman, G., Kronvang, B., Rubæk, G.H., Ulén, B., and Dorioz, J.M. (2014). Mitigation options to reduce phosphorus losses from the agricultural sector and improve surface water quality: A review. Science of The Total Environment, 468–469: 1255-1266. https://doi.org/10.1016/j.scitotenv.2013.08.061

Stutter, M.L., Langan, S.J. & Lumsdon, D.G. (2009) Vegetated buffer strips can lead to increased release of phosphorus to waters: A biogeochemical assessment of the mechanisms. Environmental Science & Technology. 43(6): 1858-1868. DOI: 10.1021/es8030193

Tsai, Yushiou & Zabronsky, Hope & Zia, Asim & Beckage, Brian. (2022). Efficacy of Riparian Buffers in Phosphorus Removal: A Meta-Analysis. Frontiers in Water. 4. https://doi.org/10.3389/frwa.2022.882560

Uusi-Kämppä, J., Braskerud, B., Jansson, H., Syversen, N. and Uusitalo, R. (2000), Buffer Zones and Constructed Wetlands as Filters for Agricultural Phosphorus. Journal of Environmental Quality, 29: 151-158. https://doi.org/10.2134/jeq2000.00472425002900010019x

Weisner S, Johannesson K, Tonderski K. Näringsavskiljning i anlagda våtmarker i jordbruket. (2020) Analys av mätresultat och effekter av landsbygdsprogrammet (in Swedish). Jordbruksverket, Rapport:7.

Welsh Government. (2016). Glastir Management Options 1-46 verifiable standards https://gov.wales/sites/default/files/publications/2018-01/glastir-management-options-1-to-46-verifiable-standards.pdf

Zabronsky, H. (2016). Phosphorus Removal in Agricultural Riparian Buffers: A Meta-Analysis. https://epscor.w3.uvm.edu/pdf/2016_symposium/07_Zabronsky_Hope_2016_file.pdf

Zhang, Tiequan & Zheng, Zhiming & Drury, Craig & Hu, Q.C. & Tan, Chin. (2020). Legacy Phosphorus After 45 Years With Consistent Cropping Systems and Fertilization Compared to Native Soils. Frontiers in Earth Science. 8. https://doi.org /10.3389/feart.2020.00183.