Technical Note: Nutrient Neutrality for the River Clun – Nitrogen and Phsophorous

Background to Nutrient Neutrality at the River Clun

1.1 The River Clun SAC is designated for its freshwater pearl mussles (*Margaritifera margaritifera*). Good water quality is important to the freshwater pearl mussel at all life stages. Nutrient enrichment from increased phosphorus and nitrogen levels contribute to eutrophication characterised by increased filamentous algae and macrophyte growth. Agriculture has been identified as a significant contributor of nitrogen and phosphorus to the River Clun, although sewage treatment plants contribute 35% of current phosphorus levels.

1.2 The Shropshire Local Plan HRA identifies that improvements to the Bishops Castle WwTW have been made to reduce orthophosphate at the SAC to 0.01 mg/l P, Total Oxidized Nitrogen to 1.5 mg/l and suspended solids to 10mg/l by 2027. However, following case law (Cooperatie Mobilisation for the Environment UA and Vereniging Leefmilieu v College van gedeputeerde staten van Limburg and College van gedeputeerde staten van Gelderland C-293/17 C394/17 – 'Dutch Nitrogen Case') and recent legal interpretation, this can no-longer be relied on. The existing NMP does not provide enough certainty to ensure that favourable conservation status will be achieved at the SAC. Until an updated NMP, with predictable and definite outcomes, is drawn up in partnership with stakeholders, and can be enforced, only limited development can pass an Appropriate Assessment and hence be granted planning permission. The HRA of the Shropshire Local Plan concluded that all new allocations within the Clun catchment could, in combination, result in an adverse effect on the integrity of the Clun SAC.

1.3 Whilst the School Lane (BISH013) allocation is provided within the overarching Shropshire Local Plan, and the issue of nutrient neutrality is best addressed at a higher authority, as the issue has not yet been addressed at the higher Local Plan level, it is necessary to consider nutrient neutrality at the lower Neighbourhood Plan level.

Background to the Nitrogen Nutrient Neutrality Calculations

1.1 The main contribution to nitrogen release into surface water is provided by agricultural runoff inputs, however effluent discharge from household waste water is a considerable contributor.

1.2 Since the issue remains under investigation at this stage no nutrient neutrality calculation methodology for the River Clun SAC has been developed. However, a methodology for calculating the nitrogen release of new development (through both changes in land use and, particularly, release of treated sewage effluent) has been developed for Stodmarsh SAC, SPA and Ramsar site in Kent and the calculation methodology would be essentially identical if Natural England did determine that development in the Wye and Usk catchments also needed to achieve nutrient neutrality. Nitrogen nutrient neutrality calculations have therefore been undertaken for the residential site allocation (School Lane – BISH013) provided within the Neighbourhood Plan using the phosphorus calculation method developed for Stodmarsh.

Background to the Phosphorous Nutrient Neutrality Calculations

1.4 The main contribution to phosphorus release into surface water is provided by the effluent discharge, and as such increased residential development should not be ignored. In comparison to nitrogen, diffuse pollution from agricultural runoff is likely to provide a small contribution to phosphate levels and this issue is managed via Catchment Sensitive Farming). As described by Jarvie *et al.*[1], new residential units within the hydrological catchment for the River Clun are likely (through increased sewage production) to add phosphates to a site via wastewater treatment effluent.

1.5 Since the issue remains under investigation at this stage no nutrient neutrality calculation methodology for the River Clun SAC has been developed. However, a methodology for calculating the phosphate release of new development (through both changes in land use and, particularly, release of treated sewage effluent) has been developed for Stodmarsh SAC, SPA and Ramsar site in Kent and the calculation methodology would be essentially identical if Natural England did determine that development in the Wye and Usk catchments also needed to achieve nutrient neutrality. Phosphorous nutrient neutrality calculations have therefore been undertaken for the residential site allocation (School Lane – BISH013) provided within the Neighbourhood Plan using the phosphorus calculation method developed for Stodmarsh.

Appropriate Assessment

1.6 New residential development provided by Neighbourhood Plan will be serviced by the Bishops Castle Wastewater Treatment Works (WwTW), that discharges into watercourses that ultimately drain to the River Clun SAC. The Council has identified which WwTW is expected to service the new development within Bishops Castle. At this stage it has not been confirmed which WwTW will service a particular site allocation. This will generally not occur until a water company has a planning application to consider. For the purposes of this assessment, the WwTW identified by the Council to service each particular residential allocation has been used. A more detailed and accurate Nutrient Neutrality calculation may therefore need to be provided by each the applicant at the individual planning application stage.

1.7 Achieving nutrient neutrality is one way to address the existing uncertainty surrounding the impact of new development on designated sites. Natural England advises that a nitrogen budget (referred to as a Total Nitrogen (TN)) and a phosphate budget (referred to as Total Phosphorus (TP)) can be calculated for new developments and has provided a guidance document to enable this to be calculated[2]. That document was specifically prepared for the Stour catchment in Kent. However, the basic nitrogen and phosphate calculation methodology is transferable to other internationally designated sites. The main reason for this is that both systems are freshwater systems that are

[1] Jarvie, H. P., Neal, C., & Withers, P. J. (2006) *Sewage-effluent phosphorus: a greater risk to river eutrophication than agricultural phosphorus?* Science of the total environment, *360*(1-3), 246-253.
[2] Natural England (November 2020). Advice on Nutrient Neutrality for New Development in the Stour Catchment in Relation to Stodmarsh Designated Sites - For Local Planning Authorities.

likely to have similar sensitivities to phosphorus, the primary growth-limiting nutrient in freshwater ecosystems. This HRA uses the methodology for the Stour Valley catchment to estimate the nutrient balance for the Bishops Castle Neighbourhood Plan within the River Clun. The results are summarised in **Table 1** below; with full detail provided in Appendix A.

Phosphorus Balance within the Bishops Castle Neighbourhood Plan

1.8 The nutrient neutrality calculations undertaken for the Bishops Castle Neighbourhood Plan indicate whether development would avoid harm to protected sites (in this case the River Clun SAC) from nitrogen and/ or phosphate discharge (generally by resulting in a net reduction in nitrogen and / or phosphorus entering the catchment), or whether mitigation would be required to ensure that there is no adverse effect from nitrogen and/ or phosphorus discharge.

1.9 The nutrient budget calculation for the Bishops Castle Neighbourhood Plan residential site allocation involved four stages:

- Stage 1: Future nitrogen and phosphorus load in treated wastewater effluent
- Stage 2: Nitrogen and phosphorus loss due to conversion of existing land uses
- Stage 3: Nitrogen and phosphorus leachate from future land uses
- Stage 4: Overall nitrogen and phosphorus budget for the site

1.10 Existing land use was determined at this high-level by assessing satellite imagery on Google Maps. Future land uses (e.g. the extent of the urban fabric and any open space) were identified either by calculating the broad area that would be taken up by residential development using a standard housing density of 30 dwellings per hectare and defining the resulting area as the ‘urban’ land on the developed site. Unfortunately, for this assessment, no masterplans were available to determine the amount of green SANG space that is to be provided by the allocation. All collected information fed into the nutrient calculation described below. Each type of broad land use (urban, park/SANG, cereal, lowland grazing etc.) has an N and a P load assigned to it in the nutrient neutrality calculation methodology. Therefore, converting land from (for example) cereal cropping to urban land considerably reduces both the N and the P load. However, whether this is enough to offset the increased N and P load due to treated sewage effluent is dependent on the types of habitat involved and the area of land involved.

1.11 Note that the calculations make a series of broad assumptions about a) the existing habitats on site (and thus the amount of phosphorus they currently release into the catchment) and b) how each site is to be developed (the areas to be altered) and thus the future balance between areas of housing and areas of retained greenspace. Therefore, the calculations undertaken for this report would need to be re-run by the applicants for each housing scheme and planning application as each scheme is developed and a detailed masterplan became available.

1.12 These calculations are based on a worst-case assumption that all phosphorus discharged from this allocation will reach the River Clun SAC site.

The below table (**Table 1**) identifies which WwTW the allocation will discharge to and that ultimately discharges to the River Clun SAC designated site and the amount of nitrogen and phosphorus the allocation is predicted to produce as a result of the changed land use and residential development. Those site allocations identified in red in the final column (Allocation P Budget with 20% Buffer) are calculated to result in a nitrogen and phosphorus surplus.

Table 1: Site Allocations That Are Likely to Ultimately Discharge to the River Clun SAC, and Associated WwTW.

Site Allocation	Number of Residential Dwellings	Likely Wastewater Treatment Works (WwTW)	Allocation N with 20% Buffer	Allocation P with 20% Buffer
School Lane (BISH013)	40	Bishops Castle	91.26	2.48

1.13 The nutrient neutrality assessment of the above site allocation at School Lane (BISH013) (provided in **Table 1**) identified that this site is likely to result in a net increase in nitrogen and phosphate levels within the River Clun in comparison to current land use. As such, both nitrogen and phosphorus offsetting will need to be identified before planning consent could be granted.

1.14 In the long-term it is acknowledged that the issue of nutrient neutrality is difficult to address purely at the Neighbourhood Plan level and will likely require cross work with the County Council, wastewater company and Natural England and their permitting teams. None the less, it may be necessary for the Parish to address the potential need for avoidance measures and / or mitigation for nitrogen and phosphate discharge from the site allocation within the Neighbourhood Plan identified to ultimately discharge to the River Clun SAC.

1.15 The below table outlines the current or already planned future nitrogen and phosphorus discharge permits for Bishops Castle WwTW, and the expected nitrogen and phosphorus discharge resulting from the Neighbourhood Plan. Detail of the surplus from the residential site allocation is provided in **Appendix A**

Table 2 Summary of Calculation of Increased WwTW / STW Nitrogen and Phosphorus Output Due to the Neighbourhood Plan.

Nutrient Inputs	Number of Residential Dwellings	Current or Future Planned Environmental Permit per WwTW (mg/l) TN/ TP	Surplus discharge resulting from the Plan (kg/P/yr)
Nitrogen	40	27 (Bishops Castle WwTW does not have its own specified environmental permit for nitrogen)	91.26
Phosphorus	40	0.4	2.48

1.16 **Table 2** indicates that the new residential (as identified in red in **Table 1**) will result in an exceedance of both the existing permitted nitrogen and phosphate discharge limits when compared to a 'no change' in existing land use scenario.

1.17 Based on the calculation described above, there will be an increase in both nitrogen and phosphorus output into the hydrological catchment of the River Clun SAC as a result of new housing allocated within the Neighbourhood Plan. Therefore, nutrient neutrality would not be met in the absence of mitigation.

1.18 It should be noted that the above calculations have only been undertaken on site allocations identified within the Bishops Castle Neighbourhood Plan. By their nature, any windfall development has not been included within the above calculation since it is not known where these would be located, how they would change existing land use or how many dwellings would be delivered on each site. Nutrient Neutrality will require consideration at the individual planning application stage once the location, and extent of that windfall development has been identified.

Potential Avoidance Strategies / Solutions to Explore

Nitrogen

1.19 Assuming the developer's nutrient neutrality calculation confirms that mitigation is required, and this is agreed with the competent authority, it is likely that the following may be required.

1.20 Nitrogen is much easier to remove from a catchment then phosphorous (see next section).

1.21 Removing additional land from agricultural production –Agriculture is the main contributor to nitrogen inputs within a catchment. For example, each hectare of lowland grazing land (such as that within the allocation) generally contributes approximately 12.2 kilograms of nitrogen per year. Therefore, removing additional land from agricultural production and putting it down to parkland (which has a relatively low nitrogen loss rate 5kg N/Ha/yr) instead would offset the nitrogen released in treated wastewater from the new housing. Initial calculations for this HRA indicate that approximately 13ha of farmed land (similar to the land use being lost) would need to be removed from agricultural production (over and above that which would be lost to the development footprints themselves) within the River Clun catchment respectively to offset the nitrogen produced by the new housing.

1.22 Since wetlands are able to remove some nitrogen, an offsetting solution being explored elsewhere is to deliver new wetlands, not to treat effluent from development, but to remove an equivalent amount of N from agricultural runoff that would otherwise enter the rivers.

Phosphorous

1.23 Assuming the developer's nutrient neutrality calculation confirms that mitigation is required, and this is agreed with the competent authority, it is likely that some or all of the following may need to be undertaken.

1.24 If mitigation is required, the following should be explored:

i. Removing additional land from agricultural production – While agriculture does not contribute as much phosphorus to watercourses as treated sewage effluent, it does contribute some phosphorus. For example, each hectare of lowland grazing land (such as that within the allocation) generally contributes approximately 0.24 kilograms of phosphorus per year. Therefore, removing additional land from agricultural production and putting it down to parkland (which has a relatively low phosphorus loss rate) instead would offset the phosphorus released in treated wastewater from the new housing. Initial calculations for this HRA indicate that approximately 25ha of farmed land (similar to the land use being lost) would need to be removed from agricultural production (over and above that which would be lost to the development footprints themselves) within the River Clun catchment respectively to offset the phosphorus produced by the new housing;

ii. Identifying an alternative wastewater discharge location - Discharging to ground would 'bypass' surface waterbodies, ultimately contributing to groundwater. It is considered that this would reduce the phosphorus loading in surface water and help in protecting the River Clun. This is because adsorption and metal complex formation retain most of the potentially mobile phosphorus and thus reduce mobilisation from groundwater into surface waters;

iii. Utilising local packaged WwTW - A local packaged WwTW associated specifically with the development could be used to provide a removal route for the additional phosphorus. However, treatment would require the use of a chemical dosing system which would still only achieve a 1mg/l phosphorus concentration. The only method to achieve a lower concentration through packaged treatment would be to include a further tertiary treatment method such as reedbeds and similar. However, this requires increased operational effort and eventually will require a Water Authority to adopt and operate it for its asset life;

iv. Utilising downstream wetlands - A wetland/reedbed filtration system that was not linked to a WwTW would be unlikely to be effective in removing phosphorus from sewage effluent (although it would contribute to removal of phosphorus from surface runoff). The UKWIR Chemical Investigations Programme (CIP)[3] identified a relatively poor phosphate (as opposed to nitrogen) removal performance. In the UK, such wetlands are rarely used for wastewater treatment because on their own. Evidence[4] suggests wetlands are only c. 50% efficient at removing phosphates. It is for this reason that, in the UK, such wetlands are rarely used for wastewater treatment because on their own they are not expected to achieve a lower phosphate concentration than 2mg/l. Therefore, they are most suitable as a tertiary sewage treatment method following initial treatment stages at a WwTW or packaged treatment plants.

v. Since wetlands are able to remove some phosphorus, an offsetting solution being explored elsewhere is to deliver new wetlands, not to treat effluent from development, but to remove an equivalent amount of P from agricultural runoff that would otherwise enter the rivers. It should be noted that the science behind wetland P removal efficiency is variable and generally wetlands are only considered to be about 50% efficient at removing phosphates[5].

[3] Available at: https://ukwir.org/the-chemicals-investigation-programme-phase-2,-2015-2020 [Accessed 13/10/2020].
[4] Land et al (2016) How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal? A systematic review. Environmental Evidence. 5:9
[5] Land et al (2016). How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal? A systematic review. Environmental Evidence 5:9

Appendix A: Nitrogen Nutrient Neutrality Calculations

The following Tables show the workings for the nitrogen nutrient neutrality calculations for the Bishops Castle Neighbourhood Plan following the methodology set out in Natural England's Advice on Nutrient Neutrality for New Development in the Stour Catchment in Relation to Stodmarsh Designated Sites[6]

Stage 1 – WwTW Effluent

A	B	C	D	E	F	G	H	I	J	K	L	M
Proposed Allocation		Step 1 - Additional Population		Step 2 - Wastewater Generation by Development		Step 3 - Receiving WwTW permit limit				Step 4 - TN discharged after WwTW		
Sub-Allocation	Site Name	Number of Residential Dwellings	Number of new residents assuming 2.4 residents/dwelling occupancy	Water consumption person / day (litres)	Total wastewater generated by development (litres / day)	Likely Wastewater Treatment Works (WwTW)	TN Environmental permit for WwTW (mg/l TN)[7]	90% of consent limit[8]	Deduct 2 mg/l to allow for natural nitrogen load	TN Discharge after WwTW treatment (mg/TN/day)	TN Discharge after WwTW treatment (kg/TN/day)	TN Discharge after WwTW treatment (kg/TN/year)
BISH013	School Lane	40	96	110	10560	Bishops Castle WwTW	27	27	25	264000	0.264	96.36

[6] Natural England (November 2020). Advice on Nutrient Neutrality for New Development in the Stour Catchment in Relation to Stodmarsh Designated Sites - For Local Planning Authorities.
[7] No permit identified so 27ml/d used as per the Solent (Stodmarsh NE guidance)
[8] 90% correction not used in accordance with NE Stodmarsh Guidance.

Stage 2 – Loss from Farm Types

A	B	C	D	E	F	G	H	I	J	K	L
Step 1 - Total area of existing (agricultural) land					**Step 2 - Identify current land use in site allocations**						**Step 3 - Determine nitrogen loss from current land use**
Allocation	**Site Name**	**Site area (ha)**	**Discounted land use (ha)**	**Site area discounting non-agricultural uses (ha)**	**Current Land Use**	**Comments**	**Confident (Y/N)**	**Site Visit (Yes/No)**	**Confidence after site visit (Y/N)**	**Estimated Total Nitrogen Loss (kg/ha/yr)**	**Estimated Total Nitrogen Loss (kg/TN/yr) for whole allocation (Column E * Column K)**
BISH013	School Lane	2.43	0	2.43	Lowland grazing	Sheep shown grazing on Google maps	Y	No	NA	12.2	29.646

Stage 3 – Future Land Use

Note: Masterplans and vision statements (often early versions) are only available for a few of the site allocations. The size of greenspaces and public open spaces (have a different phosphate leaching rate) has been done using the best available information and completing measurements in GIS

A	B	C	D	E	F	G	H	I	J	K	L	M
Proposed Allocation				Steps 1 + 2 New urban area and associated leachate				Steps 3 + 4 New open space area and associated leachate				Step 5 Combined nitrogen leachate from future land uses
Allocation	Site Name	Number of new residents (from Stage 1 Column D)	Total Site area (ha) (from Stage 2 Column C)	Type of development (urban, open spaces, food growing)	Total urban surface area (ha)[9]	Urban nitrogen leachate standard (kg N/ha/yr)	Total urban nitrogen leachate for site allocation (Column F * Column G)	Public Open Space (Y/N)	Total open space area (ha)[10]	Greenspace nitrogen leachate standard (kg N/ha/yr)	Total greenspace nitrogen leachate for site allocation (Column J * Column K)	Overall leachate from all surfaces (kg/TN/yr)(Column H + Column L)
BISH013	School Lane	96	2.43	Urban	1.3333	14.3	19.06662	Y	1.096667	5	5.483333333	24.54995233

[9] Total urban area = 40 no. of net new dwellings/ 30 dph
[10] GI calculated= site area. 2.43-(40 no. of dwellings / 30 dph)

Stage 4 – Site Budget

Note: Individual site allocations with an overall phosphorus deficit are shaded green, whereas site allocations with a nitrogen surplus (i.e. requiring mitigation) are marked in red

A	B	C	D	E	F	G	H	I
		Stage 1 - Treated WwTW Effluent	**Stage 3 - Future land use**	**Stage 2 - Loss of nitrogen from current farm types**	**Stage 4 - Total nitrogen budget**			
Allocation	Site Name	TN Discharge after WwTW treatment (kg/TN/year) (Stage 1, Column M)	Overall leachate from all surfaces (kg/TN/yr)(Stage 3, Column M)	Estimated Total Nitrogen Loss (kg/TN/yr) for whole allocation (Stage 2, Column L)	Nitrogen Balance Present and Future Land Uses (Column D - Column E)	Overall Nitrogen Budget (Column C + Column F)	20% Buffer (from values in Column G)	Allocation Nitrogen Budget (with 20% buffer where applicable) (kg/TN/year)
BISH013	School Lane	96.36	24.54995233	29.646	-5.096047667	91.26395233		91.26

Appendix B: Phosphorus Nutrient Neutrality Calculations

The following Tables show the workings for the phosphorous nutrient neutrality calculations for the Bishops Castle Neighbourhood Plan following the methodology set out in Natural England's Advice on Nutrient Neutrality for New Development in the Stour Catchment in Relation to Stodmarsh Designated Sites[11]

Stage 1 – WwTW Effluent

A	B	C	D	E	F	G	H	I	J	K
	Step 1 - Additional Population		Step 2 - Wastewater Generation by Development		Step 3 - Receiving WwTW permit limit			Step 4 - TP discharged after WwTW		
Site Allocation	Number of Residential Dwellings	Number of new residents assuming 2.4 residents/dwelling occupancy	Water consumption per person / day (litres)	Total wastewater generated by development (litres / day)	Likely Wastewater Treatment Works (WwTW)	TP Environmental permit for WwTW (mg/l TP)	90% of consent limit	TP Discharge after WwTW treatment (mg/TP/day)	TP Discharge after WwTW treatment (kg/TP/day)	TP Discharge after WwTW treatment (kg/TP/year)
School Lane	40	96	110	10560	Bishops Castle WwTW	0.4	0.36	3801.6	0.0038016	1.387584

[11] Natural England (November 2020). Advice on Nutrient Neutrality for New Development in the Stour Catchment in Relation to Stodmarsh Designated Sites - For Local Planning Authorities.

Stage 2 – Loss from Farm Types

A	B	C	D	E	F	G	H	I	J	K
Step 1 - Total area of existing (agricultural) land				Step 2 - Identify current land use in site allocations						Step 3 - Determine phosphate loss from current land use
Site Name	Site area (ha)	Discounted land use (ha)	Site area discounting non-agricultural uses (ha)	Current Land Use	Comments	Confident (Y/N)	Site Visit (Yes/No)	Confidence after site visit (Y/N)	Estimated Total Phosphate Loss (kg/ha/yr)	Estimated Total Phosphate Loss (kg/ha/yr) for whole allocation (Column D * Column J
School Lane	2.43	0	2.43	Lowland Grazing	Sheep shown grazing on Google maps	Y	No	NA	0.24	0.5832

Stage 3 – Future Land Use

Note: Masterplans and vision statements (often early versions) are only available for a few of the site allocations. The size of greenspaces and public open spaces (have a different phosphate leaching rate) has been done using the best available information and completing measurements in GIS

A	B	C	D	E	F	G	H	I	J	K	L
			Steps 1 + 2 New urban area and associated leachate				Steps 3 + 4 New open space area and associated leachate				Step 5 Combined phosphate leachate from future land uses
Site Name	Number of new residents (from Stage 1 Column C)	Total Site area (ha) (from Stage 2 Column D)	Type of development (urban, open spaces, food growing)	Total urban surface area (ha)[12]	Urban phosphate leachate standard (kg P/ha/yr)	Total urban phosphate leachate for site allocation (Column E * Column F)	Public Open Space (Y/N)	Total open space area (ha)[13]	Greenspace phosphate leachate standard (kg P/ha/yr)	Total greenspace phosphate leachate for site allocation (Column I * Column J)	Overall leachate from all surfaces (kg P/ha/yr)(Column G + Column K)
School Lane	96	2.43	Urban	1.33333	0.83	1.1066639	Y	1.09666667	0.14	0.153533333	1.260197233

[12] Total urban area = 40 no. of net new dwellings/ 30 dph
[13] GI calculated= site area. 2.43-(40 no. of dwellings / 30 dph)

Stage 4 – Site Budget

Note: Individual site allocations with an overall phosphorus deficit are shaded green, whereas site allocations with a phosphorus surplus (i.e. requiring mitigation) are marked in red

A	B	C	D	E	F	G	H
	Stage 1 - Phosphate in treated WwTW Effluent	**Stage 3 - Phosphate leachate from future land use**	**Stage 2 - Loss of phosphorus from current farm types**	**Stage 4 - Total phosphorus budget**			
Site Name	TP Discharge after WwTW treatment (kg/TP/year) (Stage 1, Column K)	Overall leachate from all surfaces (kg P/ha/yr)(Stage 3, Column L)	Estimated Total Phosphorus Loss (kg/ha/yr) for whole allocation (Stage 2, Column K)	Phosphorus Balance Present and Future Land Uses (Column C - Column D)	Overall Phosphorus Budget (Column B + Column E)	20% Buffer (from values in Column F)	Allocation Phosphorus Budget with 20% buffer
School Lane	1.387584	1.260197233	0.5832	0.676997233	2.0646	0.412916247	2.48