REPORT

River Lambourn Phosphate Budget Calculator

Technical Reference Report

Client: West Berkshire Council

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1 Introduction

West Berkshire Council (WBC) have commissioned Royal HaskoningDHV to produce key deliverables for the catchment of the River Lambourn Special Area of Conservation (SAC). A nutrient calculator specific to the catchment and maps presenting wastewater treatment works (WwTW) within the catchment form part of these deliverables, as set out in the River Lambourn Phosphate Mitigation Strategy Roadmap Report (Ref. PC4122-RHD-ZZ-XX-RP-Z-0002) dated 15 November 2022.

The River Lambourn phosphate budget calculator is a catchment-specific tool designed to rapidly calculate the phosphate loading from new development in the River Lambourn SAC catchment. This report presents the principles and key assumptions on which the calculator is based and follows review comments made by Natural England dated 25 July 2023.

1.1 Evidence Based Approach

The River Lambourn phosphate budget calculator utilises the best available scientific evidence and research and nutrient neutrality guidance (Natural England, 2022). The calculator adopts the most regional-specific and scientifically accurate approach. As a result, some of the calculator inputs and assumptions deviate from published guidance. Evidence used for these deviations is presented within this report.

Whilst the best available evidence and research was used, some inputs are based on professional judgement and the values used are subject to a degree of uncertainty. As such, a precautionary approach was applied in line with existing legislation and case law. Furthermore, a precautionary buffer was added to the total phosphate loading values for developments. Applying a precautionary approach provides reasonable certainty to the local planning authority that the development, in combination with other developments, will avoid significant increases in phosphate loading to the designated sites.

Under the requirements of the Conservation of Habitats and Species Regulations 2017 (as amended) (herein referred to as the Habitats Regulations), a Habitats Regulations Assessment must demonstrate that there is no reasonable scientific doubt as to the absence of adverse effects on a habitats site. However, absolute certainty is not required. In order to meet the requirements, where possible, scientific evidence was used instead of generic assumptions.

1.1.1 Characterisation of the River Lambourn catchment

The River Lambourn catchment is described in the Lambourn (2022) webpage as characterised by a largely rural setting, with mixed farming as the main industry, and there are extensive deciduous woodlands on the catchment boundary. It is a chalk river in the Berkshire Downs approximately 26 km long and flows through the Kennet Valley in a south-easterly direction to Newbury where it joins the River Kennet.

One important tributary is the Winterbourne Stream, which flows into the Lambourn from the north-east, just upstream of Newbury. The underlying bedrock is chalk, with overlying river gravels. The upper part of the river between Lambourn and Great Shefford is seasonal with water running approximately six months of the year when the water table in the chalk rises and the springs start to flow.

Globally significant chalk streams are mentioned specifically in the Environment Improvement Plan 2023 as a priority for action and support of the Chalk Stream Restoration Strategy 2021 and Implementation Plan 2022.

The Environment Agency's Catchment Explorer provides the following information is relation to the Lambourn (Source to Newbury) water body[1] (water body ID GB106039023220):

- 32.58 km in length;
- 214.834 km^2 catchment area; and
- Moderate ecological status classification in 2019.

1.1.2 Use of the Calculator

The calculator is only applicable to developments that impact the River Lambourn SAC, or any water body that subsequently discharges into this site. This calculator may not necessarily be used for major developments such as those requiring an Environmental Impact Assessment (EIA). The reason is some major developments may extend across the boundary of West Berkshire Council's remit as competent authority. For EIA schemes, the Planning Inspectorate is the competent authority according to the requirements of the Town and Country Planning (Environmental Impact Assessment) Regulations 2017. This tool is specific to West Berkshire as the lead authority for development within the Lambourn SAC and competent authority for planning applications within their authority area. The calculator has been developed generally for residential developments, although it may be possible to adapt it and use for other types of developments. The surface water catchment area that will impact phosphate contributions to the designated site is presented as Figure 1-1.

A full list of the Wastewater Treatment Works (WwTW) that discharge into the surface drainage network upstream of the designated site and could therefore supply phosphates is presented as Appendix A. For any development proposals that would be located outside of the defined surface water catchment area, which would discharge effluent to a WwTW within the surface water catchment, stages 2 and 3 do not apply.

No assessment is necessary for any development proposals that would drain to a WwTW that discharges outside of the surface water catchment. However, in these cases the use of SuDS should be considered because a development proposal may influence the scale of nutrient export from surface water as a result of the change in use of the land. Recognising that the size of a development proposal will influence the scale of nutrient export from surface water as a result of the change in use of the land, Natural England recommends that this only applies to development proposals below the EIA threshold. Relevant EIA developments should make a bespoke assessment of implications from land use change on nutrient export to the river.

The methodology applies to all developments that could result in increases of nutrients such as phosphorus entering habitats sites, such as population increases via new homes, student accommodation, tourist attractions and tourist accommodation as these developments would have wastewater implications as well as large-scale change in land use implications. Commercial developments where overnight accommodation is included should be included; however, generally commercial developments do not include overnight accommodation. As such, they are not typically included, as it is assumed that people working in a commercial building will live within the same catchment and the wastewater implications of the individuals are considered when assessing housing. Assessing both housing and commercial developments could therefore lead to 'double-counting'.

[1] https://environment.data.gov.uk/catchment-planning/WaterBody/GB106039023220#:~:text=Catchment%20area%2021483.369%20ha,Catchment%20area%20214.834%20km2%20Classifications

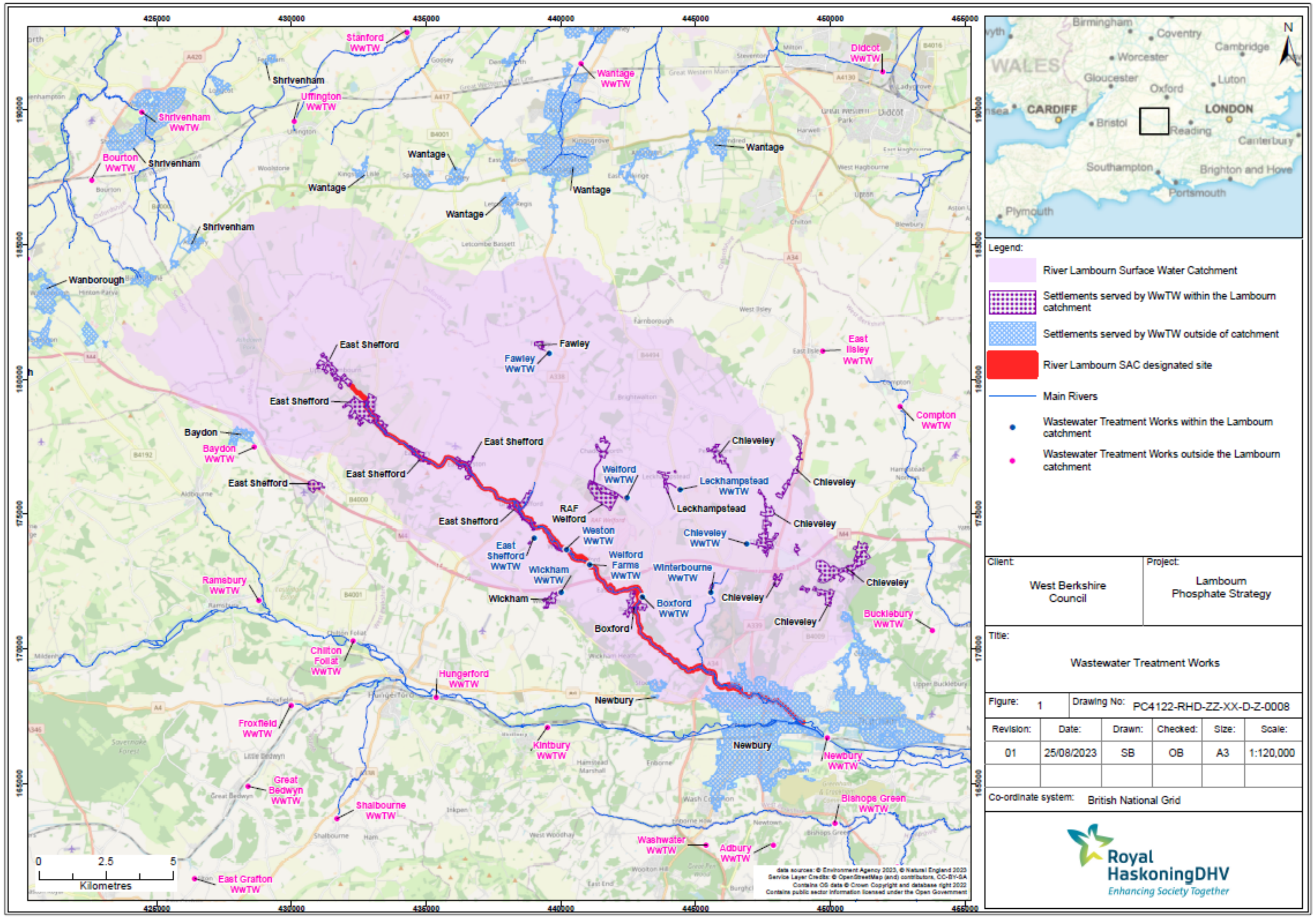

Figure 1-1: Surface Water Catchment Map

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2 Methodology

2.1 Overview

A flow diagram for the application of the four-stage process used in the River Lambourn phosphate budget calculator is presented in Figure 2-1.

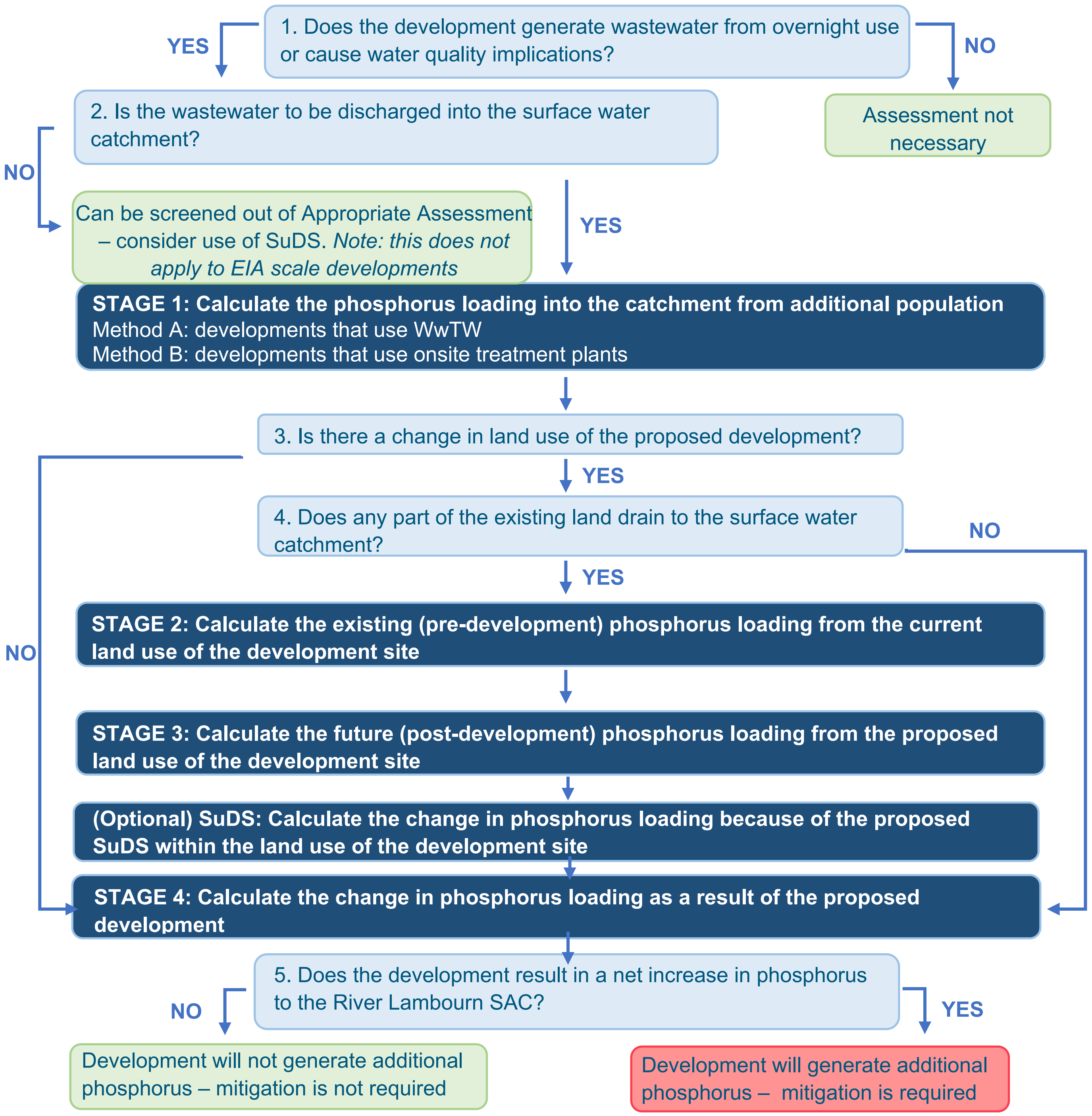

Figure 2-1: Nutrient Neutrality Flow Diagram

2.2 Stage 1: Calculate Phosphate Loading from Additional Wastewater

2.2.1 Stage 1: Methodology

Phosphate loading is calculated by multiplying the number of proposed dwellings by the assumed population increase rate (persons/dwelling) to calculate the population increase from the development. This is then multiplied by the water usage (l/person/day) and the effluent discharge concentration (mg/l) to calculate the phosphate loading, which is converted into kg/yr.

$$\boldsymbol{No. of\ dwellings \times Population\ increase\ rate\ = P_i} \qquad \textit{Eq. 1}$$

Where $\boldsymbol{P_i}$ represents the population increase.

$$\boldsymbol{P_i \times Water\ usage = W\ (Litres\ per\ day)} \qquad \textit{Eq. 2}$$

Where $\boldsymbol{W}$ the wastewater volume generated.

$$\boldsymbol{W \times (WRC\ discharge\ level) = L_w\ (mg\ per\ day)} \qquad \textit{Eq. 3}$$

$$\boldsymbol{\frac{phosphate\ load}{1000000} \times 365\ = L_w (kg\ per\ year)} \qquad \textit{Eq. 4}$$

Where L_w represents the loading from wastewater.

2.2.2 Population Occupancy Rate

The current Natural England nutrient neutrality guidance (2022) derives average housing occupancy rates by considering the total population within a catchment against the total number of dwellings. This housing rate is then applied to all new developments within the catchment. This approach assumes that all new dwellings will result in an increase in the population within the catchment and does not account for some new dwellings, which will often by occupied by people who are already living within the catchment (and therefore already contributing to wastewater).

West Berkshire Council note that that with respect to existing planning applications within the system and projected future growth <300 houses in the period to 2041. In addition, West Berkshire Council's Core Strategy 5 Delivering[2] New Homes and Retaining the Housing Stock states:
…. delivery of at least 10,500 net additional dwellings and associated infrastructure over the period 2006 to 2026. Delivery will be phased and managed in order to meet at least an annual average net additional dwelling requirement of 525 dwellings per annum and to maintain a rolling five year supply of housing land.

Alternatively, regional specific data can be used, providing it is robust and provides an indication of occupancy rates over a period of at least five years.

Three options were proposed to calculate the population change rate and Option 1 was selected. Option 2 and 3 are detailed within Appendix B.

[2] https://www.westberks.gov.uk/media/36358/Core-Strategy-CS1-Delivering-New-Homes/pdf/Core_Strategy_-_CS1_-_Delivering_New_Homes.pdf?m=638047963626670000

Option 1: Using the Office for National Statistics (ONS) census data

This option is selected by West Berkshire Council's and fulfils the requirements as outlined in Natural England's nutrient neutrality guidance.

An average regional specific occupancy rate of **2.38 persons/dwelling** was derived from the Office of National Statistics (ONS) Census data for 2011 and 2021. This represents the average value for the entire West Berkshire region. The total population estimates from the census results were compared against the number of households to derive a regional specific occupancy rate.

The chosen average occupancy rate will be applied to all residential dwellings within the catchment, regardless of the number of bedrooms. This consistent approach reduces the risk of underestimating or overestimating the total occupancy levels across the catchment. For houses in multiple occupation, the average occupancy rate is applied to additional rooms above 6 residents.

In the case of hotels or guest houses, an average occupancy of **2.38 persons/dwelling** is assumed, alongside estimations on the number of weeks open per year (1-52) and typical occupancy (1-100%) which are applied as multipliers. Accounting for the number of weeks open and typical occupancy allows for the most accurate determination of the wastewater volume that will be produced by the development.

In the case of single bedroom care-homes, bespoke occupancy rates should be agreed with the relevant Local Planning Authority.

2.2.3 Water Usage Per Person

The optional higher Building Regulations standard for water use per person of 110 litres/person/day is used within the calculator by default. Similarly, the Environment Agency's 2021 Water Stressed Area Classification Report[3] shows that Thames Water covers an area of serious water stress. The more stringent value for new developments in water stressed areas standard of 110 litres per head per day is therefore justified to be used in the calculator. Within the calculator, the user can still choose to apply up to the Building Regulations legal maximum water use per person standard of 125 litres/person/day or a water use per person standard that is even greater than the optional higher standard.

The West Berkshire Local Plan 2022 – 2041 (currently undergoing Regulation 19 review) sets out the requirement for all new residential developments to meet a water efficiency of 110 litres per person per day and that planning conditions will be applied to ensure the water efficiency standards are met. There is a clear local need for tighter requirements, which is supported by the Water Cycle Study (2021) produced for the Local Plan development process.

The River Lambourn phosphate budget calculator uses a value of **120 l/person/day**, which is aligned to that set in the Natural England calculator. Natural England nutrient neutrality guidance (2022) indicates that an additional 10 litres per person per day should be applied to the 110 litres per head per day water usage standard to account for potential changes to less water efficient fittings throughout the lifetime of the development. Evidence in literature is noted (Waterwise, 2018 and Andrewartha and Scott, 2018) to suggest that water usage per person per day does not increase over time.

[3] https://www.gov.uk/government/publications/water-stressed-areas-2021-classification

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2.3 Wastewater Discharge Concentrations

2.3.1 Wastewater Treatment Works

In order to calculate the phosphate contribution from wastewater, an estimate is made on the phosphate concentrations in the treated wastewater generated by the new development. Wastewater from a new development is preferably treated at a mains WwTW, where phosphate is removed by treatment processes. Some WwTW have dedicated phosphate removal processes and the final effluent concentrations will comply with permitted concentrations. Other WwTWs, usually more rural, will not have a permitted limit on the concentration of final effluent discharges.

Permitted WwTWs are operated so that they have some headroom between the final effluent concentrations and the level that has to be met for compliance with the permit. This is to ensure that WwTW will remain compliant with their permits as well as to provide water quality benefits. Where a permit limit is set to decrease, water companies will sometimes operate at this lower concentration in advance of the permit changes. Natural England's guidance assumes that WwTW discharge at 90% of their permit limit, and as such apply a multiplier of 0.9 to the permit limit. This makes a general assumption on the average discharge concentrations, which is likely to vary between each WwTW, and typically represents an overestimation on the actual discharge concentrations in the final effluent from the WwTW.

A more catchment specific and evidence-based approach is to use measured discharge concentrations from the WwTW within the catchment that operate under permit limits. However, due to potential future changes (either increases or decreases) in the discharge concentration, a precautionary approach was adopted which assumes that the WwTW discharge at one standard deviation[4] from the mean. This precautionary approach provides sufficient buffer for potential future increases in the average concentration. In order for the calculator to remain up to date with measured concentrations, a review of the measured data should be conducted at regular intervals and the calculator updated to reflect any changes. At the time of completing the Habitats Regulations Assessment, the calculator will represent the best available evidence. Regularly reviewing the discharge concentration data ensures that is still the case in the future.

The discharge concentration data was supplied by Thames Water and supplemented with Environment Agency open water quality archive data (Environment Agency, 2022) and in most cases ranges from January 2020 to June 2022. West Berkshire Council propose to review the Environment Agency data each year to determine if the water quality data is consistent and note it would be necessary to amend if concentrations are different.

Table 2.1 presents the WwTW concentrations used within the River Lambourn phosphate budget calculator for the permitted sites. A full list of WwTWs and their assumed discharge concentrations are provided in Appendix A.

Table 2.1: Measured Discharge Concentrations of Permitted WwTW

WwTW	Permitted P limit (mg/l)	Assumed P concentration (mg/l)	Average Measured Discharge mg/l	Assumption applied (Average + STDEV)*
Chieveley	1	0.9	0.53	0.86

[4] Standard deviation is a statistic that measures the dispersion of a dataset relative to its mean. This is calculated as the square root of the variance using the formula $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(X_i - \mu)^2}$ where σ is the standard deviation, μ is the mean average, N is the sample size and X the observed values. A low standard deviation indicates the values tend to be close to the mean, while a high standard deviation indicates the values are spread out over a wider range. Under a normal distribution (i.e. bell-shaped curve), one standard deviation away from the mean in either direction account for 68.2% of the values.

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WwTW	Permitted P limit (mg/l)	Assumed P concentration (mg/l)	Average Measured Discharge mg/l	Assumption applied (Average + STDEV)*
East Shefford	1	0.9	0.37	0.51

** These figures should be used within the calculator*

Chieveley

The Chieveley data ranges from April 2020 to October 2022 (Figure 2-2). The WwTW currently has a permit to discharge effluent at 1 mg/l. The site has minimal headroom between the measured discharge and the permitted limit. The average concentration over this period was 0.53 mg/l. The standard deviation upper limit is 0.86 mg/l and was exceeded on three occasions over this period.

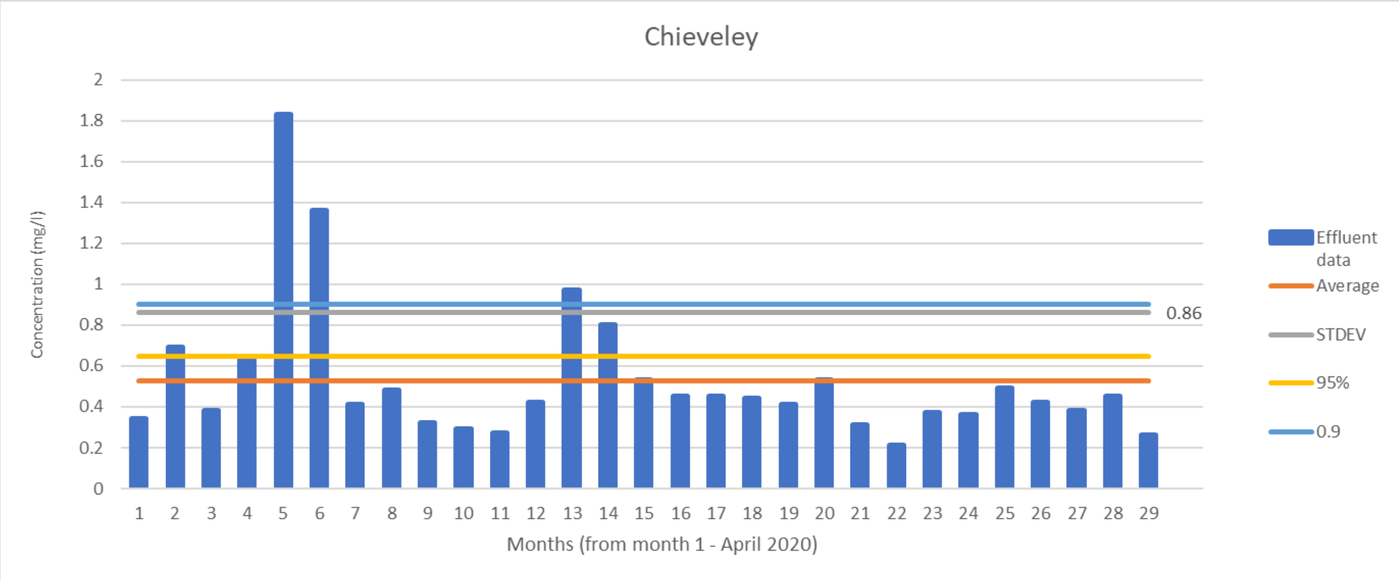

Figure 2-2: Chieveley Discharge Concentrations

East Shefford

The East Shefford data ranges from April 2020 to October 2022 (Figure 2-3). The WwTW currently has a permit to discharge effluent at 1 mg/l. However, the site has significant headroom between the measured discharge and the permitted limit. The average concentration over this period was 0.37 mg/l. The standard deviation upper limit is 0.51 mg/l and was exceeded twice, and was recorded at 0.51 mg/l on three occasions over this period.

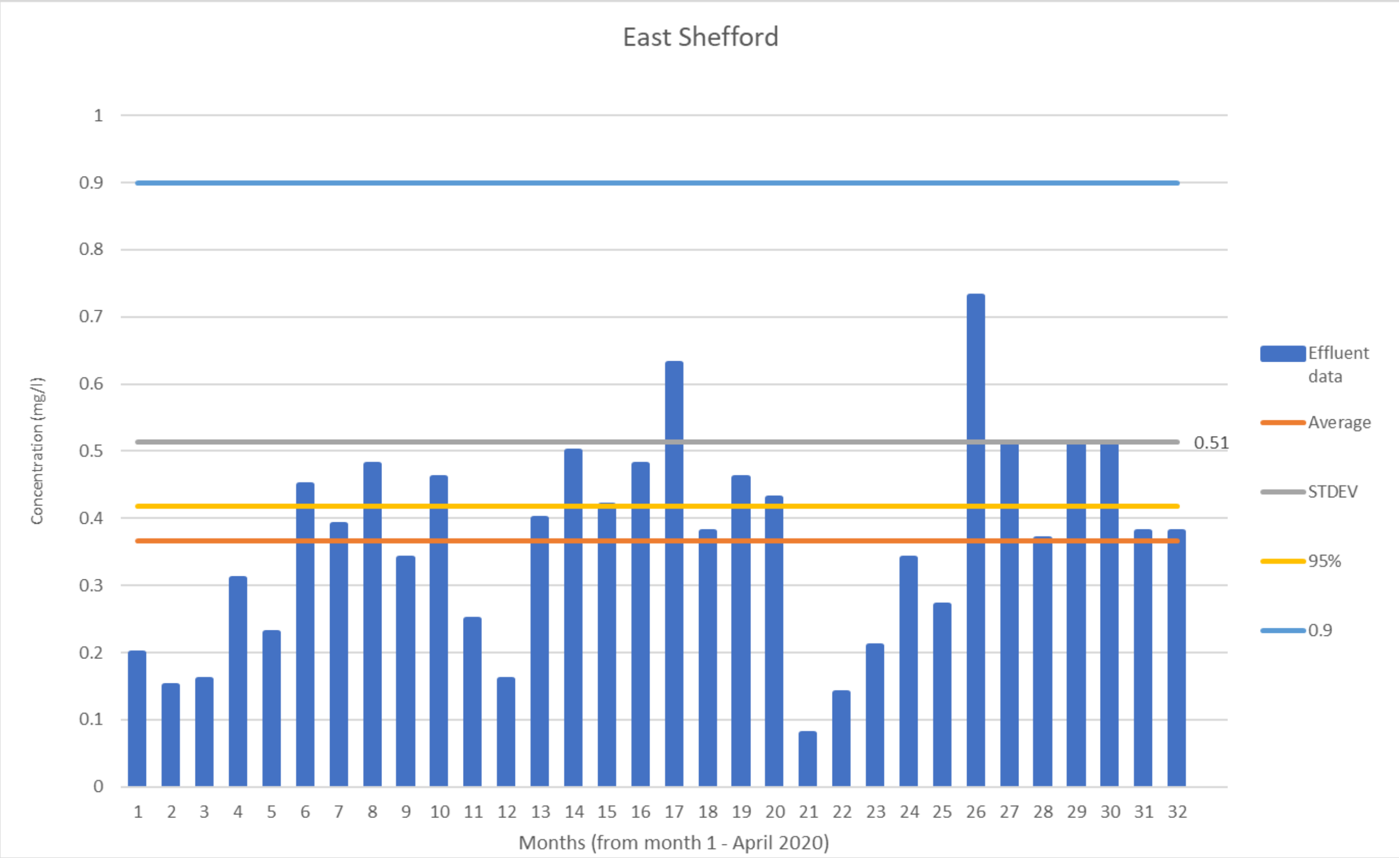

Figure 2-3: East Shefford Discharge Concentrations

Post 2025 and Post 2030

The calculator also incorporates post 2025 (the end of Asset Management Plan (AMP) 7) and Post 2030 (the end of AMP 8) discharge concentrations. Where the permit limit is not changing post 2025, the same discharge concentrations were assumed. Where the permit limit is changing it was assumed that the WwTW would operate at 90% of its updated permit limit. This will be reviewed once there is sufficient evidence regarding the post-2025 performance.

A statement from the Department for Levelling Up, Housing & Communities (18th November 2022) indicates that there will be a statutory obligation on Thames Water to operate WwTW with a population of greater than 2000 at the Technically Achievable Limit (TAL) within the catchment by 2030. The TAL is 0.25mg/l for Total Phosphorus (TP). The amendment to the Levelling Up and Regeneration Bill (LURB) gives confidence that the upgrades will be in place by 2030. The statement indicates that any WwTWs with a population equivalent greater than 2000 will be mandated to reach TAL.

The calculator will formally adopt these new lower permit limits once passed into legislation and enabling the use of the lower permit limits as part of a Habitats Regulations Assessment. The values are incorporated within the calculator for guidance purposes until the legislation is passed. The calculator assumes the discharge concentrations is 90% of the permit limit.

Unpermitted treatment works

Natural England guidance indicates that standard concentrations of 8.0 mg/l for TP should be assumed for unpermitted WwTW. However, recent communication between Royal HaskoningDHV and the Environment Agency has confirmed phosphorus budget calculator of **6.0 mg/l TP** for treatment works where no monitoring data is available is applicable to whole of UK. This is the value used in Environment Agency WwTW modelling of phosphorus inputs from WwTW to represent the most locally relevant default values.

2.3.2 On-site Treatment Plant

The River Lambourn phosphate budget calculator adopts default discharge concentrations for TP from Package Treatment Plants (PTPs) and Septic Tanks (STs) from the Natural England nutrient neutrality guidance (Natural England, 2022). The default values used within the calculator are presented in Table 2.2.

Table 2.2: Default On-site Treatment Plants Effluent Concentrations

Treatment Type	TP Removal (mg/l)
Default package treatment plant	9.7
Default septic tank	11.6

2.4 Stage 2 & 3: Calculate Phosphate Loading from Land Use

2.4.1 Stage 2 & 3: Methodology

In order to calculate the net change in land use, the existing phosphate input from the current land within the proposed development footprint needs to be calculated. The phosphate input is calculated by multiplying the runoff coefficient for each specific land use type by the relevant area of each land use.

$$(\boldsymbol{A_1} \times \boldsymbol{C_1}) + (\boldsymbol{A_2} \times \boldsymbol{C_2}) \ldots + (\boldsymbol{A_n} \times \boldsymbol{C_n}) = \boldsymbol{L_{current}} \qquad \textit{Eq. 5}$$

*Where **A** represents the Area in hectares, **C** the export coefficient and $L_{current}$ the phosphate load from the current land uses.*

Where land does not drain to the designated site surface water catchment it should be excluded from the calculation in Stages 2 and 3.

The phosphate load from the future land uses ($L_{proposed}$) utilises the same calculations as Equation 5.

2.4.2 Rainfall Data

The rainfall data used within the River Lambourn phosphate budget calculator differs from that used within the Natural England guidance. Rainfall data used for the Lambourn catchment was derived from HadUK gridded which provided Standard Average Annual Rainfall (SAAR) for the period 2001-2021. This data provides the best available evidence for which to base the land use runoff coefficients. The HadUK data provides a more up to date dataset than the data proposed by Natural England which was collected between 2001 – 2021.

The average rainfall across the River Lambourn is shown in Figure 2-4. The rainfall bands vary between **600 and 900 mm per year**.

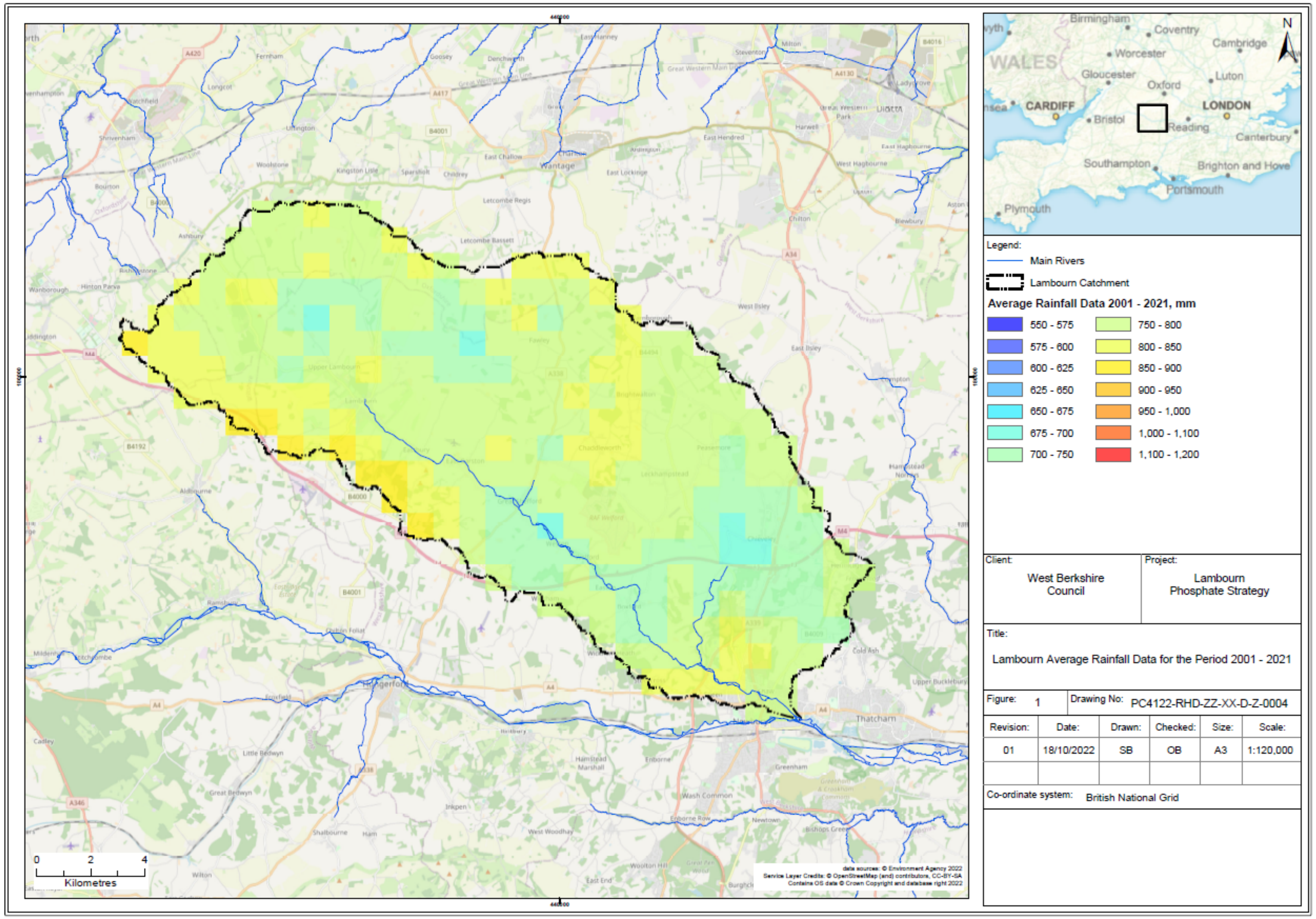

Figure 2-4: River Lambourn Annual Rainfall for the Period 2001 – 2021

2.4.3 Agricultural Runoff Coefficients

The Lambourn catchment phosphorus budget calculator employs the same methodology for deriving agricultural runoff coefficients as the Natural England guidance. TP runoff coefficients (in kg/ha/yr) were derived using Farmscoper V5 (ADAS, 2022).

The Upscale tool was used which derived runoff coefficients specific to the Kennet Operational Catchment. The agricultural runoff coefficients were modified to account for pollution incidents and illegal operations. Agricultural runoff coefficients for each operational catchment are provided in Appendix C.

The agricultural runoff rates are dependent on the following:

- Farm type;
- Operational catchment;
- Soil types; and
- Average annual rainfall.

Soil types are derived from Soilscapes (Cranfield Soil and Agrifood Institute, 2022) and characterised into the following drainage categories to conform with the Farmscoper (Table 2.3). This is consistent with the approach outlined by Natural England (2022).

The Farmscoper Upscale tool uses existing data on operating farms within a catchment to predict the average runoff coefficients. Allotments and community food growing land are derived using agricultural land export coefficients in line with the Natural England guidance (2022).

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Table 2.3: Soil Types by Drainage Category

Free draining			**Impermeable - drained for arable**			**Impermeable - drained for arable and grassland**		
Colour	ID	Name	Colour	ID	Name	Colour	ID	Name
	3	Shallow lime-rich soils over chalk or limestone		1	Saltmarsh soils		17	Slowly permeable seasonally wet acid loamy and clayey soils
	4	Sand dune soils		2	Shallow very acid peaty soils over rock		18	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils
	5	Freely draining lime-rich loamy soils		8	Slightly acid loamy and clayey soils with impeded drainage		19	Slowly permeable wet very acid upland soils with a peaty surface
	6	Freely draining slightly acid loamy soils		9	Lime-rich loamy and clayey soils with impeded drainage			
	7	Freely draining slightly acid but base-rich soils		15	Naturally wet very acid sandy and loamy soils			
	10	Freely draining slightly acid sandy soils		16	Very acid loamy upland soils with a wet peaty surface			
	11	Freely draining sandy Breckland soils		20	Loamy and clayey floodplain soils with naturally high groundwater			
	12	Freely draining floodplain soils		21	Loamy and clayey soils of coastal flats with naturally high groundwater			
	13	Freely draining acid loamy soils over rock		22	Loamy soils with naturally high groundwater			
	14	Freely draining very acid sandy and loamy soils		23	Loamy and sandy soils with naturally high groundwater and a peaty surface			
				24	Restored soils mostly from quarry and opencast spoil			
				25	Blanket bog peat soils			
				26	Raised bog peat soils			
				27	Fen peat soils			

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2.4.4 Equine Nutrient Run-Off

Unique to the Lambourn catchment is the high concentration of equine centres, particularly in the headwaters of the Lambourn close to the Lambourn Village. An entirely new paddock / significant extension that is likely to increase stocking numbers has the potential to increase nutrient loading to the catchment.

As part of the literature review in summary, research suggests that an excepted concentration of soluble P is between 3.0 and 7.9 g/day. Stocking density (the area of land per animal) in temperate climates for equine is variable but typically range from 0.4 to 0.8 hectares (ha) per animal (Singer *et al*, 2002)

It is possible to convert g/day to the unit which are input into the calculator as follows:

$$\mathbf{0.079\ kg\ animal\ day} \times \mathbf{0.8\ ha} = \mathbf{0.0632\ kg\ ha\ d} \qquad Eq.\ 6$$

$$\times\,\mathbf{365\ days} = \mathbf{2.3\ kg\ ha\ a} \qquad Eq.\ 7$$

Following literature review of available and relevant research the Lowland grazing value derived from Farmscoper for paddocks has been selected for the calculator. The Farmscoper data is regional specific and considers rainfall and soil types. Furthermore, the Natural England Stodmarsh guidance published in 2020 recommended the use of this figure.

In the majority of cases, it is anticipated that lowland grazing is appropriate, however, it should be noted that mixed livestock may be applicable in specific circumstances, such as those where livestock is intensively stocked and will depend on the case at hand. As such, bespoke consideration of each case will be needed.

2.4.5 Non-agricultural Land Run-off Coefficients

Non-agricultural land use coefficients were adopted from Natural England's nutrient neutrality guidance (2022) (Table 2.4).

The onus is on developers to select a TP runoff coefficient for constructed wetlands which is bespoke to the varying parameters input to the construction. As such, a value is not included but it is noted that a value of -8.00 has been used in other calculators which was derived from expert opinion and indicated in literature (Land *et al*., 2016).

Table 2.4: Non-agricultural Land Run-off Coefficients

Land Use Classification	TP runoff coefficient (kg/ha/yr)
Greenspace	0.02
Woodland	0.02
Shrub / heathland / bracken / bog	0.02
Water	0.00
Set aside Land	0.02

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2.4.6 Urban Land Runoff Coefficients

The derivation of urban land use runoff coefficients is primarily based on Natural England's nutrient neutrality guidance (2022) and does not deviate from the proposed method (HR Wallingford Modified Rational Method). The urban land is categorised into residential, open urban and commercial/industrial land. The River Lambourn phosphate budget calculator further sub-divides residential land into high-density, medium-density and low-density. This allows for more specific land use types to be selected, increasing the accuracy of the calculator and limits the potential for overestimations or underestimations. The following definitions are used:

- High density residential - applies to urban cores (e.g. city centres).
- Medium density residential - applies to development in larger towns where there is a high percentage of development, but outside of core cities.
- Low density residential – rural developments.

The HR Wallingford Modified Rational Method was used to calculate the phosphate loading:

$$\boldsymbol{L = R \times P_r} \qquad Eq.\ 8$$

Where L is the average runoff (mm/yr), R is the average rainfall (mm/yr) and P_r is the percentage runoff (%)

The percentage runoff was calculated using the following equation:

$$\boldsymbol{P_r = 0.829 \times PIMP + 0.078 \times U - 20.7} \qquad Eq.\ 9$$

Where $PIMP$ is the percentage of land that is impervious (%) and U is the catchment wetness index.

The catchment wetness index is calculated using the following equation:

$$\boldsymbol{U = -129.5 + (0.424 \times R) - (2.28 \times 10^{-4} \times R^2) - (4.56 \times 10^{-8} \times R^3)} \qquad Eq.\ 10$$

Eq. 8 is multiplied with Event Mean Concentrations (EMCs) to calculate the urban runoff coefficients. The EMCs outlined in the Natural England nutrient neutrality guidance (2022) were adopted and are derived from Mitchel (2005). The EMCs used within calculations are presented in Table 2.5:

Table 2.5: EMCs for Urban Land Use

Land Use	TP EMC (mg/l)
Residential	0.41
Commercial / Industrial	0.30
Open urban land	0.22

At Stage 2 and Stage 3, where there is sufficient detail on SuDS removal, it is necessary to select a default runoff coefficient based on **80% imperviousness**. There is the option to input total hectare area for SuDS usage for the proposed land uses from Table 2.4 and Table 2.7 as well as the total percentage flow entering the SUDS within that land use which is currently set to 100%. These two inputs use a combination of the rainfall category and land use runoff coefficients (Table 2.8) to calculate the annual phosphorus inputs into the SuDS feature (kg T/yr). Using the CIRIA SuDS guidance[5] to calculate the phosphorus removal from

[5] *CIRIA (2022) Using SuDS to reduce phosphorus in surface water runoff (C808F)*

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SuDS, the removal rate (as a %) for each land use (or an average from combination of the features within a land use) should be added.

Table 2.6: Default Urban Run-off coefficients

Rainfall Band (mm/yr)	Midpoint (mm/yr)	Catchment wetness (U)	Residential (kgP/ha/yr)	Commercial / Industrial (kgP/ha/yr)	Urban open space (kgP/ha/yr)
625-650	637.5	36.33	1.26	0.92	0.68
650-675	662.55	38.07	1.32	0.97	0.71
675-700	687.55	39.42	1.37	1.00	0.74
700-750	725.05	40.68	1.45	1.06	0.78
750-800	775.05	41.00	1.55	1.14	0.83
800-850	825.05	41.00	1.65	1.21	0.89
850-900	875.05	41.00	1.75	1.28	0.94

Where there is insufficient detail on site-specific SuDS, (for example at outline planning stage) it is possible to select urban runoff values with a lower imperviousness value which already accounts for SuDS. These values have been derived from available literature[6], and represent the average reported mean values (Table 2.7 and Table 2.8). By default the base calculations include no SuDS and the 80% imperviousness or lower imperviousness values will need to be selected to assess the impact of SuDS in Stage 4.

Table 2.7 presents the impervious percentages used to derive urban land use runoff coefficients.

Table 2.7: Impervious Percentages Used for the Various Land Use Types where there are no details on SuDS.

Land Use	TP imperviousness (%)
High density residential	61
Medium density residential	38
Low density residential	30
Commercial / Industrial	84
Open space urban	22

Table 2.8 presents the urban runoff coefficients used with the calculator.

Table 2.8: Urban Run-off Coefficients Derived for the River Lambourn Phosphate Budget Calculator where there are no details on SuDS.

Rainfall band (mm/yr)	Midpoint (mm/yr)	Catchment wetness (U)	Residential (kgP/ha/yr)			Commercial / Industrial (kgP/ha/yr)	Urban open space (kgP/ha/yr)
			High density	Medium density	Low density		
625-650	637.5	36.33	0.85	0.36	0.18	0.99	0.01
650-675	662.55	38.07	0.89	0.37	0.19	1.03	0.01

[6] *Exum et al., (2005); Cappiela & Brown (2001); Chormanski et al., (2008); Lu & Weng (2006); Yancey (2008); Yang & Liu (2005); Wu & Murray (2003); Xu et al., (2018); Ferguson (1998); Jiang & Fu (2015); Boyd et al., (1993); New York State Department of Environmental Conservation (2015); Tilley & Slonecker (2006); ENSR (2005); Shahtahmassebi et al., (2018); National Land Cover Data (1992)*

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Rainfall band (mm/yr)	Midpoint (mm/yr)	Catchment wetness (U)	Residential (kgP/ha/yr)			Commercial / Industrial (kgP/ha/yr)	Urban open space (kgP/ha/yr)
			High density	Medium density	Low density		
675-700	687.55	39.42	0.93	0.39	0.20	1.07	0.01
700-750	725.05	40.68	0.98	0.42	0.22	1.13	0.01
750-800	775.05	41.00	1.05	0.44	0.23	1.21	0.01
800-850	825.05	41.00	1.12	0.47	0.25	1.29	0.01
850-900	875.05	41.00	1.19	0.50	0.26	1.37	0.01

2.5 Stage 4: Calculating Phosphate Budget

2.5.1 Stage 4: Methodology

Stage 4 calculates the net change in the phosphate loading to the catchment as a whole due to the proposed development. This is calculated by summing the additional phosphate from wastewater (stage 1) and the difference between the phosphate load for the future (stage 3) and current land uses (stage 2). A precautionary buffer is then applied.

$$\boldsymbol{Total\ nutrient\ loading} = \mathbf{1.2} \times (\boldsymbol{L_W} + (\boldsymbol{L_{Proposed}} - \boldsymbol{L_{Current}})) \qquad \textit{Eq. 11}$$

2.5.2 Precautionary Buffer

Whilst the figures used throughout this model are based on scientific research and evidence and represent the best available evidence, there is some inherent uncertainty remaining. A precautionary buffer is used to recognise the uncertainty and provide, with reasonable certainty, that there will be no adverse effect on the integrity of the designated sites. As per Natural England guidance (2022), a **20%** precautionary buffer is added to the total loading value.

2.6 Mitigation

The River Lambourn phosphate budget calculator goes beyond the Natural England guidance and provides an indication of potential mitigation options. The mitigation tabs offer guidance on the change in land use that is required in order to achieve nutrient neutrality. The stages only apply to developments that will generate additional phosphates as outlined in Stage 4. The different tabs reflect the different mitigation requirements from reduction in permit limits. The mitigation tabs offer the option to implement either on-site or off-site.

2.6.1 Mitigation Methodology

In the case of off-site mitigation, the excess phosphates as a result of the proposed development must equal the change in land use of the mitigation area.

$$\boldsymbol{Total\ nutrient\ loading} = (\boldsymbol{L_{Mitigationproposed}} - \boldsymbol{L_{mitigationCurrent}}) \qquad \textit{Eq. 12}$$

Where $\boldsymbol{L_{Mitigationproposed}}$ is the total phosphate loading from the proposed land use of the mitigation area and $\boldsymbol{L_{Mitigationcurrent}}$ is the total phosphate loading from the current land use of the mitigation area.

Only land that is currently within the surface water catchment and may affect the designated sites, either by draining directly and draining to upstream locations, can be selected for mitigation land.

2.7 Zero Value Calculator

The zero-value calculator is an additional feature included within the River Lambourn phosphate budget calculator. The zero-value calculator shows the number of developments that can be built and occupied as a result of taking the entire development site out of agricultural use and partly into low-input use (e.g. semi-natural grassland) and a small part of the future use. This allows part of the development to progress and prevents delays while mitigation solutions are implemented. The calculator generates the number of properties that can be built. Unless the difference in short-term mitigation can be sourced off-site, the lower number of dwellings applies.

2.7.1 Zero Value Calculator: Methodology

The development will be 'zero value' or nutrient neutral when the wastewater contribution from the development is equal to the phosphate load from the land use change. In this case the precautionary buffer is not required because the value is not above zero.

$$L_W = ((L_{Proposed} + L_{low-input}) - L_{Current}) \quad \text{Eq. 13}$$

In order to calculate the maximum number of dwellings that could be permitted whilst remaining nutrient neutral, the permitted phosphate loading from wastewater that is neutral follows the opposite calculations to those in Stage 1.

$$\frac{L_W}{365} \times 1000000 = L_w \quad \text{Eq. 14}$$

$$\frac{L_w}{WRC\ discharge\ level} = W \quad \text{Eq. 15}$$

$$\frac{W}{water\ usage} = P_i \quad \text{Eq. 16}$$

$$\frac{P_i}{occupancy\ rate} = No.of\ dwellings \quad \text{Eq. 17}$$

3 Summary

Table 3.1 provides a summary of the key inputs and how these differ between the Natural England guidance and the River Lambourn phosphate budget calculator.

Table 3.1: Summary Comparison of Key Inputs

Calculator input	Natural England guidance	River Lambourn phosphate budget calculator	Comment
Population increase rate	2.4 persons/dwelling	2.38 persons/dwelling	Essentially no difference
Water usage	120 l/person/day	120 l/person/day	No difference in approach

Calculator input	Natural England guidance	River Lambourn phosphate budget calculator	Comment
WwTW P discharge concentrations	At 90% of permit limit for permitted sites 8 mg/l for unpermitted sites	Use of one standard deviation from the mean average. 6 mg/l for unpermitted sites	Use of measured data rather than generalised assumptions for permitted sites. Use of default values used by Environment Agency.
Onsite treatment plants	Default values used for PTP and ST from literature review	Default values used for PTP and ST from literature review.	No difference in default values.
Rainfall	1961 – 1990 SAAR data	2001 – 2021 SAAR data	Use of more up to date data.
Agricultural runoff rates	Derived using Farmscoper upscale model	Derived using Farmscoper upscale model	No difference in approach.
Non-agricultural runoff rates	Default values derived from literature review	Default values derived from literature review	No difference in approach.
Urban runoff coefficients and SuDS	Derived using HR Wallingford Modified Rational Method. Default EMCs used from Mitchell (2005) and generic impervious values of 80%.	80% imperviousness assumed and option to discount % removal from SUDS, as set out in CIRIA SuDS guidance. Where insufficient details on SuDS are known, a lower imperviousness value which estimates SuDS removal can be used. This is derived using HR Wallingford Modified Rational Method. Default EMCs used from Mitchell (2005) and impervious values derived from detailed literature review and catchment specific data. Values on whether the calculator uses the generic impervious values of 80% or lower impervious values from the literature must be selected. Option of high, medium and low density residential land use types.	Use of catchment specific data and adoption of values following detailed literature review, as opposed to generic assumptions. Use of more detailed land use types to improve accuracy of urban runoff coefficients.
Precautionary buffer	20%	20%	No difference in approach.
Mitigation	Not included	Included	N/A
Zero-value calculator	Not included	Included	N/A

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Appendix A – Wastewater Treatment Works Discharge Concentrations

Wastewater treatment works	Current TP discharge concentration (mg/l)	Post-2025 TP discharge concentration (mg/l)	Post-2030 TP discharge concentration (mg/l)	Population equivalent (from Thames Water) and comment
Boxford STW	6.0	0.45	0.45	377
Chieveley WwTW	0.9 (90% of permit limit)	0.45	0.225	5,930
East Shefford WwTW	0.9	0.09	0.09	6,360. As this is below the TAL it remains at 0.1.
Fawley WwTW	6.0	6.0	6.0	100
Wickham WwTW	6.0	6.0	6.0	234
Winterbourne STW	6.0	6.0	6.0	80

Note: >2000 PE is mandatory technical achievable limit (TAL) and <2000 uses previous permit limits.

Appendix B – Alternative Population Rate Calculation Options

These alternative calculation options have been considered but are not selected for use within the calculator.

Option 2: Using mid-year estimates vs total dwellings
This option provides an accurate year-by-year indication of occupancy /rates rather than a snapshot each decade.

A regional specific occupancy rate was derived from comparing mid-year population estimates (ONS, 2022) against the total number of dwellings (DLUHC, 2022) for the entire West Berkshire region. The occupancy rate was derived for each year between 2009 and 2021, with the average figure over this period 2.36 persons/dwelling. The data shows a downwards trend from 2.38 in 2009 to 2.30 in 2021 (Figure 4-1). The average for the previous 5 years is 2.34 persons/dwelling.

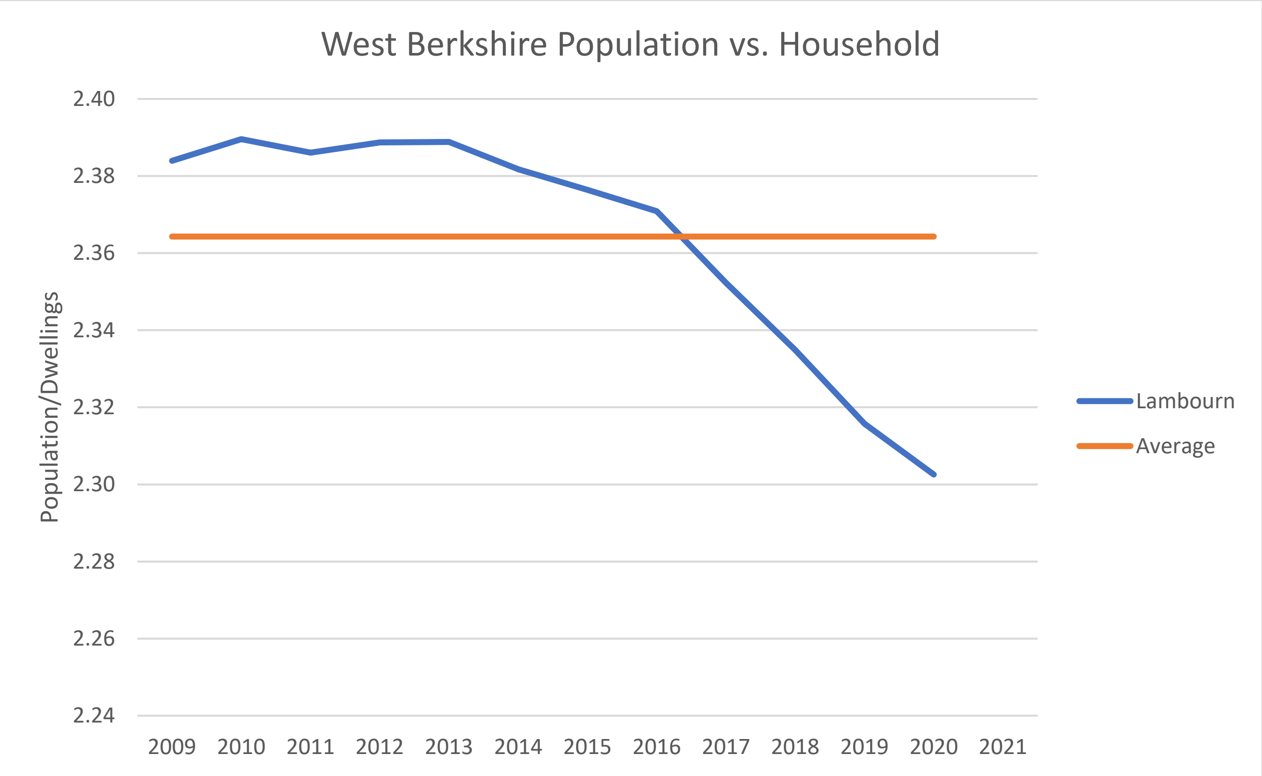

Figure 4-1: West Berkshire Population vs. Household Graph from Mid-year Estimate and DLUHC Data

Option 3: Using change in population vs net additional households
A Lambourn specific population increase rate of 2.46 persons/dwelling was derived from estimating the population changes (Office for National Statistics, 2022) and comparing this to net additional dwellings (Ministry for Housing, Communities & Local Government, 2022) for each year between 2002 and 2020. The figure 2.46 represents the average and one standard deviation above the average, which is used to provide a buffer and ensure a precautionary approach is adopted. The value also accounts for influencing factors on population change such as second homes and the origin of movers into housing within the area.

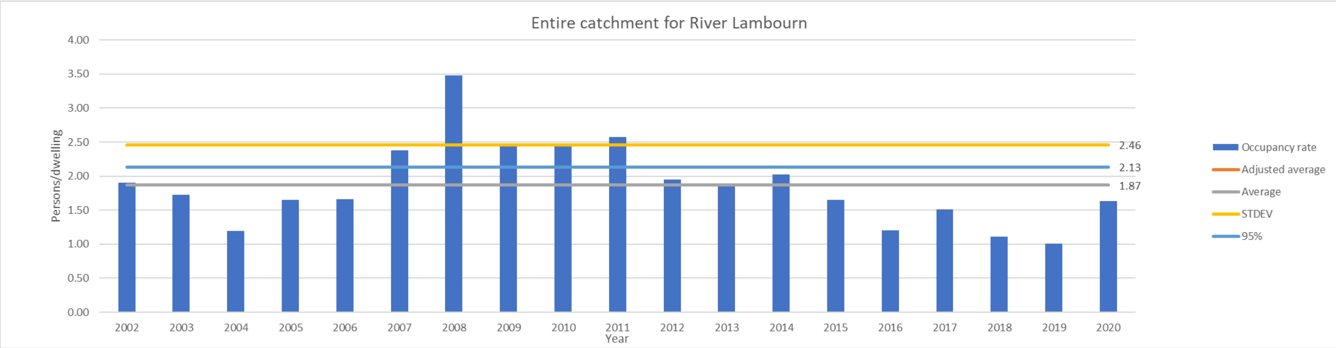

Figure 4-2: Lambourn Catchment Occupancy Rate Mid-Year Estimates

The occupancy rate specific to the River Lambourn catchment and was derived from estimating the catchment area population changes and comparing this to new dwellings (Figure 4-2). Mid-year estimate data was used which is considered to be less accurate than census data. As such it is noteworthy that upon WBC review of this document, it is anticipated this information would be removed ahead of submission to Natural England for review and is included at this stage for information only. In addition, it is understood Natural England require 5 years' worth of population data to be considered as representative.

Appendix C: Agricultural runoff coefficients

Kennet – P runoff coefficients

Kennet	600 - 700 mm/yr						700 - 900 mm/yr					
Land Use	Free draining		Impermeable - drained for arable		Impermeable - drained for arable and grassland		Free draining		Impermeable - drained for arable		Impermeable - drained for arable and grassland	
	NVZ - Yes	NVZ - No	NVZ - Yes	NVZ - No	NVZ - Yes	NVZ - No	NVZ - Yes	NVZ - No	NVZ - Yes	NVZ - No	NVZ - Yes	NVZ - No
Dairy	0.77	0.77	0.77	0.77	0.77	0.77	0.13	0.14	0.33	0.33	1.12	1.15
Lowland grazing	0.04	0.04	0.08	0.08	0.34	0.34	0.07	0.07	0.15	0.15	0.56	0.56
Mixed Livestock	0.51	0.51	0.51	0.51	0.51	0.51	0.11	0.11	0.51	0.51	0.86	0.87
Poultry	0.06	0.06	0.29	0.51	0.29	0.51	0.13	0.14	0.48	0.48	0.83	0.86
Pig	0.59	0.59	0.59	0.59	0.59	0.59	0.12	0.12	0.54	0.97	0.54	0.97
Horticulture	0.46	0.46	0.46	0.46	0.46	0.46	0.10	0.10	0.55	0.55	0.49	0.81
Cereals	0.05	0.05	0.32	0.32	0.53	0.53	0.12	0.12	0.68	0.68	0.93	0.93
General Arable	0.38	0.04	0.38	0.20	0.38	0.38	0.09	0.09	0.43	0.43	0.67	0.67
Allotment	0.20	0.20	0.20	0.20	0.20	0.20	0.40	0.40	0.40	0.40	0.40	0.40

NVZ = Nitrate Vulnerable Zone

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