Enhanced Drainage Ditch Management

A framework approach for nutrient neutrality

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

This report was commissioned by Natural England to build knowledge and understanding on a range of nature-based solutions which could be used to reduce nutrients. Greenshank Environmental Limited were commissioned by Natural England to develop a process through which a novel methodology, Enhanced Drainage Ditch Management, could be used to manage agricultural drainage ditches and small watercourses in rural areas. This report presents a framework for how future proposed schemes, when adhering to the framework, can deliver nutrient reductions in perpetuity and be used as mitigation for new developments needing to achieve nutrient neutrality.

Executive summary

Nutrient neutrality has created a requirement for approaches to environmental management that can be shown to reduce nutrient inputs to sensitive Habitats Sites. This report details a framework approach to Enhanced Drainage Ditch Management, which is a novel approach to managing agricultural drainage ditches and small watercourses in rural areas. The approach is based on a combination of three 'best management practices' (BMPs), namely two-stage channel cross-sections, low-grade weirs and allowing ditches to be vegetated. These BMPs come from American catchment management toolboxes.

Establishing the context for the Framework

The first two sections of this report show that the Framework has been commissioned in response to a requirement for new solutions that can provide nutrient mitigation that, in turn, can help new development to achieve nutrient neutrality. The Framework is intended to provide a means for Natural England staff and staff of other relevant organisations (such as Competent Authorities) to make informed and consistent judgements on proposals for managing drainage ditches and small watercourses to generate nutrient mitigation. Note that throughout the report, the term 'ditch' is used to describe the type of channels that may be suitable for the management approach described herein; but the term ditch and watercourse are interchangeable where small, rural watercourses are effectively managed as drainage ditches.

The Enhanced Drainage Ditch Management approach was formulated from a literature review that assessed the evidence for nutrient reductions from studies of drainage ditches that have been managed using one or more of the three BMPs listed above. In order to calculate the nutrient mitigation impact from a drainage ditch management scheme, the literature review determined a percentage nutrient reduction efficiency for both nitrogen and phosphorus. The earliest studies of the nutrient management impact of drainage ditch BMPs date to 2011; thus, the Precautionary Principle was key in setting nutrient reduction efficiencies that can be used to estimate the nutrient mitigation benefit from a proposed ditch management scheme.

The structure of the Framework

This Framework is structured in five stages:

- Stage 1 – Design objective
- Stage 2 – Feasibility
- Stage 3 – Design process
- Stage 4 – Implementation plan

- Stage 5 – Post-implementation monitoring

Successful proposals for Enhanced Drainage Ditch Management schemes will show how they have incorporated these five stages.

An overview of the Framework's five stages

Stage 1 of the Framework outlines the design objective for an Enhanced Drainage Ditch Management scheme. It shows how this objective to reduce nutrient inputs to a Habitats Site using the prescribed management approach is linked to how nutrient inputs to a scheme are calculated and then how the efficacy of a scheme is applied to calculate the nutrient mitigation benefit.

Stage 2 of the Framework details an array of different considerations that are required as part of a feasibility assessment for a proposed drainage ditch management scheme. Successful proposal will show that they have addressed any potential risks to scheme feasibility.

Stage 3 of the Framework provides a description of an eight-step process that should be followed to determine the key design criteria for an Enhanced Drainage Ditch Management scheme. This design process includes considerations of the geometry of the two-stage cross-section that the ditch will be reprofiled to, the spacing of low-grade weirs and the planting plan for vegetation within and adjacent to the ditch.

Stage 4 of the Framework outlines the key components of an implementation plan for a drainage ditch management scheme. It is important that proposals consider how the clearance and earthworks for a scheme will not cause adverse environmental impacts. The implementation plan should also cover vegetation establishment and detail how the scheme will manage vegetation and sediment.

Stage 5 of the Framework describes the monitoring requirements for a scheme. Good proposals should evidence how a scheme will be monitored post-deployment and how this monitoring will be used in an adaptive management routine. Monitoring is important to ensure the scheme is maintained to achieve its original design specifications and thus provide confidence the scheme will deliver nutrient mitigation in perpetuity. An optional monitoring plan is also described, where water quality and flow monitoring can be used to determine whether a scheme is outperforming the initial calculation of nutrient mitigation benefit and whether it is therefore possible to claim additional mitigation from a project.

The Framework includes a confidence assessment section where users can collate the outcomes from assessment of the five stages detailed above and summarise whether a drainage ditch management proposal has met the requirement of these stages.

Contents

Introduction

Specific approaches to agricultural drainage ditch management have the potential to generate nutrient mitigation that can be used to allow new development to achieve nutrient neutrality. This project intended to provide Natural England staff and staff of other relevant organisations (such as Competent Authorities) with a tool to make informed judgements on proposals for agricultural drainage ditch management schemes for nutrient neutrality.

This document presents a Framework for agricultural drainage ditch management proposals. It is supported by an evidence base (Annex A) that provides the rationale for using drainage ditch management for generating nutrient mitigation.

Framework aims and objectives

The main aim of the project was to distil the core findings from the evidence review detailed in Annex A into a Framework that, if followed, allows for a robust estimate of nutrient mitigation and thus nutrient credits generated by a drainage ditch management scheme. The nutrient credits quantified using the approach detailed in this Framework can be claimed prior to scheme deployment and without monitoring.

Based on this aim, the Framework had the following objectives:

- Show, by linking the evidence base to a robust approach to prescribing a scheme, that agricultural drainage ditch management can reduce nitrogen and phosphorus loads to the environment.
- Detail an approach to agricultural drainage ditch management schemes such that proposals following this approach meet the requirements of a Habitat Regulations Assessment.
- Provide a tool to promote the use of agricultural drainage ditch management for nutrient mitigation that can be used by environmental management practitioners.
- Promote the use of nature-based solutions to improve water environments.

It should be noted that while this document mostly references drainage ditches as the channels proposed for management, many catchments have small watercourses that have been altered to function as drainage ditches. These channels are often canalised, over-deepened and disconnected from their floodplains. Heavily managed watercourses of this nature may also be appropriate for the approach detailed herein, providing both nutrient mitigation and improvements to stream habitats[1]. As well as providing an ability to deliver nutrient mitigation schemes, this project was also aimed at facilitating better approaches to agricultural ditch and small watercourse management to achieve a range of environmental benefits above just nutrient management.

Framework structure

The Framework is structured in five stages, aligned to the structure of other nature-based solutions Frameworks for nutrient neutrality mitigation schemes. The second section of this document provides an overview of the process used to determine the efficacy of drainage ditch management schemes and how this is linked to calculating the mitigation potential of a scheme.

Framework stages:

1. Design objective – the design objective provides the purpose of drainage ditch management scheme.
2. Feasibility – good proposals for drainage ditch management schemes will show they are feasible in the chosen location.
3. Design process – the design process should provide the confidence a scheme will deliver on the design objective.
4. Implementation plan – schemes will need to show how they will be implemented to provide confidence they will deliver in the long-term.
5. Post-implementation monitoring – monitoring is required to inform long-term scheme management and maintenance.

Detailed descriptions of the five stages of the Framework are provided in the third section of this document. The five stages of the Framework are prescriptive, and proposals will need to follow these prescriptions to claim nutrient credits ahead of deployment. This is particularly relevant to both Stage 1 and Stage 3, while the other

[1] Note that not all small watercourses are appropriate for management using the approach detailed herein. As part of the key considerations for a drainage ditch management nutrient mitigation scheme, proposals for this approach on small watercourses will need to show that the channel has been modified and managed to function as a drainage ditch and that it won’t hinder the achievement of protected site objectives or other environmental objectives.

stages are required for proposals to provide confidence that they are practicable and will thus deliver nutrient mitigation in perpetuity.

Limitations to this Framework

This Framework details the key considerations required for an agricultural drainage ditch management scheme to be proposed as a nutrient mitigation solution. The Framework has sought a balance between the technical work required to specify a scheme that meets the requirements of a Habitat Regulations Assessment and a level of technical work that would make a scheme practically non-viable. Due to this balance, there are limitations to the Framework, as detailed below.

This Framework relies on expert judgement, both in its formulation and in its use: Certainty of the efficacy of a scheme beyond reasonable scientific doubt is essential, however absolute certainty is not required for a scheme to be deemed appropriate. Adherence to the requirements of this Framework should provide confidence that a precautionary approach has been taken to specifying drainage ditch management schemes. Users of the framework will need to apply expert judgement in both how to apply the Framework to scheme proposals and in use of the Framework to assess proposals.

This Framework does not apply to similar river restoration techniques: The drainage ditch management design proposed herein has similarities to other types of river restoration techniques. While similar river restoration design approaches *may* have nutrient mitigation benefits, there is not necessarily the same evidence to support them. As such, this Framework cannot be extrapolated to propose nutrient mitigation schemes using other river restoration approaches. Other types of river restoration nutrient mitigation schemes should refer to *Information on How to Deliver and Assess River Channel Re-Naturalisation for Nutrient Mitigation: Part 2 – Framework for River Channel Re-Naturalisation* (Lloyd et al., 2024).

This Framework cannot be used to specify detailed engineering design: Although this Framework contains a specific approach to determine the key parameters for design of a drainage ditch management scheme, the outputs will not constitute a detailed engineering design. If required, scheme owners should use the key geometry outputs from the design process detailed below within a detailed engineering design for the scheme.

Drainage ditch management mitigation efficacy

Nutrient reduction efficacy

The evidence base to support drainage ditch management is provided in Annex A to this Framework. The proposed approach to drainage ditch management detailed herein is an amalgamation of studies of three types of ditch management:

- Vegetated drainage ditches
- Two-stage ditches
- Low-grade weirs

Most research is from the USA, where these three approaches are drawn from a toolbox of 'Best Management Practices (BMPs)' which are akin to agricultural management prescriptions under English agri-environment schemes.

Annex A provides an analysis of evidence from studies of ditch BMPs that have been used to determine a % reduction efficacy for N and P. The focus of this analysis was on studies of TN and TP load[2] reduction, as these are the variables output by the Natural England Nutrient Budget Calculators that are used to determine the mitigation requirement for new developments. There are a number of studies that report the impact of drainage ditch BMPs on fractions of N and P, and on N and P concentrations as opposed to load. These studies were used as supporting evidence.

Studies of drainage ditch BMPs are relatively new. The earliest study found in the evidence review in Annex A was published in 2011. Thus, the evidence base is smaller than for other mitigation methods (e.g., wetlands and riparian buffers) that have guidance frameworks which support the ability to calculate nutrient mitigation for nutrient neutrality prior to deployment. The studies analysed in Annex A regularly note how the use of drainage ditch BMPs results in the promotion of processes of nutrient retention and removal that are seen in wetland systems; these studies often

[2] Nutrient load is expressed as a mass per unit time, e.g., kg/year, which is the required units for calculating nutrient reductions due to mitigation methods and aligns to the Natural England Nutrient Budget Calculators.

refer to drainage ditches managed using BMPs as linear wetlands. Based on first principles, there is compelling case for the use of drainage ditch BMPs as nutrient mitigation solutions.

Studies of TN and TP load reductions due to drainage ditch BMPs showed consistently good results but with a range of values seen, from 10% to 77% for TN and 17.6% to 90% for TP. There were also consistently positive results seen for TN and TP concentrations reductions due to drainage ditch BMPs. Results are more variable for studies reporting reductions in concentrations and loads for fractions of TN and TP; however, results were generally positive. Where studies showed negative results, this was due to BMP design and site-specific environmental and hydraulic factors. It was also found that most studies of drainage ditch BMPs were for periods of less than one year. However, studies that were longer than one year reported results suggesting that drainage ditch BMPs can remain effective for nutrient reduction through periods of seasonal variation that impact the environmental conditions required for nutrient reduction processes.

Most studies only report results from using one drainage ditch BMP and a common conclusion of these studies is that better results are likely achievable using more than one BMP in a single ditch. Furthermore, studies that reported poor performance of BMPs for nutrient reduction were able to pinpoint design factors that resulted in low or negative nutrient reduction efficacies. The analysis in Annex A highlights these design factors and provides recommendations on how drainage ditch BMPs can be designed to increase the confidence that a drainage ditch management nutrient mitigation scheme will deliver an estimated amount of nutrient mitigation. A key recommendation from this analysis is that drainage ditch management schemes for nutrient neutrality *must include all three of the BMPs listed above*.

By redesigning drainage ditches to include the three BMPs listed above plus a 10 m vegetated margin adjacent to the ditch, as well by adhering to the design principles detailed in this framework and in Annex A, it is possible to attain sufficient confidence in the nutrient reduction potential of drainage ditch management proposals such that the nutrient load reductions (in kg/year of TN and/or TP) can be determined in advance using a percentage reduction efficiency associated with a drainage ditch management proposal. As detailed in Annex A, the nutrient reduction efficiencies are:

- 28% for TN
- 28% for TP

These reduction efficiencies are to be applied to the baseline nutrient load input to a drainage ditch. By quantifying the baseline TN and/or TP load input to a drainage ditch management scheme and reducing it by relevant reduction efficiency, it is possible to estimate the nutrient mitigation that should be delivered through a drainage ditch management scheme. It is important to note that the above nutrient reduction efficiencies were determined using an analysis that was guided by the Precautionary Principle, with lower bound estimates of nutrient reduction efficiencies used. As detailed in Annex A, the average nutrient reduction efficiencies from the analysed studies are higher than efficiencies recommended for use in this framework.

The requirement for baseline nutrient load input estimation

In order to claim nutrient credits prior to the deployment of a drainage ditch management scheme, a robust approach to calculating the baseline nutrient load input is required. The baseline nutrient input to a drainage ditch describes the estimated current input of nutrients to a drainage ditch. It can be quantified by using either modelling or monitoring approaches. For practical reasons, it is likely that most proposals will use modelling to estimate the baseline nutrient load input to a drainage ditch. The 'Estimating the baseline nutrient load input' section outlines a modelling method that is considered to be robust enough for the quantification of the baseline nutrient load input, as well as the requirements for monitoring if monitoring data are being used to estimate the baseline. A worked example showing how the baseline nutrient load input is combined with the above percentage reduction efficiencies is detailed in the 'How nutrient credits are calculated' section.

Framework for drainage ditch management nutrient mitigation proposals

Key considerations

To support the successful implementation of drainage ditch management nutrient mitigation schemes, the following key considerations should be addressed. Proposals for drainage ditch management schemes should contain the evidence provided in Table 1. Where this evidence is not provided, it should be requested from the scheme owner. If any of the evidence detailed in Table 1 cannot be provided or is unsatisfactory, the proposal may not be viable.

Table 1: Key considerations checklist. Note some cells have been left blank in order to be filled in by Framework users.

Key considerations	Evidence to be provided	Evidence provided and satisfactory (Y/N)
Is the ditch currently vegetated?	Photographic evidence that a drainage ditch is not already densely vegetated. Low density vegetation is unlikely to result in significant mitigation benefits and thus is acceptable.	
Does the ditch have a trapezoidal cross-section?	Photographic evidence and/or cross-sectional measurements and drawings should be provided to show that the ditch has a trapezoidal cross-section. This is required to show that the ditch does not already have a two-stage cross-section (see the 'Design criteria' section for an example of a two-stage cross-section).	
Are there any low-grade weirs or similar small impounding structures installed within the ditch?	Photographic evidence should be provided to show that there are no existing artificial structures within the drainage ditch that may perform a similar impounding function to the low-grade weirs that are required as part of a drainage ditch management scheme design.	

Key considerations	Evidence to be provided	Evidence provided and satisfactory (Y/N)
Does the ditch flow perennially or ephemerally? If the ditch is ephemeral, can it be shown that water flow in the ditch is connected via surface water pathways to downstream waterbodies that ultimately drain into a Habitats Site?	Visual evidence should be provided showing that the proposed ditch location flows following rainfall events and transports water and nutrients to downstream receiving environments. This is to remove the risk of applying the drainage ditch management approach to ditches that are currently acting as retention basins / wetland-type habitats that will confer some existing benefit for nutrient management.	
Can the proposal show that a watercourse proposed for a scheme is heavily managed and low in natural features?	Proposals for drainage ditch management on heavily managed small watercourses should provide visual evidence that the channel is significantly impacted by current management and therefore does not contain many/any natural features that would be impacted by the proposed drainage ditch management design. The features may include meanders, bars and bedforms that give rise to varied eco-hydrological characteristics that should be preserved.	

Key considerations	Evidence to be provided	Evidence provided and satisfactory (Y/N)
Are there any other mitigation schemes and/or natural features within the catchment of a drainage ditch/watercourse that might impact the baseline nutrient input to the scheme?	Nutrient inputs to drainage ditch management scheme may come from point or diffuse sources that are transported via existing mitigation scheme and/or natural features that result in nutrient reductions. Where these are present, proposals need to consider the impact that a mitigation scheme or natural feature has on the baseline nutrient input to the scheme, as this will impact the quantification of mitigation potential.	
Is the channel at the deployment location a Water Environment Regulations (WER[3]) waterbody?	Designation of a watercourse as a WER waterbody may cause problems for deployment due to long-term objectives to restore WER waterbodies to good ecological status. Proposals will need to show that have engaged with the Environment Agency and gained their permission to deploy a drainage ditch management scheme on	

[3] Formally the Water Framework Directive.

Key considerations	Evidence to be provided	Evidence provided and satisfactory (Y/N)
	a WER waterbody. This is linked to the below consideration.	
Is there a risk that the proposed drainage ditch management scheme will have an adverse impact on, or hinder restoration of any protected sites or species, or negatively affect existing habitats, or negatively affect the ability to achieve other environmental objectives?	A statement will be required identifying whether the scheme may result in any adverse impacts to protected sites or species, and/or whether it might hinder the achievement of protected site objectives or other environmental objectives, e.g., compliance with the WER, or habitat restoration. Where a scheme may cause adverse impacts / impact on environmental objectives, the proposal may not be able to be approved unless these impacts can be mitigated. This statement is likely to be provided as part of a robust feasibility assessment for a scheme.	
Are there any existing legal obligations on the management of the drainage ditch? For example, existing grant schemes such as Countryside Stewardship.	Where a drainage ditch is currently under a management prescription due to an existing legal obligation that provides financial reward, this legal agreement will need to be ended in order for a drainage ditch management scheme to	

Key considerations	Evidence to be provided	Evidence provided and satisfactory (Y/N)
	provide mitigation for nutrient neutrality.	
Are there any other agencies / organisations that may require consultation to gain permissions or consents to deploy the scheme?	The scheme proposer should provide a statement detailing whether any external stakeholders (e.g., Environment Agency, Internal Drainage Boards, Lead Local Flood Authorities) require consultation in order to gain permissions / consents to deploy the scheme. Where consultation is required, evidence should be provided showing the outcome of the consultation.	

Stage 1 – Design objective

Setting the design objective

Understanding the design objective for a drainage ditch management nutrient mitigation scheme should underpin a proposal that meets the requirements of nutrient neutrality.

The design objective is:

> **To reduce nutrient inputs to receiving waters within a Nutrient Sensitive Catchment using a specific approach to designing and managing agricultural drainage ditches and small watercourses.**

To achieve this design objective, proposals should clearly show how they have considered the requirements detailed in the sections from ‘Defining the source of nutrients’ to ‘How nutrient credits are calculated.’ This will support a robust estimate of the nutrient mitigation potential of the proposed drainage ditch management scheme and is important for meeting the requirement for *reasonable scientific certainty* under the Habitat Regulations.

Defining the source of nutrients

By draining farmland to reduce the risk of waterlogging and localised flooding, agricultural drainage ditches receive water from agricultural fields that is transported along surface runoff and shallow subsurface 'preferential' flow pathways. These flow pathways are also the pathways for nutrient transport from agricultural land to drainage ditches. Thus, in most cases the main source of nutrients to a drainage ditch management scheme will be diffuse agricultural pollution.

Some drainage ditches may also receive nutrient inputs from point sources. Point sources of nutrients will generally be from farmyard runoff and/or private/municipal wastewater treatment systems. In some cases, there may also be industrial nutrient point sources that contribute flow and nutrients to a drainage ditch.

It should be noted that a section of a drainage ditch that is proposed for a nutrient mitigation scheme can receive diffuse and point sources that drain directly to the section of ditch proposed for management, *and* from upstream/upslope areas within the watershed that contributes flow to the proposed ditch management location. It is important to consider all sources of nutrients within the watershed of a drainage ditch management scheme.

Key information required:

- Proposals should define the sources of nutrients to a drainage ditch management scheme.

This information should be provided as part of estimating the baseline nutrient load input and will depend on characteristics of the watershed that drains to the section of drainage ditch proposed for management.

Estimating the baseline nutrient load input

As detailed in the 'Drainage ditch management mitigation efficacy' section, the baseline nutrient load input is required to estimate the nutrient mitigation potential of a drainage ditch management scheme prior to deploying the scheme. The baseline nutrient load input can be obtained through modelling, monitoring or a combination of both. For practical reasons, it is likely that most drainage ditch management proposals will use modelling to estimate the nutrient input baseline.

As detailed above, drainage ditches may receive nutrient inputs from point and diffuse sources. The modelling approach detailed in Table 2 can be used to estimate the baseline nutrient load input from agricultural diffuse sources. This approach uses a range of freely available secondary data sources and is aligned to the methodology used for selecting agricultural nutrient export coefficients in the Natural England Nutrient Budget Calculators. In Table 2, the ‘mitigation site’ refers to the landholding(s) within which the drainage ditch or ditches are located. An approach for estimating the nutrient input from point sources is detailed below. However, it is possible that the baseline nutrient input load does not need to take account of all sources, as applying the percentage nutrient efficacies to a proportion of the input load will provide a precautionary nutrient reduction load.

It should be noted that as part of the process of quantifying the diffuse baseline nutrient input load, proposals should show how they have accounted for nutrient losses to groundwater. Nutrient inputs to drainage ditches and small watercourses are predominantly from surface runoff and subsurface nutrient transport pathways. Nutrients that leach to groundwater may not be transported to the mitigation scheme to receive treatment. Thus, in order to avoid overestimating the baseline nutrient load input to the ditch / watercourse from diffuse sources, proposals will need to show a robust approach to accounting for nutrient losses to groundwater.

Table 2: Recommended modelling approach for quantifying the baseline nutrient load input from agricultural diffuse sources. Some cells are left blank.

Step	Dataset	Outputs
Map the mitigation site boundary	A polygon showing the land ownership boundary within which the scheme will be deployed.	
Map drainage ditch deployment locations	A polygon showing the drainage ditch, or ditches proposed for management.	A map that shows a land boundary and the locations within that boundary where the mitigation scheme will be deployed.

Step	Dataset	Outputs
Delineate the watershed for the drainage ditch	A digital elevation model (DEM)[4].	A map showing the watershed of the drainage ditch. Proposals should describe the methodology used to delineate the watershed, including the use of a hydrologically condition DEM.
Extract the areas of land uses within the ditch watershed	Crop Map of England (CROME) and Less Favoured Area (LFA) and Moorland Lines[5].	The area of different agricultural and non-agricultural land uses within the ditch watershed. Proposals should use all available CROME data (currently covering the period 2016-2021) and use the most commonly occurring land uses in each CROME polygon to extract the areas of

[4] There are several sources of elevation data that can be used to delineate the catchment of drainage ditch that vary significantly in terms of spatial resolution. The main sources of DEM data are the EA Lidar survey (1-2 m spatial resolution) and the Shuttle Radar Topography Mission (SRTM; 30 m spatial resolution). It is recommended that EA Lidar survey data are used in the process to estimate the baseline nutrient load input.

[5] Dataset produced by the Rural Payments Agency and shows the areas of England classed as LFA. Available from: https://environment.data.gov.uk/explore/8dc2b71d-8cf5-427f-8af9-41a9dbba495a?download=true, accessed on: 11/04/2024.

Step	Dataset	Outputs
		different land uses in a watershed. Areas classed as grassland that overlap with the LFA should be classed as LFA for the purposes of later steps. For land under the control of the landowner, proposals should verify the CROME land use classification with the landowners and amend it as appropriate.
Determine the soil drainage class associated with each land use in the watershed	Cranfield Soilscapes soil map or Hydrology of Soil Types (HOST)[6].	Proposals should show how they have linked agricultural land uses in the watershed to the soil drainage class for land under a specific land use. Areas of the catchment that are under natural / semi-natural habitats do not need to consider soil drainage classes.
Determine the average annual rainfall (AAR) for the watershed	Centre for Ecology and Hydrology Gridded Estimated Areal Rainfall (CEH-GEAR; Tanguy et	Ideally, proposals will show that they have compiled a rainfall dataset covering the most recent

[6] Soilscapes is available to view for free in a web application. HOST data have to be licenced at a cost. Both data sources are available via LandIS here: https://www.landis.org.uk/, accessed on: 11/04/2024.

Step	Dataset	Outputs
	al., 2021) or data from a local EA rainfall gauge[7].	30-year period available in either CEH-GEAR or EA rainfall records and used this to determine AAR. In lieu of a more detailed analysis, AAR can be obtained from maps hosted on the National River Flow Archive[8].
Check whether the watershed is within a Nitrate Vulnerable Zone (NVZ)	NVZ 2021 Designations[9].	Proposals should show that they have checked whether the watershed is within an NVZ.
Identify the WER Operational Catchment the watershed is in	WER Surface Water Operational Catchments Cycle 2[10].	Proposals should show that they have checked which WER Operational Catchment the watershed is within.
Select nutrient export coefficients for land	Agricultural export coefficients available in	Proposals should show how they have used the

[7] EA rainfall data are available from: https://environment.data.gov.uk/hydrology/explore, accessed on: 11/04/2024.

[8] Rainfall maps can be found on river flow gauging station pages here: https://nrfa.ceh.ac.uk/data/search, accessed on: 11/04/2024.

[9] Available from: https://www.data.gov.uk/dataset/77ffd32c-13db-4d83-a1f8-044c5397bc34/nitrate-vulnerable-zones-nvz-2021-designations, accessed on: 11/04/2024.

[10] Available from: https://www.data.gov.uk/dataset/71581966-1935-411e-ab66-f32d960497e8/WER-surface-water-operational-catchments-cycle-2, accessed on: 11/04/2024

Step	Dataset	Outputs
uses within the watershed	the Natural England Nutrient Budget Calculators.	outputs from the above steps to select the relevant nutrient export coefficients for the land uses in the watershed. It is also necessary to detail how nutrient export coefficients have been corrected to account for nutrient losses to groundwater that are unlikely to be intercepted by drainage ditches.
Use the groundwater-corrected nutrient export coefficients with areas of each land use in the watershed to calculate the baseline nutrient input load	Groundwater-corrected nutrient export coefficients and land use areas (output from the steps detailed above).	Proposals should show how they have combined the areas of each land use within the watershed with groundwater-corrected nutrient export coefficients to calculate the baseline nutrient load input.

Point source nutrient inputs to a drainage ditch management scheme may come from the following sources:

- municipal wastewater treatment works (WwTWs);
- combined sewer overflows (CSOs);
- onsite sewage treatment systems (septic tanks or package treatment plants (PTPs);
- agricultural points sources, such as farmyards and slurry lagoons; and
- industrial point sources.

CSOs, agricultural point sources and industrial points sources are likely to require monitoring data to estimate their impact on the baseline nutrient load input. Proposals that meet the minimum criteria for monitoring (see below) to determine the nutrient input to a drainage ditch management scheme will capture the inputs from these point sources. These criteria ensure that monitoring captures the combined inputs from diffuse and point sources within the catchment of a drainage ditch. Monitoring plans may also wish to account for the varying temporality of point sources, i.e., nutrient inputs from CSOs and agricultural points sources are either wholly or partly driven by rainfall events, whereas industrial point sources may be more continuous. A combination of event-based and fixed frequency sampling may therefore be appropriate to capture the inputs from these sources, depending on which sources are present within a drainage ditch catchment.

WwTW and onsite sewage treatment systems will result in a more continuous nutrient load input within a drainage ditch catchment. Proposals seeking to incorporate treated wastewater points sources in baseline nutrient load input estimates should:

- Map the locations of treated wastewater point sources to show they are within the catchment of a drainage ditch.
- Consult the Environment Agency Consented Discharges to Controlled Waters with Conditions register[11] to confirm whether a discharge is to ground or to surface water. Note that the receiving environment (i.e., surface water or to ground) is stated for each entry in the discharge consent register. Discharges to ground may not contribute nutrients to a drainage ditch and are therefore only to be used as supporting evidence.
- Only include discharges from properties that are likely to have private sewage systems but do not have discharges on the consent register if it can be shown they discharge directly to a watercourse.

Treated wastewater point sources can be quantified using monitoring, however it is also possible to estimate nutrient load inputs by applying the approach to quantifying wastewater nutrient loadings specified in the NE Nutrient Budget Calculators. Table 3 outlines the steps required to estimate the nutrient input from treated wastewater based on the population served by a treatment system, the daily effluent discharge from the system and the nutrient concentration of this effluent.

[11] Available from: https://www.data.gov.uk/dataset/55b8eaa8-60df-48a8-929a-060891b7a109/consented-discharges-to-controlled-waters-with-conditions, accessed on: 02/07/2024

Table 3: Recommended approach for estimating nutrient loads from treated wastewater point sources.

Step	Dataset	Outputs
Obtain the number of people served by a sewage treatment system	For municipal WwTWs, consult the relevant water company to obtain the population served by a WwTW. For onsite sewage treatment systems, determine the number of houses served by the system and apply the average occupancy rate detailed in the relevant NE Nutrient Budget Calculator.	The number of people contributing wastewater to a treatment system.
Calculate the volume of wastewater being output by the treatment system	Number of people served by the wastewater treatment system. Estimated water use of 120 l/person/day[12].	An estimate of the daily volume of treated sewage effluent output from a treatment system.
Calculate the annual nutrient load being output by the treatment system	The estimated daily treated effluent volume. The nutrient concentration of treated sewage effluent, which should be one of the following:	An estimate of the *annual* nutrient load output from a treatment system, in units of kg/year.

[12] This daily water use is aligned to the NE Nutrient Budget Calculators. It is lower than UK and regional average daily water use estimates and is therefore precautionary.

Step	Dataset	Outputs
	90% of the nutrient permit limit for WwTWs with nutrient permits. A default nutrient concentration of 27 mg TN/l and/or 5 mg TP/l[13]. The default PTP effluent concentrations provided in the NE Nutrient Budget Calculators[14].	

Alternative approaches to determining the baseline nutrient load input

The approach detailed in Table 2 is considered robust enough to determine the baseline nutrient input for a drainage ditch management scheme. However, other modelling approaches are available, and proposals may also use monitoring data. In these cases, the key considerations are as follows:

- Proposals using alternative modelling approaches should provide justification for the use of an alternative model. It is likely that this justification will be that a more detailed model is available for the drainage ditch watershed. Proposals

[13] Note that the default total phosphorus (TP) concentration is lower than that used in the NE Nutrient Budget Calculators as it is known that non-permit limited WwTWs tend to output treated effluent at concentrations that generally range from 5-8 mg TP/l. In the case of calculating nutrient budgets, it is more precautionary to use 8 mg TP/l, whereas using 5 mg TP/l is more precautionary when using these values to calculate mitigation potential.

[14] The default PTP nutrient concentrations are deemed appropriate as small sewage discharges to watercourses are allowed from PTPs under the Environment Agency's General Binding Rules, whereas discharges from septic tanks direct to watercourses are not allowed. The default PTP concentrations should be used even if it is known that a property is discharging sewage effluent via a septic tank direct to a watercourse. This will account for the minimum standard of regulatory compliance for small sewage discharges.

using alternative models should provide a detailed description of the model and how it was calibrated and validated.

- The model description should also detail how the alternative model has accounted for compliance with relevant regulations that are intended to reduce nutrient export from agriculture[15] and reduce the risk of pollution from treated wastewater[14].

- Proposals may choose to use monitoring data to calculate the baseline nutrient load input. This may be primary data from a monitoring programme designed specifically for the proposed scheme, or secondary data collected for another purpose but that can be used to calculate the baseline nutrient load input. The following minimum criteria should be applied where monitoring data is used:

    1. Monitoring data for both flow rate and nutrient concentration in ditch flow is required. These variables are combined to calculate nutrient load.

    2. Data should be obtained at the downstream end of the section of drainage ditch proposed for management, in order to capture all inputs to the ditch.

    3. Nutrient transport to drainage ditches is largely rainfall driven. Monitoring designs collecting primary data should include reactive sampling to monitor ditches after rainfall events. Where secondary data are used, the monitoring design used to collect these data should either be reactive or include sampling at a high enough frequency to capture the episodic nature of nutrient transport in ditches.

    4. A monitoring dataset should be a minimum of one year in duration to capture seasonal variation in nutrient transport within the drainage ditch catchment.

    5. The monitoring plan can show that all farms and point sources in the catchment draining to the proposed deployment location are compliant

[15] To generate the Farmscoper nutrient export coefficients suggested for use in modelling approach detailed in Table 2, an exercise was conducted to model the nutrient export associated with different types of farming where the farms were assumed to be 100% compliant with relevant agricultural regulations.

with the relevant regulations. This is required to provide confidence that mitigation is not being credited due to treating pollution from agriculture or points sources greater than would be expected where farms/point sources are legally compliant.

Key information required:

- Proposals using the modelling approach detailed in Table 2 should clearly show how they have followed the steps outlined above.
- Proposals that use an alternative modelling approach should provide a detailed description of the modelling methodology.
- Proposals that use monitoring should provide a detailed description of the monitoring design, showing how the monitoring used to quantify the baseline nutrient load input meets the five points listed above.

How nutrient credits are calculated

Proposals for drainage ditch management schemes should evidence a robust approach to estimating the baseline nutrient load input (meeting the requirements detailed above) and adhere to the requirements of Stages 2-5 in this framework. By showing how a drainage ditch management scheme meets these requirements, proposals should provide confidence that the scheme will achieve the design objective detailed in the 'Setting the design objective' section. This in turn will provide confidence that nutrient credits can be claimed prior to deploying the scheme. Nutrient credits from a scheme are calculated as shown in Box 1.

Box 1: Calculating nutrient credits delivered by a drainage ditch management scheme

1. The baseline nutrient load input to the scheme was calculated as:
    a. 4682 kg TN/year
    b. 157 kg TP/year
2. Using the percentage reduction efficiencies detailed in Section 2.1, nutrient credits that can be claimed prior to deployment from the scheme are therefore:
    a. 4682 kg TN/year x 0.28 = 1310.96 kg TN/year
    b. 157 kg TP/year x 0.28 = 43.96 kg TP/year

The 'Confidence assessment' section at the end of this Framework and be applied to drainage ditch management proposals. Proposals that pass the confidence assessment will be able to claim nutrient credits calculated using the approach shown above.

Key information required

- Proposals should show how they have calculated the nutrient credits the scheme will generate.

Additional benefits

Drainage ditch management schemes can provide additional benefits over and above water quality improvements. These benefits may include:

- Natural flood management
- Carbon sequestration
- Habitat and biodiversity improvements
- Low flow support to rivers
- Water resources management

The habitat and biodiversity improvements that result from drainage ditch management schemes may also provide some recreational benefits, however most drainage ditches are likely to be on private land and may not be accessible to the wider the public.

For the purposes of nutrient neutrality, there is no requirement to perform a formal assessment of additional benefits. Proposals may wish to include some consideration of how additional benefits can be promoted through scheme design as these may be relevant to other local planning policies or wider environmental policy goals.

Schemes seeking to also create Biodiversity Net Gain units through the drainage ditch management approach will need to carry out a separate Biodiversity Net Gain assessment.

Optional information to provide

- An analysis of the additional benefits that a drainage ditch management scheme may deliver.

Evaluation of the design objective

Drainage ditch management proposals must show how they have provided the key evidence and information detailed in the above 'Stage 1 – Design objective' sections. Proposals that clearly meet the requirements detailed above are robust enough to meet the requirements of the Habitat Regulations in relation to mitigation for nutrient neutrality. If any information is missing or the information provided is not detailed enough to meet the tests of Habitat Regulations compliance, proposals must be strengthened and reevaluated.

The table below can be used to assess whether a proposal meets the design objective for a drainage ditch management scheme.

Some cells in this table have been left blank for Framework users to complete.

Report section	Requirement	All information has been provided in an appropriate format (e.g., mapped, tabular and descriptive)	There are gaps in the information provided
Defining the source of nutrients	Source of nutrients to the drainage ditch clearly defined.		
Estimating the baseline nutrient load input	Proposal uses robust approach to estimating the baseline nutrient load input.		
How nutrient credits have been calculated	Clearly show how nutrient credits from the scheme have been calculated.		

Select the appropriate response based on the information provided to inform the design objective for the scheme.

	Response statements
If ALL required information provided	The proposal meets the requirements of the design objective for a drainage ditch management scheme.
If SOME required information missing	The proposal is missing information or is not detailed enough to meet the design objective of a drainage ditch management scheme. More information is required to provide confidence in the scheme.

Stage 2 – Feasibility

Introduction

Proposals for drainage ditch management nutrient mitigation schemes will need to consider whether this mitigation approach is feasible in a given location. The sub-sections below detail the key factors that will impact the feasibility of a drainage ditch management scheme. Proposals may identify constraints that impact the feasibility of a scheme. These constraints can often be mitigated. The feasibility assessment should detail mitigation measures required for successful scheme deployment. There are some circumstances where evidence to show feasibility is not required but is strongly recommended. These areas are highlighted in the text along with the optional information that should be incorporated where possible. Including optional information to support scheme feasibility will help to reduce the risk of unforeseen problems in delivering the scheme.

Topography and levels

Key questions

- **How steep is the channel?** Drainage ditches and small watercourses are located where local topography routes water to the channel, and they will have levels that ensure they drain under gravity. Notable differences in inlet and outlet levels may result in steep channels. Channel slopes > 3% can alter channel bed morphology (Montgomery & Buffington, 1997) in a manner that might undermine the design of a drainage ditch management scheme.

- **Has the proposal considered channel slope?** Proposals should show that they have used a measure of channel slope to determine whether this may impact the design of the scheme. Slope can be measured from a DEM, however only if the proposal has used a DEM with a spatial resolution ≥ 1 m. Where channel slopes are shown to exceed 3%, proposals should show how the slope will be reduced to ≤ 3% through the use of low-grade weir height and spacing (see the 'Stage 3 – Design process' section).

Key information required

- A statement of the channel slope at the deployment location.
- Where channel slopes are > 3%, the design should show how low-grade weirs are being used to reduce slope to ≤ 3%.

Geology and hydrogeology

Key questions

- **Are there any sources of non-agricultural pollution within the drainage ditch catchment?** Drainage ditch management schemes should aim to increase infiltration of water within the drainage network. This may in turn increase the connectivity of surface water and groundwater. If there are any sources of water pollution from non-agricultural sources within a ditch catchment, there is a risk that these other sources may contaminate groundwater and should thus be considered.
- **What is the local geology and hydrogeology?** Proposals should consider whether the local geology and hydrogeology facilitates connectivity between surface water and groundwater. Where there is connectivity between surface water and groundwater and a drainage ditch management scheme may increase this connectivity, proposals should consider the severity of the groundwater contamination risk. If the risk is too significant, it may mean a proposal is not feasible. Particular attention to groundwater contamination risks will be required where deployment location intersects a Source Protection Zone.

Key information required

- A statement describing whether there are any sources of non-agricultural water pollution within the drainage ditch catchment.
- If there are sources of non-agricultural water pollution within the catchment, the feasibility assessment should consider whether these sources pose additional risks above pesticide and faecal contamination risks associated with agricultural activities.

- Proposals should provide the following maps and use these to assess the potential risk to groundwater:
    - A map showing whether a Source Protection Zone intersects with the deployment location.
    - A map showing the bedrock geology at the deployment location.
    - A map showing any superficial geological deposits at the deployment location.
    - A map showing the hydrogeology at the deployment location.

Soil and sediment

Key questions

- **Has the proposal considered sediment mobilisation risks?** Excavation works to deploy a drainage ditch management scheme have the potential to mobilise sediment. This may have an impact on downstream waterbodies.

Key information required

- An assessment of the potential for sediment mobilisation during excavation works and details of how sediment mobilisation risks will be mitigated.
- Risk mitigation for sediment mobilisation should be included as part of implementation planning (see the 'Site clearance and earthworks' section).

Flood risk

Key questions

- **Is the deployment location in Flood Zone 2 or 3?** Drainage ditch management schemes should provide natural flood management and deployment locations will often be in areas mapped as at risk from surface water flooding. Retaining surface water flood flows is an important aspect of how drainage ditch management schemes generate nutrient mitigation. In some cases, a deployment location may be within a river floodplain. Where a deployment location is shown to be within Flood Zone 2 or 3, consideration should be given as to whether flooding may impact the integrity of the scheme.

Key information required

- A map showing whether the deployment location is within Flood Zone 2 or 3.

- If a deployment location is within either of these flood zones, an assessment of the impact this may have on a) nutrient reduction potential when the ditch is inundated; and b) the risk of the ditch being damaged during flood events.

Protected sites and species, and Invasive Non-Native Species (INNS)

Key questions

- **Will the proposed scheme impact a protected site?** If the deployment location for the drainage ditch management scheme is within, or near, a protected site, either its implementation or operational phases may impact the site. The following authorisations might be required:

    - As the owner or occupier of a SSSI, notice must be given, and Natural England's permission (consent) is required before a planned activity is carried out on the site. This only applies to owners of land within the SSSI itself.

    - Public bodies must give notice and get Natural England's agreement (assent) before carrying out a planned activity that may damage a SSSI or land near the site's boundary.

    - For proposals within or outside the site which could potentially have a likely significant effect on a European sites and Ramsar sites, a competent authority must undertake an HRA for any plan or project which is not necessary for management of the site. Competent authorities must also consult Natural England (advice) if proposals are likely to impact a SSSI.

- **Will the proposed scheme impact protected species?** If protected species are present at or near the deployment location and could be impacted by the scheme, this will require a conversation with Natural England to gain consent for deployment.

- **Are there any known INNS at the deployment site?** There may be INNS at the deployment location, which would require an INNS risk assessment to show how these species will be removed and disposed. This is required to remove the risk of spreading INNS to other locations.

- **Will the proposed scheme impact other protected sites or environmental objectives?** The scheme should not impact other protected sites, such as National Parks, National Nature Reserves and other similar designations. It should also not negatively impact the ability to achieve other environmental objectives, for example Water Framework Directive objectives.

Key information required

- Map showing the location of the deployment site relative to international (SAC, SPA, Ramsar) and national (SSSI) protected sites for nature conservation.

- Map of locally protected nature / environment sites (Local Nature Reserves, Local Wildlife Sites) and other protected areas (National Parks, AONBs, National Nature Reserves) that may have requirements which need consideration when deploying a drainage ditch management scheme.

- Map of priority habitats showing whether the scheme may impact habitat restoration areas.

- Map of INNS sightings using the National Biodiversity Network INNS Mapper[16]. Where INNS are present at the deployment location, an INNS risk assessment is required.

- Depending on the interaction of the scheme with the above designations, a full ecological assessment may be required. The implementation plan for the scheme (see the 'Stage 4 – Implementation plan' section) should detail any mitigation measures required to provide confidence there will be no impacts on the above designations due to the scheme.

Land use

Key questions

- **Is the site currently under any land management agreement?** If the deployment location is currently under a legal agreement for a specific drainage ditch management regime, for example agri-environment schemes like Countryside Stewardship, this agreement will need to be ended to allow payments for nutrient mitigation.

Key information required

- A statement that the deployment site is either not in under a legal agreement for a specific management regime or that any agreement will be ended when the nutrient mitigation scheme is active.

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[16] Available from: https://innsmapper.org/map, accessed on: 02/05/2024

Ownership

Key questions

- **Is there an agreement with the landowner(s) to deploy the scheme at the deployment location?** Nutrient mitigation schemes delivering permanent mitigation will need to be secured for a period of 80+ years. Securing a scheme legally will require either a Section 106 Agreement or a Conservation Covenant. Legal agreements will not be in place until the end of a scheme proposal process; however, scheme proposals should show that the landowner has consented to the scheme being deployed for up to the in perpetuity period.

Key information required

- A statement confirming that a landowner has consented to the deployment of the scheme on their land.
- Confirmation that the landowner is aware and consents to the requirement of the monitoring, management and maintenance requirements for the scheme.

Rights of way and public access

Key questions

- **Is a public right of way going to be affected by the scheme?** Public rights of way cannot be closed or diverted, even temporarily, without permission from the Local Authority. Implementing a drainage ditch management scheme has the potential to affect public rights of way.
- **Are there wider benefits associated with public access?** Public access to a drainage ditch management scheme will improve the scheme's amenity value, with the potential to provide education and public awareness of nutrient pollution issues. However, it may also increase the risk of degradation that might reduce nutrient removal efficiencies, as well as causing problems for other activities being carried out by landowners.

Key information required

- Map of the nearest public rights of way and plans for any required mitigation should scheme implementation affect a public right of way.
- Demonstration that the local authority has been engaged regarding changes to public rights of way, if required.

Optional information to provide

- If possible, consider opportunities for public access for education purposes and raising public awareness, with consideration given to minimising the risk of degradation of the scheme.

Bird strike risk

Key questions

- **Is the proposed scheme location near an airfield?** Drainage ditch management designs can attract birds. This may be an issue if the site is near an airfield, especially for large flocks of birds such as starlings. The risk of bird strike will depend on the type of airport and its associated usage by planes. A risk assessment needs to be within the context of the type of airport.

- **Will a bespoke bird strike risk assessment be needed?** Airports may have their own bird strike risk management programmes or plans. These should be consulted, and any mitigation of bird strike risk should be derived through consultation and the development of a mutually agreed strategy.

Key information required

- Map showing the nearest airfields and the type of airfield (commercial, military etc) along with any proposed mitigation strategy.

Nature recovery

Key questions

- **Does the drainage ditch management scheme have the potential to be part of a habitat network or Nature Recovery Project?** Proposals should consider the location of the scheme relative to habitat network mapping and priority river habitats. Drainage ditch management designs should provide habitat improvements to agricultural drainage ditches and small, heavily managed watercourses. However, if the scheme location intersects with priority river habitats or Local Nature Recovery projects, it may be that the drainage ditch management approach is not aligned to required habitat restoration goals and legally securing the mitigation scheme in perpetuity would therefore be an impediment to nature recovery.

- **Are there are other river restoration plans for the proposed deployment location?** A drainage ditch management deployment location may have been identified as a location for a future project to restore more natural function to a watercourse. Proposals should seek to identify any such plans and determine whether the proposed mitigation scheme will be an impediment to achieving the restoration goals of an existing plan. It is possible that the drainage ditch management approach may be complementary to existing plans, and this should be explored if such plans exist.

- **Is there a risk the proposed scheme may impact nature restoration in adjacent habitats?** Artificial drainage ditches and watercourses that are managed as drainage ditches may be causing impacts to adjacent habitats, either in more natural reaches of a watercourse directly upstream and downstream, or in areas that are connected laterally to the existing ditch, e.g., wetland habitats. Proposals should consider whether a drainage ditch management approach is compatible with actions to restore a more natural function to the deployment location when compared with other restoration approaches that may benefit adjacent habitats.

Key information required

- Map showing the locations of habitat networks and priority river habitats, and consideration of whether the project could be an impediment to a Nature Recovery Project.
- Proposals should provide a statement that they are aware of any plans that would be impeded by application of a drainage ditch management approach.
- Proposals should detail a consideration of the characteristics of adjacent habitats and how the proposed drainage ditch management approach compares with other restoration approaches to benefit adjacent habitats.
- In time, the Local Nature Recovery Strategy (LNRS) should be used to maximise the benefits that can be derived from a drainage ditch management scheme.

Unexploded ordinance

Key questions

- **Is there a risk of encountering unexploded ordinance at the deployment location?** Uncovering unexploded ordinance will delay project progress and increase costs.

Optional information to provide

- Identify presence or absence of unexploded ordinance prior to implementation of the scheme.

Services and infrastructure

Key questions

- **Has an assessment of overhead services (electricity, telecoms) been conducted?** Where overhead services are present at the site, proposals need to consider whether the use of plant machinery has the potential to disrupt these services. Because drainage ditch management schemes will not require excavation below the current bed level of a ditch or watercourse, buried services should not be disrupted by construction works.

Key information required

- Overhead services will be visible at the deployment location. Proposals should provide a statement that there are either no services present or describe how any risk to these services will be mitigated.

Regulatory considerations

Key questions

- **Does implementation of the scheme require an environmental permit or other permissions / consents?** Regulatory requirements might include, but are not limited to, the following:
  - Environmental permits
  - Flood risk assessment
  - Flood defence consent from the EA when works are within 8 m of a main river
  - Wildlife licences
  - Planning permission
  - Ordinary watercourse consent

Key information required

- A list of the permits and licences required along with an assessment of the likelihood that they will be granted.

Constraints and options assessment

Key questions

- **Is the proposed location suitable for drainage ditch management scheme?** The feasibility assessment may have identified a range of constraints requiring mitigation and any information gaps that will be filled as a project progresses. It will be useful to condense the key information identified in the feasibility assessment into a summary which, in a successful proposal, will highlight that the proposed deployment location is suited to the scheme. This step is not mandatory; however, it will show that the proposal has given significant thought to the feasibility of the mitigation scheme.

Optional information to provide

- A summary table of the constraints and mitigation measures identified through the feasibility assessment.

Evaluation of the feasibility assessment

For a drainage ditch management scheme to pass the feasibility assessment, it must include information listed as *required* in the feasibility assessment sections above. To establish whether the feasibility assessment has indicated the scheme is robust in the proposed location, the tables below can be used.

Some cells in this table have been left blank for Framework users to complete.

Feasibility consideration	Required / optional	All required information has been provided in an appropriate format (e.g., mapped, tabular or statements)	There are gaps in the required information provided
Topography and levels	Required		
Geology and hydrogeology	Required		
Soil and sediment	Required		
Flood risk	Required		
Protected site, species and INNS	Required		

Feasibility consideration	Required / optional	All required information has been provided in an appropriate format (e.g., mapped, tabular or statements)	There are gaps in the required information provided
Land use	Required		
Ownership	Required		
Rights of way and public access	Required (with some optional information)		
Bird strike risk	Required		
Nature recovery	Optional		
Unexploded ordinance	Optional		
Services and infrastructure	Required		
Regulatory considerations	Required		
Constraints and options assessment	Optional		

Select the appropriate response based on the information provided to inform the design objective for the scheme.

	Response statements
If ALL required information provided	The proposal meets the requirements of the feasibility assessment for a drainage ditch management scheme.
If SOME required information missing	The proposal is missing information or is not detailed enough to provide a robust feasibility assessment of a drainage ditch management scheme. More information is required to provide confidence in the scheme.

Stage 3 – Design process

Introduction

The sections below provide the design criteria for a drainage ditch management scheme. Proposals will need to meet these design criteria in order to claim the nutrient reduction efficacies detailed in the 'Nutrient reduction efficacy' section and thus claim nutrient credits prior to scheme deployment.

The design criteria detailed below provide enough information to specify key dimensions for a drainage ditch management scheme but do not constitute sufficient information for detailed engineering design. Detailed engineering design is advisable, but it may not be required if the landowner or other contractors feel they are able to implement the scheme to meet the key dimensions determined using the design criteria.

Design criteria

Figure 1 shows the conceptual design of a two-stage ditch, highlighting the three components that comprise a two-stage geometry. Drainage ditch management schemes will need to specify dimensions that conform to this geometry, as well as incorporating low-grade weirs and vegetation planting. The steps for specifying two-stage ditch dimensions in small, trapezoidal UK agricultural drainage ditches are described below. These steps are based on guidance detailed in USDA (2007) and Powell et al. (2007). Design criteria are also provided for low-grade weir heights and spacing, and vegetation planting. For ease of reference, the steps below will refer to different parts of the two-stage ditch design by the names shown in *Figure 1*.

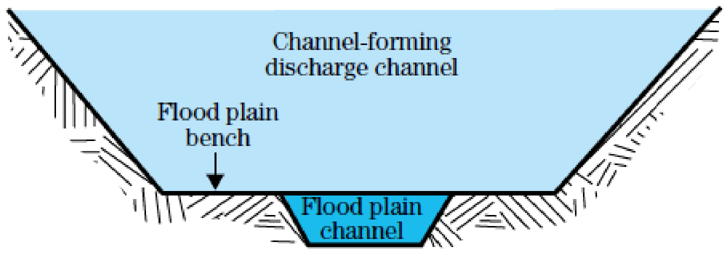

Figure 1: Conceptual design of a two-stage ditch. Source: USDA (2007).

Step 1: Existing ditch dimensions

- Measure the existing dimensions of the trapezoidal ditch that is proposed for reengineering.
- Measurements should be taken of the:
    - Average bankfull width
    - Average channel bed width
    - Average channel depth
- These measurements will be incorporated into the floodplain channel width and depth, the floodplain bench widths and the channel-forming discharge channel width and depth.

Step 2: Determine a regional curve

- Refer to Annex A for details of a regional curve.
- A regional curve can be developed by measuring channel widths in satellite imagery.
- Points should be located at the downstream end of WER waterbody catchments within the relevant Operational Catchment. The river width should be visible and measurable in satellite imagery. Waterbody catchment drainage areas can be obtained from the WER waterbody catchment polygon.
- Additional measurements of channel width should be taken from small tributaries within the WER waterbody catchment in which the scheme is proposed for deployment. Drainage areas for these locations can be determined using a high resolution lidar DEM.
- A regression relationship between drainage area and channel width should be derived. Note that depending on the size of the Operational Catchment,

proposals may need to apply non-linear regression. It should be specified whether linear or non-linear regression was used.

- Using the drainage area for the proposed two-stage ditches and the regression relationship derived from the regional curve, proposals should provide an estimate of the approximate bankfull width for the two-stage ditch.

- It is recognised that measurements of channel width taken from satellite imagery will be prone to error and the output from a regional curve generated in this way should be used to guide sizing two-stage channel width, rather than a definitive measure of the appropriate width.

Step 3: Estimate the channel slope

- Two-stage ditch design guidance does not provide recommendations on a critical slope beyond which increased stream power may cause erosion that would undermine the two-stage channel geometry.

- As detailed in the 'Topography and levels' section, it is recommended that where channel slope is > 3%, low-grade weir heights and spacing are used to reduce the channel slope below this gradient.

- While full topographic surveys to measure channel slope are recommended, they are not essential, and slope can be measured using a DEM with a minimum 1 m spatial resolution.

Step 4: Determine a conceptual channel geometry

Data obtained in Steps 1 and 2 can be used to determine a conceptual two-stage channel geometry. Table 4 describes how the geometry of a two-stage ditch should be specified. It should be noted that Steps 4 to 6 may need to be iterative in order to specify a channel geometry that is sufficient to convey the likely range of flows that the ditch / watercourse currently conveys.

Table 4: How proposals should determine the geometry of a two-stage ditch.

Two-stage ditch geometry component	Dimension	Input	Notes
Floodplain channel	Bankfull width	Existing channel width at ~33% of the existing bankfull channel depth	The bankfull width and depth of the floodplain channel should be set based on the width of the existing channel at a depth considerably lower than the existing bankfull channel depth. This should result in good connectivity between the floodplain channel and the floodplain benches. Hodaj et al. (2017) reported good levels of connection between the floodplain channel and floodplain benches at a bench height that was 33% of the existing channel depth. The optimal existing channel depth at which to set the bankfull floodplain channel width and depth will be locally specific. Proposals can use values other than 33%, but the chosen value should be low enough to provide confidence that the floodplain channel and benches will have good connectivity.
Floodplain channel	Bankfull depth	~33% of the existing channel depth	As above.
Floodplain bench	Width	Bankfull floodplain channel width	As a rule of thumb, total floodplain bench widths should be two to four times the bankfull floodplain channel width (see Annex A).

Two-stage ditch geometry component	Dimension	Input	Notes
			This rule can be relaxed (i.e., floodplain bench widths > 4 times the width of the floodplain channel) where a scheme is proposing the management of a small watercourse as it may be more ecologically beneficial to allow the channel to develop small meanders.
Channel-forming discharge channel	Width	Bankfull floodplain channel width and floodplain bench width	Summing the bankfull floodplain channel width and total floodplain bench width will provide the width of the base of the channel-forming discharge channel. Proposals should reference the channel width estimated from the regional curve. The channel-forming discharge channel width should be at least as wide as the width estimated from the regional curve, in order to provide added confidence that the ditch will convey the flows it is likely to receive.
Channel-forming discharge channel	Bankfull depth	Existing channel depth	The channel-forming discharge channel depth can be retained at the existing bankfull channel depth. Proposals may choose to slightly deepen the existing channel to add additional flow conveyance capacity.

Note that where proposals specify floodplain bench widths > 4 times the floodplain channel width, bank toe protection using natural materials should be installed and maintained until dense vegetation has established across the floodplain benches and the banks of the channel-forming discharge channel. Bank toe protection is required to reduce the risk of bank erosion due to meander development. It may be necessary to maintain bank toe protection as part of an adaptive management regime.

Step 5: Estimate flow conveyance capacity of the two-stage ditch geometry

- The two-stage ditch geometry is characterised by nested trapezoidal channels. It is thus possible to estimate the flow conveyance capacity of each channel using Manning's equation for open-channel flow.

- Manning's equation should be used to estimate flow in the floodplain channel at bankfull discharge and in the channel-forming discharge channel at bankfull discharge. The equation has the form:

$$V = \frac{1}{n} R_h^{2/3} S^{1/2}$$

where *V* is the cross-sectional velocity (m/s), *n* is the Manning coefficient, R_h is the hydraulic radius (m), *S* is the stream slope (m/m). Calculation of *V* allows for an estimate of discharge using the velocity-area method:

$$Q = AV$$

where *Q* is discharge (l/s) and *A* is the cross-sectional area of the channel (m^2).

- It is recommended that Manning's *n* is set to 0.1 to reflect the dense vegetation on the floodplain benches and the low-grade weirs in the floodplain channel[17]. However, proposals can use other values of *n* with appropriate justification.

- The estimated flow conveyance capacity of each of the trapezoidal channels should be summed to obtain an estimate of the flow conveyance capacity of the two-stage geometry.

Step 6: Estimate the discharge in the channel for a range of return periods up to the 1-in-100 year runoff event plus climate change.

[17] Manning's *n* for vegetated channels can be higher 0.1, however the floodplain channel will largely be unvegetated and thus will have lower flow resistance.

- Proposals should provide an estimate of the discharge conveyed by the channel at a range return periods up to the 1-in-100 year runoff event.

- Proposals should state how these values have been estimated. A greenfield runoff rate estimation tool[18] can be used, as well as more sophisticated modelling approaches such as Low Flows 2.

- If using a greenfield runoff rate estimation tool, the estimated runoff rates are sensitive to soil drainage class. Where a proposal has identified more than one soil drainage class within the catchment of a scheme as part of estimating the baseline nutrient load input (Section 0), runoff rates should be determined for multiple locations within each soil drainage class and an average taken.

- Greenfield runoff rates should be adjusted to account for climate change. This will involve increasing the predicted runoff rates to account for more extreme rainfall events in the future. It is recommended that the 'upper end' Environment Agency Climate Change Allowances[19] for the scheme location are used, though other climate change allowances can be specified with justification.

- The runoff rates plus climate change allowances should be compared to the ditch conveyance capacity calculated in Step 5. The ditch conveyance capacity should be sufficient to convey flows from low return period runoff events.

Step 7: Specify low-grade weir heights and spacing

- Proposals should specify the height at which low-grade weirs will be installed within the floodplain channel. It is recommended that weirs are deployed at heights > 20% of floodplain channel depth (see Annex A) with the intention of promoting more sediment deposition and greater floodplain bench connectivity.

- There are no specific recommendations on weir spacing. However, as detailed in Section 0, where channel slope exceeds 3%, weir spacing should be shown to reduce the channel slope to below 3%. Proposals should also calculate an estimated reduction in channel slope due to the weirs, in order to evidence that they will help to increase the hydraulic residence time of ditch flows.

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[18] Such as the HR Wallingford greenfield runoff rate estimation tool. Available from: https://www.uksuds.com/tools/greenfield-runoff-rate-estimation, accessed on: 07/05/2024.

[19] Available from: https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall?mgtmcatid=3017, Accessed on: 07/05/2024.

Step 8: Vegetation planting plans

- Proposals should detail the vegetation they plan to establish on the floodplain benches.
- Ditches will also require a 10 m vegetated margin to be planted along each side of the ditch. The vegetated margin serves a dual purpose, helping to provide visual evidence that should indicate the drainage ditch has not been reverted back to its previous form and providing additional nutrient reduction potential to flow pathways that enter the channel laterally.
- Proposals should specify fast-growing grass species for establishment on floodplain benches.
- The vegetation margin should have two zones: a grass zone at the upslope edge of the margin, transitioning to a tree zone bordering the ditch channel. Willow or other fast growing, native tree species that tolerate saturated soil conditions are recommended at planting densities that allow for access to the channel for maintenance.

Evaluation of scheme design

Proposals that adhere to the design criteria listed above are considered to provide reasonable scientific certainty that the scheme will deliver the nutrient reductions calculated through the approach detailed in Stage 1 of this framework. The table below can be used to record whether the proposal meets the design criteria.

Report section	The proposal clearly meets the design criteria	The proposal does not meet the design criteria
Design criteria		

Select the appropriate response based on the information provided to inform the scheme design.

	Response statements
If the proposal clearly meets the design criteria	The proposal meets the design requirement of a drainage ditch management scheme.
If the proposal does not meet the design criteria	The proposal does not meet all the design criteria and is not detailed enough to provide reasonable scientific certainty that it will achieve the calculated nutrient

	Response statements
	mitigation. More information is required to provide confidence in the scheme.

Stage 4 – Implementation plan

Introduction

Drainage ditch management schemes will need to be supported by an implementation plan that shows consideration of how the scheme will be delivered. The sections below cover aspects of scheme implementation that are considered relevant to reducing risks of environmental impacts due to the scheme and ensuring the scheme will deliver as designed. The 'Site clearance and earthworks' section – should be linked to the feasibility assessment (the 'Soil and sediment' section) if it has been shown that soil and sediment mobilisation may impact downstream habitats. The implementation plan should reference the mitigation measures required to limit impacts on protected sites.

Site clearance and earthworks

Key questions

- **Is vegetation clearance required on land adjacent to the existing ditch?** It may be necessary to remove vegetation that is currently present in the area of floodplain next to a ditch. If ditches are only flanked by areas of short grass or agricultural crops, this is not a material consideration for the implementation plan.

- **Does the ditch flow year-round or only after rainfall?** Ditches that flow perennially have a greater risk of transporting sediment that is mobilised during earthworks. Sediment mobilisation risks in ephemeral ditches can be mitigated by planning earthworks for periods of forecast dry weather. Where there is a risk of sediment mobilisation, the implementation plan should identify mitigation measures.

- **Can spoil be disposed of onsite?** Spoil from earthworks will need to be disposed of in line with waste management procedures and if possible, it should be disposed of within the catchment of the ditch management scheme. Disposal within the ditch management catchment should use spoil in a manner that reduces the risk of onward transport to river environments.

Key information required

- The implementation plan should detail control measures to minimise the risk of environmental pollution due to site clearance and earthworks. The plan should show that:

    - Ecological risks identified through the feasibility assessment will be mitigated.
    - Soil compaction will be minimised.
    - Soil erosion and sediment mobilisation will be minimised and mitigated.
    - Topsoil and subsoil are handled separately. Schemes should aim to dispose of spoil within land under the landowner’s control, preferably within the ditch catchment. Spoil disposal offsite will likely require waste management licences.

Vegetation establishment and management

Key questions

- **Does the implementation plan match the design criteria?** As detailed in the Stage 3 ‘Design criteria’ section, proposals should detail the planting plans for vegetation both on the floodplain benches and in the 10 m vegetated margins adjacent to the ditch. Implementation plans for vegetation establishment should tally with the proposed design.
- **Is there consideration of vegetation management requirements?** Vegetation both on the floodplain benches and the vegetated margin strips will require appropriate management. Removal of vegetation will help to remove nutrients from the ditch system and is beneficial to the nutrient mitigation function of the ditch. Consideration should be given to replacing vegetation that is removed by high flows.
- **Is fencing required?** Fences may be required to stop animals from grazing vegetation in the vegetated margin and the ditch, and to stop them entering the ditch and causing erosion/disturbing sediment. The requirement for fencing is contingent on whether livestock can access the ditch and may impact vegetation establishment.

Key information required

- The implementation plan should describe how it will implement the planting plans detailed as part of the scheme design.
- If fencing is not required, justification should be given as to why.
- Details of vegetation management plans should be provided. They should consider how vegetation management will enhance the mitigation potential of the scheme.

- Implementation plans should include considerations of the requirement to replace vegetation that is removed by high flows.

Outline management plan

Key questions

- **Why is an outline management plan required?** For drainage ditch management schemes to deliver nutrient mitigation in perpetuity, it is likely that schemes will require management and maintenance. The outline management plan should provide confidence that the scheme will be managed and maintained for its lifetime.

- **What aspects of the ditch design may require management and maintenance?** If fencing is required, this will need to be maintained. Low-grade weirs may degrade over time and be damaged by high flows. Sediment removal from the channel may be required periodically. The banks of both parts of the two-stage ditch may need periodic maintenance if they start to erode. Vegetation will require appropriate management.

Key information required

- An outline management plan should be provided detailing:
    - The organisation or individuals responsible for managing and maintaining the scheme.
    - Details of remedial maintenance that may be required in response to:
        - Damage to fencing (if installed).
        - Damage to low-grade weirs.
        - Sediment accretion behind weirs that reduces their capacity to store water and/or to increase connectivity with the floodplain benches.
        - Sediment accretion on floodplain benches that reduces connectivity between the floodplain channel and the benches.
        - Sediment accretion on floodplain benches that buries vegetation and results in areas of bare sediment that may increase sediment erosion risk.
        - Bank erosion that removes vegetation from either floodplain benches or vegetated margins.
    - How vegetation will be managed on the floodplain benches and vegetated margins in order to maintain vegetation as detailed in the ditch design.

- Details of vegetation or sediment removal to remove nutrients permanently from the ditch and reduce the risk of remobilisation, this is more important for phosphorus than for nitrogen. Sediment removal should be periodic and in response to accumulation that reduces the conveyance capacity of a ditch. Removal of sediment should be balanced with the requirement to retain vegetation cover on the floodplain benches of the ditch and, similarly, vegetation removal should not compromise the hydraulic effects of vegetation that are important for retaining nutrients.
- A plan incorporating adaptive management in response to monitoring (see the 'Post-implementation monitoring section' section) would be appropriate.

Evaluation of the implementation plan

Proposals should show that they have given sufficient consideration to how a drainage ditch management scheme will be implemented. In doing so, this will provide confidence that the scheme will be implemented as designed, while minimising risks to the environment and planning for the management and maintenance required to keep the scheme functioning in perpetuity. The table below can be used to record whether the proposal has provided a robust implementation plan.

Some cells in this table have been left blank for Framework users to complete.

Implementation requirement	All required information has been provided	There are gaps in the required information provided
Site clearance and earthworks		
Vegetation establishment and management		
Outline management plan		

Select the appropriate response based on the information provided to inform the design objective for the scheme.

	Response statements
The proposal includes a robust implementation plan.	The proposal provides sufficient confidence that it will be implemented in a manner that will deliver nutrient mitigation in perpetuity.

	Response statements
The proposal does not include a robust implementation plan.	The proposal does not provide confidence that the scheme will be implemented robustly. An implementation plan addressing all the required information should be provided.

Stage 5 – Post-implementation monitoring

Introduction

Drainage ditch management schemes will ***require*** monitoring to ensure the system maintains its original design. Monitoring of the scheme can inform an adaptive management regime where maintenance is carried out in response to requirements identified by periodic visual inspections. Proposals will not need to use monitoring to validate the number of nutrient credits claimed by a scheme using the steps outlined in Stage 1 of this Framework.

Successful proposals will have incorporated sufficient precaution such that monitoring of the scheme's performance in reducing nutrient loads is an ***optional*** exercise. Scheme owners may carry out monitoring of scheme performance to gain additional mitigation from a scheme. If scheme owners choose to conduct additional monitoring to determine scheme performance, they will need to specify a monitoring strategy that meets the minimum requirements detailed in this Framework.

Monitoring to support adaptive management

Key questions

- **What is monitoring to support adaptive management?** Degradation of a scheme to the point where it no longer maintains its original design will not occur over fixed timescales. Rare, high intensity rainfall events may trigger high flows that damage a scheme, triggering the requirement for maintenance. Conversely, a number of years may pass with environmental conditions that do not trigger the need for scheme maintenance. Regular monitoring should support an adaptive management regime, with monitoring data used to inform appropriate maintenance activities that will maintain the function of a scheme.

- **What are the monitoring requirements to support adaptive management?** Regular visual inspections and repeat, fixed-point photography can be used to identify maintenance requirements. For example, visual inspections may highlight damage to a low-grade weir and trigger maintenance actions. Fixed-point photography may highlight where sediment deposition is beginning to reduce flow conveyance capacity and needs removing. Monitoring to support adaptive management should be conducted annually for the lifetime of the scheme. It is likely that a well-designed ditch system will be largely stable, requiring minimal maintenance in response to annual monitoring. Frequencies of monitoring to support reporting on a scheme to competent authorities may differ from annual monitoring to support management. This will be agreed separately with the competent authority.

Key information required

- A post-implementation monitoring plan. The plan should incorporate:
    - Visual inspections conducted at the end of spring, after the high flow season.
    - Fixed-point photography captured at the start of spring, prior to the vegetation growth season.
    - The monitoring plan should be linked to the requirements of the outline management plan (see the 'Outline management plan' section) to show how an adaptive management plan will ensure remedial maintenance is carried out as required.

Monitoring to claim additional mitigation

Key questions

- **What is monitoring to claim additional mitigation?** Because the process to calculate the mitigation potential of a drainage ditch management scheme (Stage 1) is precautionary, monitoring a scheme post-deployment may show that it is delivering more mitigation than initially estimated.

- **When should monitoring to claim additional mitigation be employed?** If possible, baseline monitoring (monitoring prior to scheme deployment) will help to understand the additional nutrient reductions due to the scheme. However, the considerable expense of baseline monitoring combined with the ongoing expense of post-implementation monitoring may make requiring baseline monitoring to claim additional mitigation cost prohibitive. Monitoring to claim additional mitigation can therefore be conducted post-scheme deployment.

- **How should monitoring be carried out?** A monitoring methodology that will enable claiming additional mitigation is detailed in Appendix 1. This methodology specifies an approach to monitoring water quality and flow that can be used estimate the impact of the scheme on nutrient load transport. Proposals that wish to determine whether they can claim additional credits through monitoring should follow this methodology. The methodology includes the minimum length of a monitoring programme to allow additional mitigation to be claimed.

- **What will happen to the monitoring data?** The data collected will need to be analysed to show that the scheme is delivering more mitigation than initially predicted. There will be a requirement for validation of the data and the analysis to confirm the allocation of additional mitigation potential to a scheme. This will require engagement with Natural England and the Local Planning Authority. Other stakeholders, such as the Environment Agency, environmental NGOs and academics may also be interested in the data collected and the analysis. It would be beneficial to think about how monitoring data can be shared with a range of stakeholders.

Optional information to provide

- Proposals wishing to carry out post-implementation monitoring to claim additional credits should develop a monitoring methodology that adheres to the methodology detailed in Appendix 1.

- It is not necessary to submit a monitoring methodology at the point of proposing a drainage ditch management scheme, however the monitoring methodology will be required at the point when a scheme owner / manager applies to claim additional mitigation.

Evaluation of post-implementation monitoring plans

Proposals should specify how they intend to monitor drainage ditch management schemes, in order to support successful long-term management and maintenance. Successful proposals will provide confidence that a scheme will be well managed and continue to function as designed, in perpetuity. While not a requirement, proposals may also include a monitoring methodology for water quality and flow sampling that can be used to show the impact of the scheme on nutrient load transport. To claim additional mitigation from the scheme, monitoring methodologies should adhere to the minimum requirements detailed in Appendix 1 and show that the scheme is outperforming initial mitigation estimates. The table below can be used to record whether the proposal has provided a robust post-implementation monitoring plan.

Some cells in this table have been left blank for Framework users to complete.

Type of monitoring	Required/optional	All required information has been provided	There are gaps in the required information provided
Monitoring to support adaptive management	Required		

Type of monitoring	Required/optional	All required information has been provided	There are gaps in the required information provided
Monitoring to claim additional mitigation	Optional		

Select the appropriate response based on the information provided to inform the design objective for the scheme.

	Response statements
The proposal includes a suitable monitoring plan to support adaptive management.	The proposal provides sufficient confidence that it will be monitored in a manner that will facilitate long-term management of the scheme to deliver nutrient mitigation in perpetuity.
The proposal does not include a suitable monitoring plan to support adaptive management.	The proposal does not provide confidence that the scheme will be monitored robustly and there are concerns that this could lead to poor scheme maintenance. A revised monitoring plan is required, addressing the missing monitoring information.

Confidence assessment

Proposals for nutrient mitigation schemes using drainage ditch management should follow the five stages detailed above. Each stage has specific information that is required for a proposal to provide confidence that it will deliver the nutrient mitigation potential estimated in Stage 1 of this Framework. Table 5 below can be used to collate the outcomes from the evaluation of each stage. Where all the information that is stated as required has been provided, proposals will have high confidence that the scheme will achieve its design objective and thus be able to claim the number of nutrient credits that the scheme is estimated to deliver. Proposals that have not provided all required information will either not be able to claim nutrient credits prior to deployment and monitoring or will have to address the missing information and be reassessed.

Table 5: Confidence assessment for determining whether a drainage ditch mitigation scheme can provide claim nutrient credits prior to deployment. Some cells in this table have been left blank for Framework users to complete.

Stage	All required information provided (Y/N)
1 – Design objective	
2 – Feasibility	
3 – Design process	
4 – Implementation plan	
5 – Post-implementation monitoring	
Required information provided for all stages – high confidence in proposal (Y/N)	

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Glossary

Nutrient neutrality: Within the hydrological catchments of Habitats Sites that are failing conservation objectives due to elevated nutrient concentration, nutrient neutrality is a requirement for new developments, especially those increasing overnight stays, to show they will not increase nutrient inputs to the Habitats Site.

Nature-based solutions: Using the power of nature to tackle societal issues by promoting better ecosystem functioning and improving biodiversity.

Catchment management: Also referred to as integrated catchment management, it is a framework for how to manage river catchment systems that considers the whole system and its interactions that combine to drive healthy terrestrial and riverine ecosystems.

BMP: Best Management Practice – a term used to describe catchment management approaches that can have benefit for river management.

Nutrients: Used to collectively describe nitrogen and phosphorus.

Diffuse source: A source of nutrients that is not directly inputted to a receiving waterbody, instead being transported to a waterbody via several potential pathways.

Point source: A source of nutrients that is directly input to a waterbody, such as from a pipe.

Baseline nutrient load input: The nutrient load input to a drainage ditch management scheme from diffuse and/or point sources.

Flood Zone: Areas around rivers classified by the Environment Agency into zones based on the probability of flooding.

Adaptive management: A management approach that does not prescribe management actions at fixed intervals or milestones but seeks to use monitoring to establish when and what management a scheme may be required.

Appendices

Appendix 1

Monitoring methodology to claim additional mitigation

As described in the ‘Monitoring to gain additional credits’ section, scheme owners may wish to use water quality and flow monitoring to assess whether a drainage ditch management scheme is outperforming the initial estimate of nutrient mitigation potential. The sections below detail a monitoring methodology that is the minimum requirement for monitoring to enable a scheme to claim additional nutrient credits. The methodology also includes recommendations for optional sampling approaches that will yield better data on scheme performance. It is possible that by applying the minimum monitoring requirements to put forward a claim for additional nutrient credits, the data collected may not be able to show a scheme is outperforming initial estimates with sufficient certainty. Thus, using the suggested optional sampling approaches may be an investment that will help to release additional nutrient credits from a scheme.

The following sections provide a breakdown of the parameters that need to be sampled, the sampling locations, the frequency and minimum duration of sampling, and the data analysis requirements.

Parameters for sampling

Sampling is required for both nutrient concentrations and flow. These parameters can be combined to calculate nutrient load. The following specific parameters are the minimum sampling requirement:

- Total nitrogen (TN; normally in units of mg/l)
- Total phosphorus (TP; normally in units of mg/l)
- Flow (normally in units of m^3/s)

Schemes in catchments where either nitrogen or phosphorus are the only nutrient of concern do not need to sample for both TN and TP, though it is recommended to sample for both parameters to help develop a better understanding of the efficacy of drainage ditch management schemes. Sampling for fractions of TN and TP is not required but is welcomed if studies wish to provide a more detailed analysis of nutrient dynamics. Similarly, sampling of other, non-nutrient water quality parameters is encouraged. The monitoring methodology should also provide a description of:

- How samples were collected.
- Any required sample preservation techniques, including cold transport of samples to a laboratory.

- The limits of detection for the analytical method being used at the laboratory analysing the samples.
- Any problems with sample preservation, transport and storage that may impact the accuracy of results (this is normally provided in lab reports).

Flow gauging should either use:

- The velocity-area method.
- A flow gauging instrument that provides a direct measurement of discharge.
- A continuous water level sensor combined with spot flow gauging to derive a stage-discharge relationship.

The monitoring methodology should provide a description of the approach taken to flow gauging.

Sampling locations

At a minimum, the monitoring methodology should incorporate an upstream-downstream sampling design. Water quality and flow samples should be taken at the upstream end of the managed section of channel, where water enters the scheme, and the downstream end, where water exits the managed section of channel. Sampling should be carried out upstream and downstream of the first and last low-grade weirs, respectively, and upstream/downstream of any vegetation that may influence results. The sampling locations should also be as close as possible to the upstream and downstream ends of the managed ditch, to minimise the impact of additional sources of water that are not treated by the scheme.

Additional sampling locations at intervals along the ditch are recommended but not required. These additional sampling points would help to understand how nutrient inputs and reductions vary along the length of the ditch.

If possible, monitoring methodologies should seek to also monitor a reference ditch that is hydrologically linked to the managed ditch but is not impacted by the management prescription. This reference site should be upstream within the ditch network and should be the same length as the managed length of ditch. This could be achieved by locating a third monitoring point further upstream from the ‘upstream’ monitoring point that is required as part of the monitoring methodology.

Sampling frequency and duration

As nutrients in agricultural catchments are predominantly mobilised during rainfall events, sampling is required to follow an event-based sampling design. Event-based sampling aims to capture nutrients in transport following rainfall events. Fixed frequency, low temporal resolution (e.g., monthly) sampling has the potential to miss nutrient transport events and thus not accurately represent how the scheme is performing. Where a managed drainage ditch does not flow year-round, event-based sampling will be a necessity. At a minimum, event-based sampling should capture samples:

- At least 8 times per year.
- For a minimum period of 3 years.
- With at least one event per meteorological season.
- For perennially flowing watercourses, one sample per year should be captured at baseflow (i.e., after a period of dry weather).
- Sampling should capture a range of rainfall event magnitudes.

While not essential, it is suggested that studies should analyse local rainfall datasets, if available, to determine different magnitude rainfall events to target. It is recognised that event-based monitoring can be logistically challenging. As such, an alternative approach would be to use high frequency, fixed interval monitoring. At a minimum, this would require:

- Weekly sampling.
- For a period of 3 years.

If possible, studies are encouraged to deploy continuous water quality and level sensors. These sensors are capable of recording data at sub-daily temporal resolutions (normally down to 15-minute intervals). It is currently cost-prohibitive to deploy continuous TN and TP sensors. Continuous sensors currently on the market for phosphorus generally monitor orthophosphate, while continuous nitrogen sensors can measure ammonia, nitrite and nitrate. As these inorganic nitrogen and phosphorus variables are components of TN and TP, it is suggested that studies employing continuous water quality monitoring also take spot samples of TN and TP. It may be possible to then derive a relationship between the continuous measurements of nitrogen and/or phosphorus variables and TN and/or TP. Calculating changes in nitrogen and phosphorus loads based on inorganic fractions of TN and TP is considered precautionary as it does not account for the particulate and organic components of TN and TP which are also likely to be reduced due to a scheme.

Continuous water quality monitoring should be combined with continuous water level sensing and the rating of the water level data series to create a stage-discharge relationship. This approach will enable a very high temporal resolution data series that will capture the full range of variability in nutrient load entering and exiting the managed drainage ditch. This in turn will provide the most comprehensive analysis of the performance of the scheme. It is recognised that at present, continuous water quality sensors are costly and thus may not be viable. They may also not be suitable for deployment in ephemeral watercourses.

Data analysis

For the purposes of claiming additional nutrient credits, analysis should be of the nutrient load at the upstream and downstream sampling points. Nutrient load is calculated as:

- Nutrient concentration x discharge

Where studies are using an event-based or weekly spot sampling strategy, the load should be converted to units of kg/day. The instantaneous measurements of nutrient concentration and discharge are taken as representative of the day of sampling, though it is recognised that this is an assumption that will be impacted by sub-daily fluctuations of both concentration and discharge.

Studies will need to calculate the average annual reduction in nutrient load due to the scheme. It should be shown that:

- The analysis incorporates statistical testing of the difference in nutrient load between the upstream and downstream monitoring points.

- That the difference between the nutrient loads at the upstream and downstream sampling points is statistically significant. Where statistical significance is not shown, more sampling and further statistical testing will be required.

- How data captured at the chosen sampling frequency have been converted to an annual average nutrient load reduction.

Where analysis shows that the reduction in nutrient loads due to the scheme is greater than the efficacy of the scheme estimated prior to deployment, this difference can be claimed as additional nutrient credits.

If studies are using continuous water quality and discharge data, they may wish to do more detailed analyses of sub-daily changes in nutrient load dynamics. There is also a greater probability that high frequency monitoring datasets will show statistically significant differences between the upstream and downstream sampling points, thus increasing the probability that additional credits can be claimed after the initial three-year monitoring period.

Where studies have also monitored a reference site, the analysis should consider whether the refence site suggests an unmanaged drainage ditch would already be providing some nutrient load reductions.

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