Information on How to Deliver and Assess Engineered Logjams for Nutrient Mitigation

Part 2 – Framework for Engineered Logjams

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Report details

Author(s)

Peggy Lloyd

Jenny Mant

Gabriel Connor-Streich

Natural England Project Manager

Helen Wake, Water Quality Senior Specialist, Chief Scientist's Directorate

Contractor

Ricardo Energy & Environment

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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 potentially could be used to reduce nutrients. Ricardo was commissioned by Natural England to understand the mechanisms of nutrient removal for the different solutions, the factors which affect this and review the evidence on the scale of nutrient reductions that they could achieve. This report sets out a framework for the design, implementation, monitoring and maintenance and how to determine scheme specific nutrient reductions for engineered logjam schemes that will provide sufficient scientific certainty in the assessment of nutrient neutrality mitigation schemes.

Executive summary

The objective of this project is to provide support to Natural England (NE) employees and those of other relevant organisations (such as Competent Authorities) to enable them to make informed judgements on engineered logjam (ELJ) proposals for nutrient mitigation. This report takes the form of a Framework, for the design, implementation, monitoring and maintenance and how to determine scheme specific nutrient reduction for engineered logjam schemes to achieve nutrient neutrality (NN). The project comprises three parts where:

- **Part 1** (the literature review) provides the evidence base on the effectiveness of four different NbS for nutrient mitigation including the methodology applied.
- **Part 2** (this document - The Framework) considers the design, implementation, monitoring and maintenance needs and how to determine a scheme specific nutrient reduction (where applicable). There are four framework documents, one for each of the four mitigation solutions considered in part 1.
- **Part 3** (the lookup tool – separate spreadsheet) comprises a user-friendly lookup tool with high-level practical information on a wider range of potential nutrient mitigation solutions.

This Framework specifically provides advice on achieving scientific certainty for ELJ schemes to achieve NN. Owing to the lack of data, nutrient credits can only be claimed post-implementation. Due to the short-term nature of the P removal processes within ELJ schemes, no credits can be claimed for P.

The Framework follows the following structure to provide a steer on what would provide greater confidence that any scheme would reduce nutrients and that this can be sufficiently evidenced to generate credits post implementation:

- Stage 1 – Design Objectives
- Stage 2 – Feasibility
- Stage 3 – Design Process
- Stage 4 – Implementation Process
- Stage 5 – Post-implementation Monitoring and Evaluation

As nutrient credits cannot be claimed upfront, this Framework outlines how to carry out baseline and post-implementation monitoring to claim credits once the scheme is functional.

Contents

1. Introduction

The overall objective of this project is to provide support to Natural England (NE) employees and those of other relevant organisations (such as Competent Authorities) to enable them to make informed judgements on Nature-based Solutions (NbS) proposals for nutrient mitigation. The overall project comprises 3 parts where:

- **Part 1** (the literature review – separate report) provides the evidence base on the effectiveness of four different NbS for nutrient mitigation;
- **Part 2** (this report known from now on as the **Framework**) considers the design, implementation, monitoring and maintenance needs and how to determine a scheme specific nutrient reduction. There are four framework documents one for each of the four mitigation solutions considered in **Part 1** (the literature review).
- **Part 3** (the lookup tool – separate excel tool) comprises a user-friendly lookup tool with high-level practical information on a wider range of potential nutrient mitigation solutions.

1.1. Framework objectives and aims

Key Aims:

Support NE staff to identify NbS for Nutrient Neutrality (NN) mitigation that are:

- Compliant with habitat regulations assessment (HRA) requirements and;
- Can achieve improvements to water quality, specifically through the reduction of nitrogen (N) and / or phosphorus (P) loading and;
- Have robust design, implementation, and monitoring and maintenance plans.

Part 2 (this document) provides the FRAMEWORK for engineered logjams (ELJ) which can be used in conjunction with the literature review in **Part 1** and also feeds into **Part 3** (the lookup tool).

The mitigation measures in this project were determined in **Part 1** (the literature review – separate report) and comprise:

- River channel re-naturalisation and floodplain reconnection;
- Engineered logjams;
- Buffer strips; and
- Agroforestry

For each mitigation measure, there is a separate Framework document. This Framework document advises on the ELJ mitigation measure and what is required to achieve scientific certainty for NN. It does not consider whether it is possible and how to achieve practical certainty that the measures can be secured.

This Framework sets out how to determine a scheme specific nutrient efficacy reduction through a combination of baseline and post-implementation monitoring as not enough evidence was found in **Part 1** (the literature review) to determine precautionary efficacy estimates without monitoring. Stages 1 to 5 (explained in Figure 1:1) of the framework set out what information needs to be provided to evidence that the scheme is appropriate for the location and all factors in the design, implementation and maintenance of the scheme have been considered to ensure that there is confidence the scheme will achieve the required nutrient reductions. Checklists are provided at the end of each section to help the assessment of whether all the required information has been provided.

Although this framework focuses on ELJs in the context of NN mitigation, there can be potential synergies between different mitigation solutions. Implementing a system of multiple NbS to achieve NN will provide greater nutrient reduction benefits through floodplain reconnection, reduced velocities, and increased contact time between nutrient rich flows and sediments to which they can bind. Capitalising on the synergies between NbS to achieve NN will allow for reduced nutrient loads from each scheme to be stacked together to achieve more nutrient credits than any one scheme would mitigate. The load reduction benefits of synergistic interactions between NbS would need to be addressed on a case-by-case basis for realistic credit generation. In addition, NbS have the potential to provide many wider benefits. These wider benefits are also considered as part of the feasibility process which may support other biodiversity and societal net gain ambitions as part of the planning process.

Part 3 (the lookup tool) when used in conjunction with this Framework enables assessment of appropriateness alongside a wider range of potential mitigation measures for a given scenario.

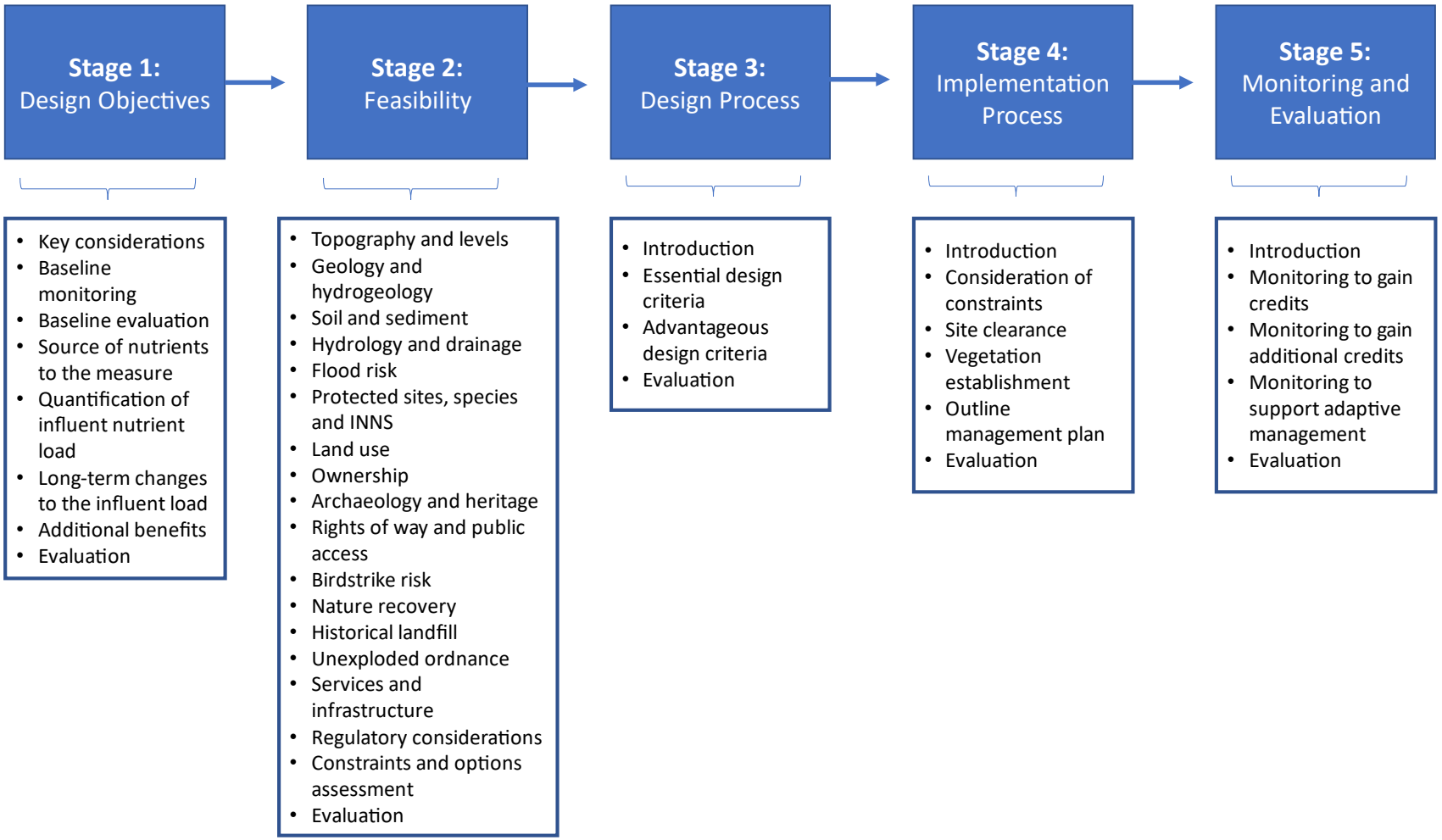

Figure 1:1 The outline structure for this framework*

*Note: the level of detail and key information categories may vary between mitigation options. A version of this figure for that can be used by screen-reading software has been included on the following page.

Stage 1: Design Objectives	Stage 2: Feasibility	Stage 3: Design Process	Stage 4: Implementation Process	Stage 5: Monitoring and Evaluation
- Key Considerations - Baseline monitoring - Baseline evaluation - Source of nutrients to measure - Quantification of influent nutrient load - Long-term changes to the influent load - Additional benefits - Evaluation	- Topography and levels - Geology and hydrogeology - Soil and sediment - Hydrology and drainage - Flood risk - Protected sites, species and INNS - Land use - Ownership - Archaeology and heritage - Rights of way and public access - Birdstrike risk - Nature recovery - Historical landfill - Unexploded ordnance - Services and infrastructure - Regulatory considerations - Constraints and options assessment - Evaluation	- Introduction - Essential design criteria - Advantageous design criteria - Evaluation	- Introduction - Consideration of constraints - Site clearance - Vegetation establishment - Outline management plan - Evaluation	- Introduction - Monitoring to gain credits - Monitoring to gain additional credits - Monitoring to support adaptive management - Evaluation

1.2. Limitations to this framework

This Framework focusses on the key considerations required for a NbS proposal to achieve suitable mitigation solutions. There are, however, limitations to its use as outlined below.

This framework relies on expert judgement related to mitigation applicability: Certainty of the efficacy of a solution beyond reasonable scientific doubt is essential even though absolute certainty is not required for a solution to be deemed suitable. Therefore, judgement over the efficacy needs to be based on a combination of the level of confidence in the data, the design, and the consistent use of precautionary input values. Judgement on a site-specific basis will be required since only a generic overview of the requirements for each mitigation scheme is provided in this Framework.

Uncertainty in quantity of nutrient mitigation for a given solution: This applies to solutions whereby percentage removal efficiencies cannot be applied to estimate nutrient load reductions before implementation. Some mitigation measures, such as ELJs, need to be deployed and monitored since predictions cannot be made in advance regarding the quantity of nutrient pollution reduction they will achieve. This limits their applicability as nutrient credits will only be provided once sufficient baseline and post-implementation monitoring has taken place.

Prescriptive monitoring: Given the uncertainties highlighted above, and potential variation of geological conditions and locations, any monitoring will need to be bespoke (based around specific criteria) and dependent on incoming nutrient loads. This Framework, therefore, emphasises the importance of showing the principles of a robust approach, without limiting the options of the provider.

Detailed engineering design: This Framework is limited to the use of ELJs for nutrient mitigation and considering at a high level the key design, implementation, monitoring and maintenance requirements of any scheme to ensure there is confidence any scheme will provide the proposed efficacy reduction relative to baseline environmental conditions. This Framework is not intended to provide detailed engineering advice on how to implement a NbS. This will need to be sought separately although this guidance provides the list of expected outputs.

2. Determining scheme specific efficacy

This section sets out how to determine a scheme specific efficacy using the results of baseline and post-implementation monitoring and undertaking a confidence assessment looking at key design criteria and the calculation of the baseline load.

2.1. Maximum efficacy reductions

A review of studies was conducted on the efficacy of ELJ schemes within **Part 1** (the literature review). Owing to the lack of data available, precautionary estimates of the quantity of N removal that can be achieved could not be determined. Additionally, it is not possible to promote these schemes as P removal solutions due to the short-term nature of the P removal processes. As such, to be able to utilise ELJs as a mitigation scheme for N, robust baseline and post-implementation water quality and velocity monitoring is required to calculate the credits available on a scheme-specific basis.

2.2. Calculating the baseline load

A good baseline of key environmental variables is needed to robustly calculate the baseline load. This is especially important related to NN, in the context of demonstrating beyond reasonable scientific doubt that the reductions will be achieved in perpetuity in line with the Habitats Regulations requirements. Without a robust baseline it will be difficult to demonstrate the benefits that a scheme provides.

Three variables need careful consideration when calculating the scheme baseline nutrient loading as indicated in Figure 2:1. With a strong understanding of these and a robust baseline monitoring method, the baseline nutrient load can be calculated.

Figure 2:1 Key variables requiring consideration to when defining appropriate design objectives

To fully understand the three variables outlined above, a robust baseline assessment method is required. Baseline assessment characterises the nutrient load within the receiving environment prior to implementation of the ELJ scheme. This provides the loading value which the results of post-implementation monitoring can be compared to in order to demonstrate credit generation. This can be done via scheme specific monitoring

or using secondary datasets[1] (i.e. data that has been collected for another purpose), (see more detail in section 3.2.2). The means by which nutrient loads are characterised and the confidence the approach will have will differ between each scheme, however the broad requirements are uniform. These are as follows:

- Quantification of the water quality and quantity that will enter the mitigation scheme. This must account for groundwater, subsurface and surface flow pathways, where required.
- **If undertaking scheme specific monitoring:** Review of evidence in **Part 1** (the literature review) indicates that a minimum of a year's baseline monitoring is necessary to confidently quantify credits that can be gained from the mitigation scheme to provide a strong understanding of nutrient cycling in the system. The length of the dataset needs to be long and frequent enough to cover the full range of likely flow and water quality conditions, which could vary spatially and temporally. The programme should aim to capture nutrient loads in the receiving environment following different magnitude rainfall / flow events. This may require a reactive sampling programme. The monitoring must account for the time lag between events that mobilise nutrients and the point at which they can be monitored in flows. The location(s) of the sampling point(s) needs to be representative of what will enter the mitigation scheme and therefore needs to be upstream and ideally close to the scheme or at least where there will be no significant additional inputs (flow or concentration) before the scheme. Whether one or multiple locations need to be monitored will depend on the type of scheme and the likely spatial variability of the flows / concentrations into the scheme. To calculate the baseline load, take a mean of the values of the flow and concentration to estimate the load of nutrients in kg / year. This approach is the minimum required.
- **If using secondary datasets (i.e. monitoring data that was collected for another purpose):** If a robust dataset already exists that can be used to quantify the baseline nutrient load entering a mitigation scheme based on the requirements detailed above, this can be used. Where secondary datasets are used, they should meet the same requirements as set out above for scheme specific monitoring on the length and frequency of the dataset, range of flow conditions and location of sampling. The use of secondary datasets will require justification to ensure that is it robust and adequately representative for determining the load into the mitigation scheme as well as documentation that details the sampling methodology, location, frequency, and duration of the sampling programme. The baseline load should be calculated in the same way as set out above for scheme specific monitoring.

Further details on baseline monitoring requirements can be found in section 3.2.2

[1] Whilst it is recognised that modelling to predict to flow rates and nutrient concentrations is possible, this would require a complex set of linked modelling approaches that account for sediment transportation and deposition modelling, amongst other variables, which is costly, time consuming, and requires extensive primary data.

2.3. Confidence assessment

A specific scheme load reduction for N can only be determined through robust baseline and post-implementation monitoring for ELJ schemes. The confidence in the load reduction calculated is dependent on the scheme being designed robustly and the baseline load being accurate. Overestimation of the baseline load will lead to an overestimation of the likely load reduction the scheme will achieve. Table 2:1 enables a confidence assessment to be undertaken on each of the key elements from the rest of the framework which will determine whether or not the baseline load has been robustly calculated. If it has been, there will be confidence in the baseline load used to calculate the nutrient reduction post implementation. Whilst filling out this table it should be noted that:

- The result (high, medium, or low) of each question's answer will help to determine whether or not N credits can be claimed post-implementation.
- Based on the criteria specified for each question, the relevant boxes should be ticked.

The key questions need to be considered at the scheme idea stage to provide upfront clarity of the requirements and to encourage consideration at an early stage of the best practices.

The requirements in Section 3.4.2 must also be considered to enable a confidence assessment of the scheme's design. The result of each question will impact the overall confidence rating of the scheme as the results inform the answers to Table 2:1

Table 2:1 Confidence assessment

	High	Medium	Low
Have you accounted for all sources of water / nutrients in your monitoring approach to calculating baseline loads?	Yes, all sources – groundwater, surface water, rainfall, point sources, etc. No – but the way it is considered is more precautionary in the context it is used	Most of the sources considered – those not considered are likely to be minor.	Only some sources considered and not considered some which could be significant source OR don't know as insufficient information has been presented.
Has the baseline load entering the scheme been accurately determined?	Yes – Any flow bypassing the scheme has been removed. For schemes which have spatially diffuse inflow (rather than one single inflow) this has been robustly characterised. The location of any monitoring points are representative of the flow and concentration entering the scheme.	The vast majority of load has been accounted for. Any flow bypassing the scheme has been removed. The location of any monitoring points means that any load inputs that are missed are minor.	No there is significant uncertainty in how it has been determined including: No consideration as to whether any flow bypasses the scheme OR If using monitoring data, there are additional significant load inputs that have not taken into account due to the location of monitoring points.
Does the baseline load calculation take account of the temporal	There is a robust estimate of temporal variability both seasonally and annually.	Not all temporal variability is accounted for, however evidence is provided that the methodology takes account of the majority of	There has been no consideration of seasonal or annual variability in flow or concentration.

	High	Medium	Low
variability including seasonality?	Monitoring data is for over a year, at a frequency which captures seasonality and different magnitude rainfall / flow events.	the seasonal and annual variability and takes into account the worst-case situations[2].	
Have you taken account of any known anticipated future long term changes in baseline load e.g. due to climate change or existing planned development/activities?	Yes – everything relevant considered and the assessment has been undertaken in a robust way applying precautionary assumptions.	N/A	There has been no consideration of known anticipated future long-term changes OR precautionary assumptions have not been used.
Is the appropriate form of N considered[3]?	Yes OR	N/A	No and the form considered is less precautionary in the context it is used.

[2] In this context, worst-case refers to scenarios where the conditions support low nutrient removal compared to the year-round average. It is not acceptable to look only at the data showing the best-case scenario for nutrient credit generation.

[3] Total nitrogen (TN) should be considered for ELJs to account for all forms of N within the system.

	High	Medium	Low
	No – but the form considered is more precautionary in the context it is used.		
Is the baseline assessment method appropriate to the scheme type?	Yes – monitoring carried out in line with the requirements in Section 3.2.2.	N/A	No – approach used is unjustified with insufficient information. For example, an unjustified modelling approach is used, or monitoring does not meet the requirements of Section 3.2.2.
Have the key design criteria been considered in Section 3.4.2?	Yes – evidence has been provided that the Conceptual Design Guidelines have been consulted and included in the design process.	N/A	No – there little or no evidence that the Conceptual Design Guidelines have been consulted and included in the design process.
Is there is robust maintenance plan?	Yes – there is a detailed maintenance plan covering all maintenance requirements for the lifetime of the scheme.	N/A	No – schemes should not be agreed without detailed maintenance plans.

After answering all questions in Table 2:1, the following criteria must be considered to enable a confidence assessment of the scheme:

- If **any** answer low, the scheme design and baseline monitoring method are not robust enough to be able to generate any credits through post-implementation monitoring
- If **all** answers medium and high, the scheme design and baseline monitoring method are robust enough to endeavour to claim credits through post-implementation monitoring

Considering how any scheme will deliver against the confidence assessment throughout its development and particularly at the start, will ensure it can be designed in a way to maximise or optimise the credits that may be generates post implementation verses the costs and taking account of any constraints.

It should be noted that once credits can be claimed via post implementation monitoring, adaptive monitoring will still be required to inform any maintenance to ensure that the scheme continues providing nutrient mitigation in perpetuity (or if using as a temporary measure for as long as the scheme is required). Adaptive management monitoring should focus on scheme function.

2.4. Calculating scheme specific load reductions

Owing to the lack of data collected in **Part 1** (the literature review), ELJ schemes cannot claim any N credits upfront and these schemes cannot be suggested for long term P removal. In the instance of heavy flooding, it is likely that the sediment bound P is remobilised back into the system. There are no design criteria which can ensure that this will not happen. As such, ELJs can be suggested as mitigation solutions for N, but not P. In order to calculate scheme specific load reductions for N, baseline and post-implementation monitoring must be carried out as per the guidelines in Section 2.2 and Section 3.6.2.

3. Framework for Engineered logjams

3.1. Key considerations

ELJs are a bio-mimicry technique which aim to emulate the natural conditions of the environment through the implementation of a series of 'leaky dams' placed across a stretch of river. Nutrient mitigation is achieved by causing long term changes to river hydro-morphology and reducing the associated nutrient loading of the downstream river channel. ELJ systems temporarily store water within the stream channel upstream, reducing flow velocities and enhancing transient storage of sediments and nutrients. These ELJs consist of the introduction of large woody debris such as logs, branches, or debris such as accumulated fresh or decomposed organic matter. Introducing woody debris in-stream increases stream heterogeneity encouraging areas of upwelling and downwelling with associated nutrients reduction benefits.

Due to the short-term nature of the P removal processes enforced by ELJ systems (sediment deposition and sorption to organic matter), these schemes cannot be deemed as long-term solutions able to achieve NN in P affected catchments. To gain N credits from these schemes, baseline and post-implementation monitoring is required as there is not enough data regarding N removal efficiencies of similar schemes to be able to calculate upfront efficacy values. As such, credits will be awarded on a case-by-case basis, dependent on the results of post-implementation monitoring.

Implementation of ELJs may not be suitable for deployment in all locations throughout a river catchment and there are certain key considerations that might indicate that proposed locations are not viable and / or need more investigation to increase the confidence of success. A checklist for these is provided below. If not enough evidence can be provided to answer any of the questions, the scheme must be further reviewed prior to proceeding in order to improve the chances of gaining credits.

Headline Messages:

- Implementing ELJ systems to achieve NN may not be suitable for deployment in all locations and only appropriate for N and not P.
- Key considerations can help identify where a proposal may not be viable and/or needs more investigation to increase confidence of success noting that evidence is required to demonstrate a favourable NN outcome.
- If sufficient evidence related to the point above is not provided, further information will need to be requested and reviewed.

A checklist for these points is provided below.

If there is insufficient data to answer any of the following questions suitably, then the proposal is unsuitable as a NN mitigation measure and will either need to be redesigned or

will not be viable in the proposed location. This, however, is not to say that it will not be suitable to provide other benefits, outside of the scope of nutrient removal.

Mitigation schemes may not be suitable for deployment in all locations within a given catchment and there are certain key considerations that might indicate proposed options are not viable. A summary of the key upfront considerations that should be considered in the first stages of planning for an ELJ scheme is provided in the checklist below.

Table 3:1 Key considerations checklist

Key consideration	Evidence to be provided	Evidence provided (Y/N)
The Local Planning Authority has confirmed that it is possible to secure the mitigation.	A nutrient mitigation scheme needs to have practical certainty that can be secured and will provide the mitigation for the lifetime of the development or if being used as a temporary measure for the length of time that the mitigation is required. It may not be possible in all cases to adequately secure that the mitigation will continue to provide the reduction for the required length of time. Mitigation proposals should demonstrate engagement with the Local Planning Authority to ensure schemes can be sufficiently secured and there is certainty that they will provide the required reductions for the length of time the mitigation is required.	
That the proposed ELJ will not have an adverse impact on or hinder restoration of any protected sites or species or negatively affect existing habitats, or the ability to achieve other environmental objectives due to associated morphological change.	An evidence statement will be required. If adverse impacts are identified, the scheme will need to be reviewed/changed noting that all ELJ schemes will be subject to ecological survey prior to implementation.	

Key consideration	Evidence to be provided	Evidence provided (Y/N)
There is sufficient hyporheic exchange[4] present in the water course to support nutrient removal processes.	The proposal will need to clearly show that it has considered the hyporheic zone availability noting that the zone thickness affects the ability to support NN and is dependent on geology, soils, and hydrogeology (e.g. clay-bed water courses generally have limited hyporheic zones).	
There are no land constraints.	Key examples include landowner agreement to alter current planform of a water course, connection to the floodplain, and proximity to infrastructure. These should be reviewed due to flood risk concerns or the potential impact to current habitats due to local potential ponding of water.	
There is sufficient and robust baseline data to calculate the baseline load?	Account for what data exists. Where insufficient, further data collection may be required prior to implementing a project. This may delay development.	
The Local Planning Authority has been engaged to ensure the mitigation will serve developments impacted by NN?	Nutrient mitigation schemes must remove at least the equivalent quantity of nutrients than what will be added by new development before impact on a Habitats site waterbody takes effect. The mitigation measure will need to be upstream of the location where the development site run off and wastewater input will have its effect on the Habitats site. This means if the wastewater/run off is direct to (i.e. within) the Habitats site boundary the measures will need to be upstream of this location. If the discharge is indirect i.e.	

[4] The rapid exchange beneath streams where constant mixing occurs between shallow groundwater and stream water. Water, dissolved gases, solutes, contaminants, and microorganisms are exchanged. This can support nutrient removal processes.

Key consideration	Evidence to be provided	Evidence provided (Y/N)
	upstream in the catchment of the Habitat site, then the mitigation measures can be up or downstream within the catchment, as long as it will provide the offsetting before the point at which the development impacts the Habitat site. Mitigation proposals should demonstrate engagement with the Local Planning Authority to ensure schemes will provide sufficient NN.	
There are no insurmountable reasons why any required permissions or consents would not be granted.	Proposal should show that the relevant competent authority (e.g. Environment Agency) has been consulted from an early stage to ensure there are no evident or insurmountable concerns early on. This approach can also mitigate any potential risks regarding consents and permissions.	

3.2. Stage 1 – Design Objectives

3.2.1. Introduction and objective setting

The implementation of ELJs aims to increase the heterogeneity of the river channel to allow for the formation of natural forms and habitats. This helps to reduce the velocity of the river whilst increasing lateral connectivity and inundation to support ecological regeneration.

To implement ELJs as a mitigation scheme, clearly defined objectives are required and must be set early in the process. In the context of NN, these objectives relate to water quality parameters, such as reducing nutrient loading. There may be other considerations within the design objectives which relate to providing wider benefits to the ecosystem especially related to enhancing biodiversity. When setting objectives, a good baseline of key environmental variables is needed. This is essential to enable demonstration of benefits through post-project monitoring. This is especially important related to NN particularly in the context of demonstrating beyond reasonable scientific doubt that the reductions will be achieved in perpetuity, in line with the Habitats Regulations requirements. Without a robust baseline it will be difficult to demonstrate scheme benefits. Setting clear primary and secondary objectives alongside associated mitigation scheme options is therefore important to state early in the process. For example, a primary objective may be related to N, P or indeed both pollutants with secondary objectives/ambitions related to a combination of hazard risk reduction (e.g. flood and drought), ecological (e.g., habitats for fish, aquatic inverts, mammals etc), and societal benefits (well-being etc).

Key Headline Messages:

Defining appropriate objectives to support NN requires initial understanding key factors including:

- Knowledge of the sources of water entering the scheme;
- Knowledge of the concentration of nutrients in the inflowing water;
- The overall quantity of water flowing into the mitigation scheme;
- Predicting how concentrations and flows might fluctuate over time; and
- The level of confidence there is in the understanding of these factors.

For the design objectives to be robust enough to meet the Habitat Regulations requirements, sufficient evidence and information needs to be provided for each of the above.

The following sections 3.2.2 - 3.2.7 need to be evaluated in this context

3.2.2. Has a robust baseline monitoring method been employed to inform scheme efficacy?

Key questions

- **Why is baseline monitoring required?** To fully understand the three variables outlined in Figure 2:1, a robust baseline monitoring method is required. The output provides the baseline loading value against which post-implementation monitoring will be compared to gain credits. Due to the current uncertainty this is the only way

to establish the degree of benefit and allow for better future estimates of percentage efficiency. This can be done via physical monitoring or using secondary datasets.

- **What is baseline monitoring?** Baseline monitoring characterises the nutrient load within the receiving environment prior to implementation. Nutrient concentration and flow rate upstream and downstream of the site where the ELJ is being deployed together with morphological (cross and planform) and sediment movement is essential as a minimum[5]. Implementation of continuous nutrient sensors (if available) used in conjunction with calibrated level sensors to provide ongoing monitoring of concentrations and discharge with minimal fieldwork requirements could be considered. The monitoring must account for the time lag between events that mobilise nutrients and the point at which they can be monitored in flows.
- **How long is baseline monitoring required for?** Baseline monitoring should be conducted for at least year with a minimum of monthly sampling to characterise nutrient loads under all seasonal conditions which affect nutrient cycling within the environment. In addition, because the source of nutrients is mainly driven by rainfall, monitoring should also capture nutrient loads in the receiving environment following different magnitude rainfall / river flow events and different time periods/seasons to take account of any application of nutrients to agricultural land. This will require the monitoring approach to have a degree of reactiveness to accurately understand the effect of different flow conditions and impacts on nutrient transport.
- **Where should baseline monitoring take place?** The aim of baseline monitoring is to robustly characterise the nutrient dynamics within the system. To successfully do this, the locations at which upstream and downstream measurements should take place need to be identified on a project-specific basis. There are, however, guidelines which must be followed. The upstream monitoring point must be upstream of the proposed ELJ location but downstream of any features which are likely to impact nutrient loads, such as point sources of pollution and confluences of tributaries. Similarly, if required, the downstream monitoring point must be downstream of the reach identified for an ELJ scheme, but upstream of features likely to impact nutrient loads[6]. Based on these requirements, it is up to the individual to identify the best locations for monitoring to characterise the nutrient removal potential of the scheme. The closer the monitoring is to the scheme, the more robust and greater confidence there will be that any reductions are due to the scheme and therefore credits can be generated.

[5] Fixed point photography at strategic location should be provided as a minimum to identify morphological and habitat changes. The use of Morph surveys is also highly recommended.

[6] Implementation of level sensors and / or continuous N sensors could be considered to provide a better long-term understanding of the flow, discharge, and concentrations.

- **Can secondary data be used for baseline monitoring?** It is recommended that open-source information is used first to establish if sufficient information is available. If field data already exists, a baseline dataset covering as long as possible and as big a range of rainfall / river flow conditions as possible can be considered. The locations of the monitoring points must still conform to the above requirements outlined for baseline monitoring. Secondary datasets will require documentation that details the sampling methodology, location, frequency, and duration of the sampling programme to determine if any supplementary monitoring is needed. The overarching requirements determining the suitability of a secondary dataset are the same as the requirements outlined for baseline monitoring (e.g. length of sampling, locations, etc.).
- **Have suitably precautionary values from the data been used?** The collected data must be considered wholistically, with specific reference to the most precautionary scenarios which have been characterised. It is not acceptable to look only at the data showing the best-case scenario for nutrient credit generation.
- **What should happen to the monitoring data?** This should be decided and agreed at the beginning of the monitoring programme including approached to assess data. It is likely to be of interest to LPAs, Natural England and other third-party stakeholders (e.g. local catchment groups and academics). Building a supporting open-source database including the efficacy rates will be highly beneficial for future programmes.

Key information required

- A baseline monitoring plan detailing monitoring methods, sampling locations, monitoring frequency and the duration of the monitoring programme. This may take the form of documentation supporting an existing monitoring programme using for example The River Restoration Centre Monitoring Planner[7].
- Clear methodology explaining how the assessments have been completed. The method must provide confidence of assessment and demonstrate it has considered the hydrogeology especially in the context of ground water versus surface water catchments. Refer to open-source information first and present this with justification of the sources used. Additional field work required only when uncertainty is deemed unacceptably high.
- **Optional:** A plan detailing how data from baseline monitoring will be made available to stakeholders.
- **If using secondary data:** An evaluation evidencing that the chosen dataset is sufficiently appropriate

[7] See: Monitoring Planner | The RRC

3.2.3. Has the source of nutrients to the measure been clearly defined

Key questions

- **Do you have a strong understanding of the number of sources of water to the water course?** Water within the channel of a river can come from a variety of sources (e.g. channel flow, groundwater, springs, agricultural runoff, and treated effluent from wastewater treatment works etc.). To robustly estimate the load of nutrients into a scheme, all sources of water, and subsequently nutrients, must be characterised and understood. This will help understand the likely spatial and temporal variation and therefore where monitoring should take place and what temporal resolution of monitoring may be appropriate.
- **Do you have a clear picture of where the nutrients will be entering the water course?** This is important to understand as it will directly determine potential project location and success (e.g. upstream or within the middle of the reach designated for a series of ELJs).
- **What is the concentration of nutrients in the river?** The concentration of nutrients in river flows will influence the location of the proposed scheme but may not greatly impact the design. Nutrient removal processes generally operate better at higher concentrations. There is likely to be a minimum concentration whereby ELJs will not provide any nutrient reduction benefit; however this is highly dependent upon the scheme's design and location, therefore it is recommended that this is considered on a site-specific basis.
- **Has a detailed condition assessment of the receiving waterbody been completed?** In general terms, demonstrating consideration of areas that are not in good status and ideally poor status is likely to provide an opportunity for greatest mitigation. Assessment should also look at waterbodies upstream of a proposed mitigation scheme to establish any level of nutrient input that may be associated with these areas that will affect the baseline.

Key information required

- Maps showing nutrient point sources and where they are/will be entering the water course.
- Detailed condition assessment of water course related to the proposed mitigation.

3.2.4. Has any allowance been made for long-term changes to the influent nutrient load

Key questions

- **Has climate change impact been considered in terms of the potential impacts on influent nutrient loads?** This could have a future impact on the efficiency of a series of ELJs for mitigating nutrient pollution in the future. At this stage it is

recommended that key open-source data is reviewed to ascertain long term local predicted trends[8].

- **Have planned improvements been considered in terms of the potential impacts on influent nutrient loads?** Already planned improvements at WwTW for example, could have a future impact on the efficiency of an ELJ scheme at mitigating nutrient pollution due to decreased loading into the scheme. A HRA would only require an allowance for changes that are known at the time of the assessment, therefore all improvements that have been secured at this stage need to be considered.
- **Are there any known site-specific land use changes that may affect long-term nutrient impacts?** An evidence log is required to understand if any currently planned changes will result in either increasing or decreasing loads.
- **How should long-term changes in influent nutrient loads be acknowledged?** Mitigation proposals will need to incorporate known long-term increases or decreases in influent nutrient loads e.g. due to climate change or already planned land use change, and the impact this might have on the amount of nutrient mitigation an ELJ will deliver in perpetuity.

Key information required

- Summary statement outlining all planned improvements within the catchment, with reference to the impacts these are likely to have.
- Evidence that the impacts of climate change have been accounted for.
- Statement of any known land use changes and potential effect (positive and negative).

3.2.5. How are credits calculated?

Key questions

- **When can N credits be calculated?** To be able to utilise ELJs as a mitigation scheme for N, credits can be calculated after a minimum of a year of baseline monitoring to account for all seasonal variability and monitoring for a minimum of three years post-implementation, or once a quasi-equilibrium i.e. stable reduction can be evidenced. No credits can be generated for P.
- **How is the generation of credits calculated?** To calculate the quantity of N credits that can be claimed by the mitigation scheme, a nutrient concentration and river flow trend analysis is recommended to provide a strong understanding of nutrient cycling in the system where the trend analysis will need to take account of

[8] To account for climate change, see: Product Selection - UKCP (metoffice.gov.uk). Search for the relevant area to determine the environmental impact of climate change on rainfall, and therefore influent nutrient concentrations. Use this to support research.

time lags between nutrient mobilisation and the point at which the nutrients can be monitored within the channel. To achieve this will require monitoring of a range of flow / concentration conditions with the aim of characterising nutrient trends.

The most applicable statistical test based on the extent of data will need to be used to carry out the trend analysis. This approach increases the understanding of local variation and helps to explain any outliers. To achieve this will require monitoring of a range of flow / concentration conditions with the aim of characterising nutrient trends. For more information see Section 2.4.

Key information required

- Evidence of a sound methodology including the calculations and justifications for the method used.
- The load of TN in kg / year which can be mitigated against by the scheme.

3.2.6. What additional benefits can be delivered through the design objectives?[9]

Key questions

- **Have wider benefits to the environment and society been considered?** ELJs may provide wider benefits than water quality, including for example, habitat resilience especially under drought conditions for a range of species, recreation enhance especially related to angling and carbon sequestration. Outside of the scope of NN, these benefits are often simplistically restricted to a small subset of values such as biodiversity net gain, natural flood management and carbon sequestration. Every scheme provides the opportunity for wider benefits via the encouragement of ecosystem services.
- **Have wider benefits been considered in the context of biodiversity net gain, natural and societal capital?** Whilst mitigation should firstly focus on NN benefits and meeting the needs of Habitat Regulation, understanding how any mitigation can support wider development requirements to support regulatory biodiversity net gain (BNG) and associated Natural Capital parameter is valuable. This understanding will help to establish how different ways of packaging multiple ecosystem goods and services can incentivise conservation-based funding support for the proposed mitigation (i.e. support stacking and bundling concepts) and avoid undervaluing nature.

[9] Whilst wider benefits assessment is out of the direct scope of NN it is highly recommended that this assessment is included since planning does require assessment of biodiversity net gain and wider net zero opportunities (e.g. carbon sequestration) whilst opportunities for natural flood and drought management and resilience can support local ambitions.

Key information required

- Consideration should be given to the potential for ELJ schemes to provide wider benefits to the local, and wider, community such as amenity value, pollination, job creation, food supply, and local climate regulation.
- An ecosystem services assessment of all available wider benefits can be carried out to support the proposal. This should seek to link the benefits to the beneficiaries, focussing predominantly on wider values at this stage. A simple assessment based on a high-level RAG assessment would be acceptable at this stage.

3.2.7. Evaluation of design objectives

For the design objectives to be robust enough to meet the requirements of the Habitat Regulations, the key evidence and information required must be provided for each of the categories in Stage 1 – Design Objectives. If any information is missing or the information provided is not commensurate with the obligations of the Habitat Regulations, the objectives must be re-considered to meet the mandatory criterion for NN mitigation.

The series of questions within the confidence assessment outline the stages required to be able to evidence that the design objectives and baseline monitoring method for an ELJ scheme are robust (Section 2.3). Table 2:1 should be completed to provide verification that likely nutrient loads entering the channel have been robustly estimated. As there are no efficacy values for ELJ schemes, the design must at least meet the minimum requirements of these tables.

To establish the strength of the design, the tables below can be used in conjunction with Table 2:1 In Section 2.3.

Report Section	Comment	All information has been provided in the relevant format (mapped, tabular, or summary)	There are gaps in the information provided
3.2.2	Baseline monitoring method		
3.2.3	Source of nutrients to the measure		
3.2.4	Allowance for long-term changes		
3.2.5	Credit calculation		
3.2.6	Additional benefits		

	Response statements
If ALL green (noting that 3.2.6 is optional)	This is a well-structured feasibility assessment that maximises the likelihood that this ELJ scheme will be a sustainable natural asset within this catchment.
If SOME red	The application is missing mandatory feasibility information, as shown by the rows populating the red column. Please provide this information so that the feasibility assessment can be evaluated.

3.3. Stage 2 – Feasibility

3.3.1. Introduction

There is currently uncertainty in terms of the level of NN benefit related to implementing series of ELJs along a river channel, although **Part 1** (the literature review) does indicate N reduction benefits for this type of scheme will occur. The sub-sections below detail the key factors that will impact of the feasibility of a proposed solution. For most of these factors, there will be options to mitigate potential constraints on feasibility. To increase the likelihood of nutrient removal success and to prevent implementation delays, an ELJ scheme must show how constraints on feasibility have been mitigated. As such, accounting for the details outlined within the subsections below will provide a stronger understanding of the environment and hence increase level of certainty of success and post-project monitoring requirements for demonstration of that success.

There are some circumstances where evidence to show feasibility is not required but is strongly recommended. These areas are highlighted in the text alongside areas where optional information 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.

3.3.2. Topography and levels

Key questions

- **Will the nutrient rich water flow towards the proposed ELJ?** The topography of the site needs to be understood prior to implementing a series of ELJs. Consideration needs to be given to the topography surrounding the source of

nutrient to ensure nutrient rich water will flow towards the restored reach, ideally under gravity[10].

- **Has local topography been looked at in terms of where the proposed mitigation is being considered?** To achieve optimum success, an ELJ will need to be carefully designed. Understanding the local topography both related to the channel and the surrounding land is essential to understand the best placement of ELJs within a catchment. The topography should also be considered in terms of stability of design, and potential flood risk or flood water level rises which could affect existing habitat. This data should be linked to flow data and sediment dynamics to understand the physical process present to support nutrient reduction.[11]
- **Is there an understanding of where an ELJ would be best placed (depth, width, planform and location)?** Ideally this would require a topographic survey but at this stage of feasibility could comprise a walk over survey. The current flow regimes should be evaluated and understood to inform the placement and design of the ELJ to ensure increased physical complexity of the riverbed stream and achieve increased hyporheic retention time. This must consider the location related to the nutrient source, but also the key topographic considerations. See The Conceptual Design Guidelines[12] for ELJ's for more information regarding where an ELJ would be best placed.

Key information required

- Map of proposed scheme with reference to the location within the catchment and source of nutrients. Pathways should be mapped with nutrient levels. Poor design and consideration of topography could reduce the lateral residence time of water. This will compromise treatment efficiency.

3.3.3. Geology and hydrogeology

Key questions

- **What is the site geology?** This is important because it provides the parent material for the soil and determines the vulnerability of any associated groundwater impacts related to water quality. It also helps to predict the likelihood of channel bed

[10] Note: using LiDAR data online maps may help to support this initial assessment together with OS contour and spot heights

[11] Note: understanding the topography is essential to good design since this relates lateral residence time of water which affects treatment efficiency.

[12] See: WAT-SG-37 (sepa.org.uk)

scour (i.e. geology permeability). Parent materials which equip the subsequently derived soils with characteristics supporting hyporheic exchange[13] are favourable.

- **Are any aquifers present which may result in upward discharge in the floodplain?** Under this scenario it is likely that the concentration of nutrients would reduce in subsurface flows, hence reducing the nutrient removal efficiency of any associated floodplain soils. The opposite is also possible if subsurface flows have high N or P concentrations. Monitoring locations therefore need to consider possible locations of springs in the channel.

Key information required

- A map of the expected geology beneath and in close proximity to the proposed mitigation site. This is likely to be highly indicative at this stage and based on open-source data.
- An assessment of the potential issues that may be caused by the catchment hydrogeology.

3.3.4. Soil and sediment

Key questions

- **What is the composition?** This will affect the nutrient removal capacities of hyporheic and floodplain soils since this affects nutrient removal capacity. Sandy soils, for example, have high infiltration capacity but much lower nutrient removal potential than clay soils.
- **What is the likely soil mobilisation during construction?** Nutrients from riparian and benthic soils may be mobilised by excavation and lost to the wider environment. This is likely to be a temporary issue but should be accounted for in the design process which will require mitigation.

Key information required

- A map of the expected sediment type or types for the designated reach and an overview of associated hydraulic properties.
- An analysis of the suitability of the local soil type for a nutrient removal scheme in the context of an ELJ (e.g. permeable soils (sandy and high gravel content) are more likely to reduce effectiveness related to nutrient reduction).

[13] The rapid exchange beneath streams where constant mixing occurs between shallow groundwater and stream water. Water, dissolved gases, solutes, contaminants, and microorganisms are exchanged. This can support nutrient removal processes.

3.3.5. Hydrology and drainage

Key questions

- **Will the mitigation allow for better connectivity with the water table?** This will be determined by the local topography (see section 3.3.2) and the proposed location of the mitigation, noting that longer channel resistance times increases the hyporheic exchange leading to greater successful removal of nutrients.
- **Have likely trends of lateral connectivity and periodic inundation been considered?** Regular wetting and drying of floodplains is a key factor promoting nutrient uptake. This sequencing is required to promote oxic and anoxic conditions, both of which are required to support denitrification[14]. This is dependent on the drainage and the underlying water table: if the water table is too high or too low in reference to the floodplain, the hydrological conditions of the system will either be consistently saturated or dry. Changes in this lateral connectivity related to ELJs may be beneficial in this context.

Key information required

- The expected lateral inundation should be characterised to ensure that it occurs periodically so as to not compromise the suitability of the design. Data from local gauging stations, predictions based on the flood estimation handbook[15] or the Institute of Hydrology report for small catchments[16] will support this.

3.3.6. Flood risk and floodplain reconnection

Key questions

- **Is there any infrastructure close to the proposed mitigation site?** Increasing lateral connectivity via the implementation of ELJ schemes is likely to increase flooding locally (extent and levels). If any local infrastructure has the potential to be affected a flood risk assessment (FRA)[17] would be required.
- **Have flood risk benefits been identified?** Re-naturalisation of a water course via introducing a series of ELJs can slow the flow locally which can in turn support flood

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[14] The primary forms of N from wastewater are nitrate and ammonia. To cycle ammonia to nitrate (as is required prior to denitrification), oxic conditions are required. The primary forms of N from agriculture are nitrate and ammonium (which also requires oxic conditions to be nitrified into nitrate). Denitrification (the process of cycling nitrate into gaseous forms of N) requires anoxic conditions. Where only anoxic conditions are present, the denitrification process to remove N from the system is limited to nitrate inputs only.

[15] See: Flood Estimation Handbook and Flood Studies Report | UK Centre for Ecology & Hydrology

[16] See: Report No.124 Flood Estimation for small catchments | Institute of Hydrology

[17] See: Flood risk assessments if you're applying for planning permission - GOV.UK

mitigation downstream. Reconnection to local floodplains can be beneficial but the impacts must be identified.

- **Have likely trends of lateral connectivity and periodic inundation been considered?** Regular wetting and drying of floodplains is a key factor promoting nutrient uptake. Constant inundation does not promote the necessary conditions and can therefore hinder the treatment efficiency of the scheme.

Key information required

- A map to show if both the current water course and any potential alterations of the course related to floodplain connectivity will result in increased flooding extent and levels.
- A map showing current flood risk extent based on the Environment Agencies flood risk mapping will support this understanding including downstream to any key infrastructure[18].
- Demonstration that the relevant FRA has been completed with an assessment if more detailed modelling will be necessary at the detailed design phase.
- Note: if areas of risk are identified they should be flagged to determine if any localised flood mitigation strategy is necessary/can be implemented.

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

Key questions

Will the proposed ELJ impact a protected site? If the deployment location for the proposed mitigation is within, or near, a protected site, either its implementation or operation phases may impact the site. The scheme should not compromise the restoration of other habitats or cause a negative impact on priority habitats. The following authorisations might be required:

- As the owner or occupier of a SSSI, notice must be given, and NE'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 NE's agreement (assent) before carrying out a planned activity that's likely to damage a SSSI or land near the site's boundary.
- For proposals within European sites and Ramsar sites, a competent authority must undertake a HRA for any plan or project which is not necessary for management of the site.

[18] See: Check the long term flood risk for an area in England - GOV.UK (www.gov.uk) and Flood Risk Maps for Rivers and Sea in England - December 2019 (arcgis.com)

- **Will the ELJ scheme impact protected species?** If protected species are present at or near the deployment location and could be impacted by the scheme. It will be necessary to discuss this with NE for their consent.
- **Have beavers been introduced into the area?** Beavers are natural dam makers, but these may not be in the correct place to support NN. However, where present the impact of their presence will need be carefully considered and determine if engineered approaches are appropriate.
- **Are there any known INNS at the site and/or upstream?** 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 of to remove the risk of spreading INNS to other locations in the catchment.
- **Will the ELJ impact other natural habitats or environmental objectives?** The scheme should not compromise the restoration of other natural habitats or cause a negative impact on existing natural habitats. It should also not negatively the ability to achieve other environmental objectives.

Key information required

- Maps of international (SAC, SPA, Ramsar) and national (SSSI) protected sites for nature conservation.
- Maps of locally protected nature/environment sites (local nature reserves, local wildlife sites and local geological sites) and other protected areas (National Parks, AONBs) that may have requirements which need consideration when deploying an ELJ scheme.
- Maps of priority habitats and areas that are currently under habitat restoration.
- Map of INNS locations using any local observations and the NBN Atlas[19] with INNS statement on pathways and impacts.

Depending on the interaction of the scheme with the above designations, a full ecological assessment may be required to provide confidence there will be no impacts on these designations due to the scheme.

3.3.8. Land use

Key questions

Can previous land use impact the efficacy of the proposed scheme? The current and previous land use needs to be considered to ascertain the risk of legacy nutrients being remobilised. This is a greater issue for P than N, as N is less readily stored in soils and is most likely to occur during implementation. It may be

[19] See: NBN Atlas - UK's largest collection of biodiversity information

necessary to test soil nutrient levels to determine potential legacy risk from land use.
Biofiltration Filter Media Guidelines (Version 3.01), prepared by the Facility for Advancing Water Biofiltration (FAWB), 2009, are recommended within the CIRIA SuDS Manual for the specification of soils for biofiltration systems. The guidelines specify the following limits:
    - Soils with TN content: < 1000 mg / kg
- **Are there interactions with other land management schemes?** If land is currently under an agri-environment scheme, payments may be lost through the deployment of ELJs and the subsequent reconnection to floodplains. This is unlikely for ELJs as the mitigation is 'in-channel', however it should still be considered.

Key information required

- Map of current land use and explanation of any previous land uses that might cause an elevated risk of pollution during project implementation.
- Map of active agri-environment schemes where appropriate.

3.3.9. Ownership

Key questions

- **Has the landowner, and any surrounding landowner agreed to the mitigation in principle?** A project can only be delivered with the agreement of the landowner and following discussion with any other landowners where there may be a direct effect. It is likely that this type of mitigation would be received favourably. A legal agreement should also be confirmed with the landowner that the land used for the ELJ will remain in place in perpetuity (practically this is 80+ years).

Key information required

- Evidence of engagement with the landowner regarding the deployment of the proposed scheme.
- Outline details of any in principle, legal or management agreements to secure the land required for the ELJ.

3.3.10. Archaeology and heritage

Key questions

- **Is there any known archaeological remains or potential for them?** Excavations, or at the very least plant crossings, are likely when implementing ELJ schemes. Some ELJs will require earthworks to move designated or imported trees and then glue or bolt the trees together during construction. Scheduled monuments have additional protection against unauthorised change and thus should not be impacted. In addition, peat soils preserve records of past landscapes and people and may therefore need to be protected. Although an ELJ itself is unlikely to impact features, it should be considered as a potential impact during implementation. Areas might include scheduled monuments, Roman remains, peat soils that have preserved

records of past landscapes and people or well-preserved water meadow systems noting that some maybe scheduled monuments. Early checks are recommended.

- **How might landscapes and heritage be impacted?** Earthworks and the removal of trees and vegetation has the potential to disrupt landscape character and heritage features (e.g. historic vistas). This will need to be discussed with the landowner and bodies such as English Heritage.
- **Has any disruption been accounted for?** The loss of landscape and heritage features can be mitigated through early identification of possible disruptions and the uses of suitable mitigation measures. In some cases, a 'no regret' policy can be implemented so that any re-naturalised reach could be returned to previous course, if necessary, but this would have implications for nutrient reduction.

Key information required

- Archaeological or heritage value risk assessment based on advice from the Local Authority.
- Map of scheduled monuments in proximity, including any channel crossings.
- In areas of high archaeological or heritage risk, a bespoke archaeological risk assessment and any planned mitigation may be required. This will minimise the risk of costly delays during construction and shows that the design is managing risk proactively.

3.3.11. Rights of way and public access

Key questions

- **What if a public right of way is affected by the proposed ELJ measure?** Public rights of way cannot be closed or diverted, even temporarily, without permission from the local authority. Implementing any ELJ scheme has the potential to result in changes in the landscape which could affect public rights of way.
- **Are there wider benefits associated with public access?** ELJs have the potential to improve the site's amenity value, especially related to walking and angling together with building public awareness of nutrient pollution issues and opportunities to provide benefits for society and the environment through such schemes. Benefits could be considered in terms of better access for all.
- **Where wider benefits have been identified would there be any risk to NN efficiencies?** Bank erosion or riparian soil compaction via access might reduce nutrient removal efficiencies locally so effective measures to avoid this would need to be considered.

Key information required

- Map of the nearest public rights of way and any plans for any required mitigation.
- Demonstration that the local authority has been engaged regarding changes to public rights of way, if required.
- If possible / relevant, consider opportunities available for education and raising public awareness while minimising risks to degradation of the scheme.

3.3.12. Nature recovery

Key questions

- **Does the ELJ plan have the potential to be part of a habitat network or natural recovery area etc?** ELJs encourage the surrounding environment to emulate natural conditions, increasing habitat diversity and encouraging wildlife to recover. It will be beneficial to look at local plans that support nature recovery plans to establish if the nutrient mitigation provides any opportunity to combine outputs. This should be considered in the context of the most beneficial placement of the ELJ.
- **Does the plan intersect with other plans identified for alternative nature recovery requirements?** There may be locations in which the NN proposal could displace more valuable habitat nature recovery opportunities.

Key information required

- Map identifying the proposed location to be suitable for the mitigation scheme to take place.
- After the mitigation scheme is established the Local Nature Recovery Strategy (LNRS) should be used to minimise the risk that a mitigation scheme may pose to the local habitat network.

3.3.13. Historical landfill, coal mining and contaminated ground

NOTE: This is unlikely to be an issue for ELJ installation unless the water course has been moved because of historical mining. It is recommended that this is checked to determine any potential risk.

3.3.14. Unexploded ordnance

NOTE: This is unlikely to be an issue for ELJ installation. Expert judgement will be required to determine if an assessment is needed (e.g. movement of plant to remote site for installation).

3.3.15. Services and infrastructure

Key questions

- **Has an assessment of services both underground and overhead (water, gas, and electricity) been conducted?** Moving services is expensive and time-consuming and requires the involvement of the service provider. Projects that require earthworks have potential to impact underground and overhead services such as water, gas, and electricity. The above services may impact the ability to deliver the project during to constraints of plant access the site.

Key information required

- A full search and a map of all local services, if any. The services should be plotted alongside the ELJ scheme to show their relative locations.
- A mitigation strategy for any services identified.

3.3.16. Regulatory considerations

Key questions

- **Does the implementation of an ELJ scheme require any environmental permits or permissions?** The regulatory requirements might include, but are not limited to, the following:
    - Environmental permits
    - Flood risk assessment
    - Flood defence consent from EA regarding works within 8m of a main river
    - Archaeology and pathway assessment
    - Wildlife licences
    - Planning permission

Key information required

- A list of permits or licenses required along with an assessment of the likelihood that they will be granted.
- A narrative on each permit identifying engagement with the relevant regulator and advice already received.

3.3.17. Constraints and options assessment

Key questions

- **Is the proposed scheme a suitable nutrient mitigation option?** The feasibility assessment may have identified a range of constraints. It is important to consider these constraints and any knowledge gaps that the feasibility assessment has found. This will help to justify that the proposed scheme is a suitable option. 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 well suited to the scheme, and that the scheme is the best option available.

  Although this step is not mandatory, it will show that the proposal has given significant thought to the feasibility of the mitigation scheme.

Key information required

- **Optional:** a summary table of the constraints associated with the scheme
- **Optional*:*** a description of the scheme's suitability in the proposed location, based on the feasibility assessment

3.3.18. Evaluation of feasibility assessment

For an ELJ scheme to pass the feasibility assessment, it must include all the required pieces of information from Stage 2 - Feasibility, including each topic from 3.3.2 - 3.3.17, noting that the requirements identified in 3.3.17 are optional. Providing evidence for each key piece of information shows that the risks have been considered, with plans in place for management and mitigation of any potential remaining risks.

To establish the strength of the feasibility assessment, the tables below can be used. Mapped information is required where possible.

Report Section	Comment	All information has been provided in the relevant format (mapped, tabular, or summary)	There are gaps in the information provided
3.3.2	Topography & Levels		
3.3.3	Geology & hydrogeology		
3.3.4	Soil and sediment		
3.3.5	Hydrology & drainage		
3.3.6	Flood risk and floodplain reconnection		
3.3.7	Protected sites & species		
3.3.8	Land use		
3.3.9	Ownership		
3.3.10	Archaeology and heritage		
3.3.11	Rights of way and public access		
3.3.12	Nature recovery		
3.3.13	Historic landfill, coal mining and contaminated ground		

Report Section	Comment	All information has been provided in the relevant format (mapped, tabular, or summary)	There are gaps in the information provided
3.3.14	Unexploded ordnance		
3.3.15	Services & infrastructure		
3.3.16	Regulatory considerations		
3.3.17	Constraints and options assessment		

	Response statements
If all green (noting that **3.3.17** is optional)	This is a well-structured feasibility assessment that maximises the likelihood that this ELJ scheme will be a sustainable natural asset within this catchment.
If SOME red	The application is missing mandatory feasibility information, as shown by the rows populating the red column. Please provide this information so that the feasibility assessment can be evaluated.

3.4. Stage 3 – Design Process

3.4.1. Introduction

To meet the objectives of the Habitat Regulations in the context of effective nutrient loads, mitigation must be designed to achieve nutrient mitigation *beyond reasonable scientific doubt*. **Part 1** (the literature review) points to ELJs having nutrient reduction benefits but does not report consistent results. Owing to the lack of available data, it is not currently feasible to estimate upfront the percentage removal efficiency of an ELJ scheme for N. To achieve this level of certainty will require further scientific proof to increase efficiency confidence. Additionally, it is not possible to promote these schemes as P removal solutions due to the short-term nature of the P removal processes.

Furthermore, there is no standard procedure regarding the use of ELJs to achieve NN as success and design are very dependent on location, geology and topography etc., as outlined in previous stages.

Each proposal will therefore need to be assessed individually based on best available information with a set of key design principles needed to achieve desirable water quality objectives within the bounds of reasonable scientific certainty based on current knowledge. The following section provides a summary of key points that will need to be assessed in conjunction with core ELJ design to ensure NN benefits remain the focus.

This document does not cover the detailed design requirements for on-the-ground deliver of an ELJ scheme.

Design process outlined in this document is related to key requirements to support the understanding of NN mitigation in the context of ELJs.

A design engineer will be required to take this forward using supporting information provided in the feasibility stage.

3.4.2. Essential design criteria

Key questions

- **Have the minimum design criteria been met?** Even through credits cannot be claimed upfront, there is a requirement for the scheme to be robustly designed with NN in mind. Due to the inability to claim upfront credits, there is no minimum design criteria, however for detailed design suggestions, see the Conceptual Design Guidelines[20] for ELJs. Evidence that the guidelines have been consulted and included in the design process is essential to ensure that any reduction evidence post implementation will be maintained.
- **Is the ELJ scheme being implemented as series of dams?** Despite not being able to claim credits upfront, it is essential for nutrient mitigation and river restoration that ELJs are implemented as a series of dams, as opposed to in isolation. This will increase the nutrient removal potential as well as providing more wider benefits to the surrounding ecosystem.
- **Have all design criteria documents been provided?** The required evidence will vary significantly from one project to another depending on the proposed scale of intervention. Stage 2 - Design Objectives will provide an indication of the level of detail required for the design together with the relevant support evidence.

[20] See: WAT-SG-37 (sepa.org.uk)

Key information required

- The table below provides a summary list of documentation that should be covered as part of the detailed design. It should be used as a 'tick list' and to check key statements related to success. Where not completed a justification will be needed.
- This will be used to provide details of on-the-ground design criteria at a level that can be used by a contractor. Confidence factors of success for ELJ schemes and NN should be included based on physical, water quality and ecological parameters. Any uncertainties should be flagged using RAG risk register.
- Channel bed scour is a common reason for ELJ failure and is the main factor that affects the scheme's longevity. If channel bed scour is not properly addressed this could lead to the dam breaching.
- The maintenance and upkeep required by the proposed mitigation scheme must be understood prior to the beginning of the scheme. This will ensure that maintenance access routes can be planned and created in advance.
- Evidence that the Conceptual Design Guidelines have been reviewed and included in the design process.

Key information to include (using data from Stage 2)	Why
Hydraulic modelling	Supports key design criteria. Must include sediment-rating curves, flow frequency and effective discharge rates. Modelling may be needed but will depend on regulatory requirements and flood / erosion risk. Extent of modelling required will depend on flood risk and design criteria. The success of ELJs is highly dependent on an understanding of the sediment size, slope and flow dynamics which drive likelihood of bed scour which could result in ELJ failure.
Land access statement	Identify risks, required mitigation to avoid damage and permits
Method Statement	Planned construction with associated maps. This should include information on slope, cross section dimensions, requirements to remove current trees or other infrastructure, requirements for pre-construction surveys, materials, specific design features and proposed timing relative to environmental

Key information to include (using data from Stage 2)	Why
	considerations. It should also consider mitigation related to sediment transport and risks during construction[21].
Construction Design and Management (CDM) statement[22]	To support health and safety
Bill of quantities	To support construction. This should include volumes of required excavation of materials, construction, silt removals, import of material to support cost estimation and how this links to land access. Reference should also be made to what is going to be done with any excavated materials. This information supports future cost estimations for material and labour.
Monitoring plan[23]	To demonstrate success in the context of NN and determine any future maintenance requirements. Upstream and downstream monitoring can support the precautionary approach to avoid overly favourable estimates from being calculated. See also Stage 5 – Post-implementation monitoring (Section 3.6)

3.4.3. Advantageous design criteria for optimisation

Key questions

- **Have design requirements beyond the minimum criteria been met?**
  Advantageous design criteria include, but are not limited to, the following:
    - ELJs are more beneficial at removing nutrients within smaller watercourses, such as becks and streams less than 2 metres in width.

[21] See Section 3.3.4 for further information regarding sediment risks during construction.

[22] See: The Construction (Design and Management) Regulations 2015 (legislation.gov.uk)

[23] Using a planner to support your monitoring may help. See: Monitoring Planner | The RRC

- Woody debris within the water column can form hotspots of N removal as woody debris increase nutrient access to bioavailable dissolved organic carbon (DOC).

Key information required

- **Optional:** Map of the local watercourses, showing the location of the proposed ELJ and the width of the watercourse.
- **Optional:** Ensuring woody debris are present within the water column to ensure access to bioavailable DOC for nutrient removal.
- **Optional:** Evidence that wider benefits as a result of the scheme have been considered.

3.4.4. Evaluation of the design process

For a scheme to be conducted with reasonable scientific certainty that it will reduce nutrient loading downstream, the design must consider and provide all the necessary information explained in Section 3.4. this process aims to minimise the uncertainty associated with the mitigation scheme whilst mitigating any possible risks. The table below should be completed at this stage to ascertain firstly if the scheme is suitable, and if relevant, where further information must be provided.

Report section	Comments	All information has been provided	There are gaps in the information provided
3.4.2	Essential design criteria		
3.4.3	Advantageous design criteria for optimisation		

	Response statements
If ALL green (noting that 3.4.3 is recommended, not required)	The information provided regarding the design detail is appropriate and sufficient.
IF SOME red (noting that 3.4.3 is recommended, not required)	Not enough information has been provided regarding the design detail proposed for the scheme. Additional information is required regarding 3.4.2. Without this information the scheme designs cannot be evaluated.

3.5. Stage 4 – Implementation Process

3.5.1. Introduction

The design of an ELJ will need to be supported by a plan for implementation of the scheme stages and issues of which need to be addressed before the scheme is deployed. These are discussed below and aim to support the eligibility of the proposal. For the plan to progress, consideration also needs to be given to the management and maintenance requirements of the scheme. These too are outlined below to aid the formulation of a plan to assess the requirements for operating and maintaining a robust and effective mitigation scheme in perpetuity.

Headline Messages:

ELJ schemes must be supported with an implementation plan. This plan must outline the following subsections:

- Constraints
- Site clearance
- Management plan

A checklist for these points is provided below.

3.5.2. Consideration of constraints

Key questions

- **Have any constraints been identified in the feasibility and design assessment?** There may have been constraints related to project deployment identified during Stage 2 – Feasibility and / or Stage 3 – Design Processes. The implementation plan should consider how these constraints will impact the implementation.

Key information required

- A description of how constraints identified will be mitigated to reduce risks both to design and nutrient uptake.

3.5.3. Site clearance and earthworks

Key questions

- **Will the location for deployment of an ELJ require preparation?** This should be provided as part of the design specification and related to a statement of risk related to the current state of the reach This will be highly dependent on the design and what is currently present.

- **Will earthworks be required?** Implementation damage from importing materials and trees and construction has the potential to impact biodiversity and cause problems such as tree root damage. Unnecessary environmental damage may be inflicted upon the site if the mitigation scheme requires earthworks.

Key information required

- An Environmental Management Plan must be provided. This must ensure that:
    - Existing biodiversity is protected;
    - Trees and vegetation are not detrimentally impacted unless they need to be cleared to plant replacement vegetation;
    - Soil compaction is minimised during construction;
    - Soil erosion and sediment pollution are mitigated during construction;
    - Buried services are protected; and
    - Topsoil and subsoil are handled separately, and the disposal of surplus soil is suitably managed. There must be a plan in place for disclosing and handling protocol of spoil materials if generated, there must also be a plan for offsite disposal.
- There must also be an indication of what site clearance and earthworks procedures are likely during the implementation phase.
- Information regarding incident management and waste management, if relevant, should be provided.
- This should be completed as part of the design criteria: review recommended.

3.5.4. Outline management plan

Key questions

- For a scheme to provide effective treatment in perpetuity, a robust management and maintenance plan needs to be formulated prior to implementation. Any routine operation and maintenance requirements must be identified and there must be certainty that these will take place. The maintenance plan is highly dependent on the observations gains from the monitoring as described in section 3.2.2.

Key information required

- Operator and stakeholder's responsibilities should be clearly identified and outlined within the management plan, covering the key roles and responsibilities related to the scheme.
- A monitoring plan that is appropriate for adaptive management that ensures continuation of process necessary to achieve nutrient neutrality. Key assessment should include:
    - Channel bed scouring to ensure the longevity of the scheme.
    - Flooding that was not predicted via modelling.
    - Structural integrity of the ELJ should be regularly assessed, and any issues identified should be addressed. If any structural damage is identified or if the

structural integrity of the dam is compromised, repair works should be carried out[24].
    - Unexpected bank failure with an investigation as to what is the cause.
    - Regular checks should take place to ensure sediment and debris build up are not obstructing the flow of water.
- The management plan should also include information regarding emergency maintenance protocols. Emergency contact information should also be included within the plan. Emergency maintenance may include the following:

3.5.5. Evaluation of the implementation process

For the proposal to progress, all pieces of information outlined above in Section 3.5 must be provided to show evidence that all possible risks associated with implementation have been reduced as much as possible and that any remaining risks will be mitigated against. Where necessary, the tables below can be used to identify which pieces of information are missing and the applicable response statement will outline exactly what steps are necessary to complete this stage.

Report section	Comments	All information has been provided	There are gaps in the information provided
3.5.2	Consideration of constraints		
3.5.3	Site clearance and earthworks		
3.5.4	Outline management plan		

	Response statements
If ALL green	This provides comprehensive information regarding the monitoring and evaluation process for the ELJ and maximises the likelihood that this ELJ will be designed appropriately, function as intended and be managed effectively.

[24] If an ELJ scheme needs to be replaced, sediment removal and removal of all immobilised nutrients must be carried out in a manner that does not remobilise deposited nutrients.

	Response statements
If SOME red	The application is missing mandatory information from Stage 4 (Section 3.5). Please provide this information so that the implementation process assessment can be evaluated.

3.6. Stage 5 – Post-implementation Monitoring and Evaluation

3.6.1. Introduction

Either monitoring, or using secondary datasets is required to estimate the nutrient load that will enter the proposed location of an ELJ scheme. Due to the lack of data, as outlined in **Part 1** (the literature review), upfront N credits cannot be claimed, therefore schemes must be monitored pre- and post-implementation in order to quantify the nutrient removal potential of the ELJ. Monitoring should also be included as part of an adaptive management regime that will support the mitigation scheme to continue providing nutrient mitigation in perpetuity. It is not possible to promote these schemes as P removal solutions due to the short-term nature of the P removal processes.

Monitoring requires a plan that is bespoke to the individual scheme, therefore the following subsections must be considered alongside the site-specific environment.

These sections **MUST** be included to claim credits:

- Baseline monitoring (See Section 3.2.2)
- Post-implementation monitoring to support adaptive management focusing on scheme function.
- Post-implementation monitoring to gain N credits.

3.6.2. Post implementation monitoring to gain N credits

Key questions

- **What is monitoring to gain N credits?** Post-implementation monitoring to gain credits for ELJ schemes is only applicable to N as there is not enough certainty in the scheme to gain ensure P reductions in perpetuity. To gain credits for N, the scheme must have baseline monitoring and be monitored post-implementation to be able to robustly characterise the nutrient reduction caused by the scheme.
- **How should post-implementation monitoring to gain credits be carried out?** Post-implementation monitoring to gain credits should be carried out using the same monitoring design as used for baseline monitoring but with the flexibility to

add additional sampling points where deemed necessary to account for any potential mitigation and / or any minor on-site design alterations (See Section 3.2.2).

- **How long is post-implementation monitoring to gain N credits required for?** To gain credits, post-implementation monitoring should be conducted for a minimum of three years to capture seasonal variation in nutrient removal efficacy at inter-annual timescales to claim additional credits. It should continue until the system can be shown to have reached a quasi-equilibrium whereby its nutrient removal efficacy is approximately stable over time. More frequent monitoring particularly in the initial few years may make it quicker to identify when stabilisation has occurred.
- **Can secondary data be used for post-implementation monitoring to gain N credits?** It is possible that existing monitoring programmes may provide a source of post-implementation monitoring. Secondary datasets will require documentation that details the sampling methodology, location, frequency and duration of the sampling programme to determine if any supplementary monitoring is needed. The requirements determining the suitability of a secondary dataset are the same as the requirements outlined for baseline monitoring (e.g. length of sampling, locations, etc.).
- **What should happen to the monitoring data?** This should be decided and agreed at the beginning of the monitoring programme including approaches to assess data. It is likely to be of interest to LPAs, Natural England and other third-party stakeholders (e.g. local catchment groups and academics). Building a supporting open-source database including the efficacy rates will be highly beneficial for future programmes.

Key information required

- For nutrient credits to be quantified, an evidence base of consistent monitoring is required. The nutrient credits should be calculated from monitoring that demonstrates at least a minimum of three years of water quality and flow data beyond the baseline. Consistent monitoring will be required to prove that an equilibrium has been reached.
- **If using secondary data:** An assessment of the validity of the secondary datasets for use in this context. Justification for using the relevant dataset must be provided.

3.6.3. Post-implementation monitoring to support adaptive management

Key questions

- **What is monitoring to support adaptive management?** Post-implementation monitoring should be implemented with a focus on the scheme's function. Regular visual inspections and repeat photography will support early identification of any requirements for adaptive management and may help to highlight conditions whereby the nutrient removal being delivered could start to reduce; for example,

problems related to the structural integrity or bank erosion[25]. The monitoring data should be used in an adaptive management regime that can highlight when different aspects of the management plan detailed in Section 3.5.4 may be required.

- **What are the requirements of monitoring to support adaptive management?** Visual inspections and repeat photography should begin after the scheme has been implemented. The period and regularity of inspections will depend on the scheme, location, and if other schemes are likely to be implemented. The scheme must be reviewed for at least 3 years annually and then the future required monitoring plan and timelines should be determined. This plan should ensure the scheme's in-perpetuity benefits, or alternatively it should ensure that the benefits are effective until other schemes are put in place (e.g. WwTW upgrades etc.).

Key information required

- A post implementation monitoring plan to support adaptive management. The monitoring plan does not need to specify water quality monitoring unless it is required to instigate maintenance. It should include consistent visual inspections and repeat photography to support adaptive maintenance. This will provide the reference base against which nutrient credits will be quantified.

3.6.4. Summary evaluation

Monitoring needs to be proportional to need. The required information outlined above in Section 3.6 should be provided to evidence that the proposed scheme has accounted for the need to monitor its performance and use this monitoring to guide any adaptive management. If necessary, the tables below can be used to identify which pieces of information are missing and the applicable response statement will outline exactly what steps are necessary to complete this stage.

Report section	Comments	All information has been provided	There are gaps in the information provided
3.6.2	Post-implementation monitoring to gain N credits		

[25] It is also noted that it could be due to a reduction in the influent nutrient load to the water course, or due to changes in soil characteristics and / or climate. These factors cannot be managed and will just need to be acknowledged if monitoring shows a reduction in efficacy that cannot be linked to vegetation or scour.

Report section	Comments	All information has been provided	There are gaps in the information provided
3.6.3	Post-implementation monitoring to support adaptive management		

	Response statements
If ALL green	This provides comprehensive information regarding the monitoring and evaluation process for the ELJ and maximises the likelihood that this ELJ will be designed appropriately, function as intended and be managed effectively.
If SOME red	The application is missing mandatory information from Stage 5 (Section 3.6) Please provide this information so that the implementation process assessment can be evaluated.

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