# Review of existing faecal indicator organism (FIO) models and future integration opportunities

## Section 1: Project Overview

### Introduction

The Centre of Expertise for Waters (CREW) intends to commission a **call down project** aligned with CREW's Water Quality and Health theme to provide a concise overview of available faecal indicator organism (FIO) models for *E. coli*, and to explore where elements could potentially be integrated to support catchment-scale source apportionment in Scotland. The project is expected to be delivered within this financial year, by the end of March 2026.

### Background

Scotland's Shellfish Water Protected Areas (SWPAs), shellfish production areas, and Bathing Waters (BWs) are sensitive to FIO contamination. *Escherichia coli* (*E. coli*), a key FIO used to assess water quality, can enter these waters from multiple sources including wastewater discharges, livestock, and wildlife.

SWPAs are particularly vulnerable to fluctuations in *E. coli*, as shifts in concentration can influence their production area classification and suitability for human consumption. These classifications are determined through Food Standards Scotland (FSS) routine monitoring of *E. coli* in shellfish flesh. At economically important sites that struggle to maintain FSS Class A status, fluctuations in *E. coli* can have significant implications for shellfish harvesting and management.

The Scottish Environment Protection Agency (SEPA) is responsible for protecting shellfish waters under The Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013. As part of this role, SEPA must investigate pressures affecting SWPAs and take forward any required actions through the River Basin Management Plan 2021-2027 (RBMP). FSS provides SEPA with annual shellfish monitoring data, which SEPA uses to support water quality classification of SWPAs and prioritise areas for further investigation.

However, routine shellfish monitoring undertaken by FSS does not provide information on potential sources or pathways of contamination, making it difficult to inform targeted measures where impacts on production areas are identified. The variability of FIO losses and the resultant fluctuations in concentrations across a catchment compound the difficulty of with environmental monitoring, which is often spatially and temporally limited. In addition, the logistics and resources required to collect sufficient samples across catchments, and the associated costs, make it difficult to build a comprehensive evidence base.

Given the challenges regarding the feasibility of investigative monitoring, there is a need to identify the most significant sources of *E. coli* losses by alternative means, such as a modelling loss from private sewage systems, treated sewage, livestock and wildlife and exploring how these could be combined into a holistic catchment model to show the relative contributions from each source.

## Knowledge gap

Considerable research has already been undertaken in developing models to quantify *E. coli* losses from livestock (e.g., VIPER, SIMCAT-FIO) and to estimate losses from septic tanks and soakaway systems. Additional studies examining FIO losses from different land-use types may also provide relevant insights. However, these models need to be made more widely accessible, more effectively integrated, and expanded to represent additional sources (e.g., losses from treated sewage, agricultural applications of sewage sludge, combined sewer overflows (CSOs), and wildlife-related sources), as well as to consider the role of natural and semi-natural habitats in mitigating risk.

While specific models exist and could potentially be used, it is unclear what range of sources are represented and whether the models are up to date and suitable to inform regulatory assessment. A concise overview is needed to understand how these could fit together, identify gaps, and consider how these might be addressed. This will be relevant to informing the development of future RBMP cycles. The review is primarily motivated by shellfish water protection, but the findings will also be relevant to bathing waters, where FIOs are also indicators of risk and similar challenges in identifying sources may be found.

## Aim and key questions

The aim of this call down project is to provide a concise overview of available FIO models for *E. coli*, and to explore where elements could potentially be integrated to support catchment-scale source apportionment.

The key questions to be addressed are:

1. Which *E. coli*/ FIO models are already available?
2. Can these models be integrated to form a holistic high-level catchment understanding to identify most significant contributing sources under various conditions (e.g. seasonal land use changes, low flow/ high flow)?
3. What changes would need to be made to allow these models to be combined?
4. What are the modelling gaps?
5. How feasible is it to fill these gaps?
6. How feasible is it to create a high-level catchment model for *E. coli* to identify most significant pressures?

## Deliverables

- A final report of c. 20 pages, excluding annexes and the bibliography, and including:
  - A review of available FIO models and their current capabilities
  - A critical assessment of how these models could complement each other to support future integration, including identification of key gaps for further development where appropriate
  - A concise set of high-level recommendations for future work or applications.
  - Cover image(s) with associated photo credits
- A plain English summary of aims and results (up to 1 page)
- Website summary (200 words)
- Communications and impact plan – supported by CREW at the start and throughout the project

**Events/meetings**

- 2 Project Steering Group meetings online (throughout the project lifecycle[1])
- A dissemination webinar (end of project)

## Intended impacts

There are multiple pathways for a project to achieve impact, and multiple factors that can impact the project's ability to achieve what it intends to do; both along the project lifecycle (A.IMPACT) and beyond project completion (B.IMPACT) (Figure 1).

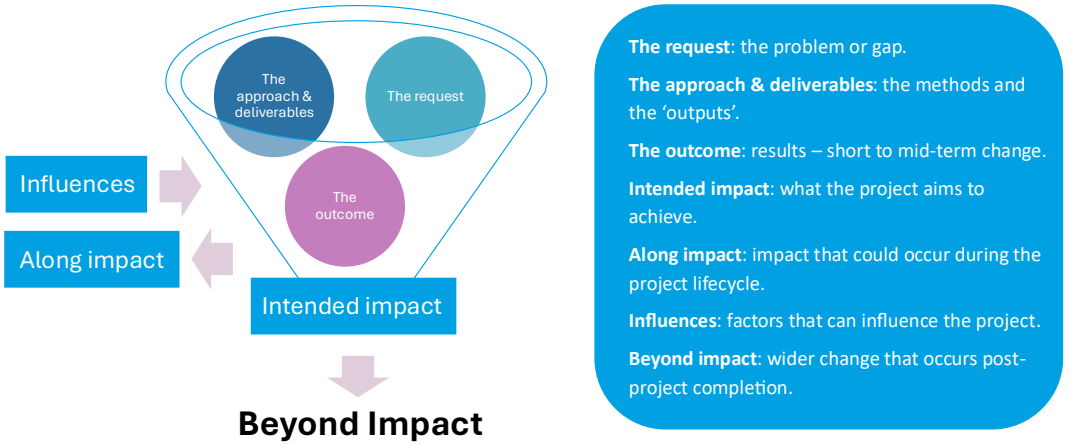


*Figure 1:Pathways to impact*

### Along Impact *(A.Impact)*:

These key stakeholders are anticipated to support this project as part of the project steering group: SEPA, Scottish Water, Scottish Government, and NatureScot.

### Beyond Impact *(B.Impact)*:

The intended audience and potential beyond impact for this project may include:

- SEPA – to support understanding of FIO sources, inform opportunities for future modelling or model development, and guide considerations of management options within future RBMPs and relevant classifications (e.g., shellfish protected water areas and bathing waters).
- Scottish Water – to support prioritisation of assets for further investigation or potential investment.
- NatureScot – to support the identification of wildlife aggregations as potential FIO sources and informing broader work relating to source-to-sea approaches in environmental management, planning and development.
- Food Standards Scotland – to support assessment of risks in new proposed production areas and to inform understanding of potential *E. coli* sources relevant to observed spikes.
- CEFAS – to support a quantified overview of relative risks associated with *E. coli* sources, which could inform sanitary surveys and identification of Representative Monitoring Point (RMP).
- Scottish Government – to support prioritisation of funding Shellfish Water Protected Areas which require "beyond compliance" measures.
- Shellfish Industry – to support understanding of contamination risk in harvested shellfish by reviewing how models represent relative *E. coli* sources, and to inform considerations for harvesting practices and classification approaches.

[1] Please note, CREW requests a brief written update c. one week prior to project steering group meetings.

# Section 2: Further information for applicants

## Eligibility

CREW call down funding is open to applications from **all relevant Scottish HEIs and Research Institutes (approved subcontractors)**. One eligible organisation must lead the bid, however an eligible organisation can sub-contract work in accordance with the Grant Terms which would include putting in place an appropriate agreement with the relevant sub-contractor(s) (updated December 2022). For CD2025_02, any UK based HEI, RI or consultancy can be sub-contracted by an eligible lead organisation (December 2025). Where successful, CREW funding would be subject to agreement to the CREW Grant Offer Letter and T&Cs ("Grant Terms"). CREW encourages applications from experienced to early career researchers (ECRs) under the supervision and mentorship of experienced researchers.

## Expectations and award criteria

A copy of expectations and the award criteria are provided on page 5 and 6, respectively.

## Project management

Day-to-day communication will be between the research/review team (the contractor) and a CREW Project Manager and is likely to involve short catchups as agreed.

## Communications and impact

CREW's impact officer will engage with the research team and project steering group on any agreed upon comms and impact activities throughout the project and for post project evaluation.

## Project steering group

A CREW representative, and representatives of Scottish Government and its delivery partners, will form part of the project steering group. They will meet with the preferred bidder(s) for a pre-contract meeting. A pre-contract meeting will take place **early February 2026.**

## Anticipated timescale

All final project deliverables should be submitted in Word format for sign off by **31st March 2026**. Output formatting is expected to take place in April, organised by CREW.

## Funding

The maximum amount of funding available **exclusive of VAT** (where applicable) is **£34,000.**

## Submitting a proposal

Please complete a **CREW Call Down Application form** outlining your proposal.

Proposals need to be submitted to Procurement@crew.ac.uk for evaluation **by 15:00 Thursday 15th January 2026.** We aim to notify the preferred bidder by week beginning **26th January 2026.**

Please contact Procurement@crew.ac.uk **by Friday 9th January 2026** if you would like any clarification on any of the above. You should highlight any potential conflicts of interest in your proposal. For queries about what may constitute a potential conflict of interest please contact the CREW Manager (Nikki.Dodd@hutton.ac.uk).

## Expectations

| No. | Criteria | Descriptor |
|---|---|---|
| 1 | Duration | The proposed duration will align closely to the details provided in the anticipated timescales section of the specification. |
| 2 | Staff time and effort | The proposed allocation of staff time and effort is appropriate and includes all deliverables. The proposal provides a commitment that named staff members will be available to work on the contract if the bid is successful. For any unnamed staff, appropriate risk identification and mitigation measures are provided. |
| 3 | Project costs | The estimated breakdown of project costs is realistic and inclusive of all deliverables. |

## Award criteria

| No. | Criteria | Descriptor |
|---|---|---|
| 1 | Understanding the project ask and policy background | The proposal should include an introduction which demonstrates a clear understanding of the project requirements. This should include an understanding of the policy background and the supporting role of this project; the need for this research; the project aim; and how the proposal will address this aim. |
| 2 | Proposed methodology | The proposal should demonstrate a high quality and workable methodology, including: how the evidence will be identified, reviewed, and assessed; consulting relevant stakeholders and/or experts where appropriate to address the key questions and produce the deliverables in the timescales required. It should explain the suitability, robustness, and limitations of the proposed methodology. |
| 3 | Milestones | The project milestones are logical, practical and include all deliverables. |
| 4 | Project Management | The staff, resources and expertise are appropriate for conducting the proposed project. The proposal should name the project lead and outline their project management experience. |
| 5 | General and specific topic expertise and experience | The proposal should provide details of individual staff members who will work on this project and demonstrate how they will meet the project requirements, specifically:<br>- general research experience and expertise;<br>- specific experience and expertise in environmental or water quality modelling.<br>- knowledge of faecal indicator organisms, including *E. coli* |
| 6 | General communication and deliverables | The proposal should describe the approach to producing the deliverables, which will be published on the CREW website. It should detail who will take lead responsibility for report-writing and overall report quality. It should provide examples of previously published reports, reviews, or similar assessments in which they have been involved. |
| 7 | Quality assurance | The proposal should provide details of quality assurance procedures to demonstrate how the contract will be continuously delivered to a high standard. It should specifically address issues of quality control at different stages of the project, including evidence gathering, analysis and report writing. It should include a timetable for delivery of tasks, project milestones and allocation of staff and staff time against each task, covering the duration of the contract. |
| 8 | Risk | The proposal should provide a risk assessment matrix detailing any risks identified in relation to the delivery of this contract, and proposed mitigation measures to minimise their probability and impact, focused particularly on risk to completion on time. |

## Annex A. Relevant reports, studies, and policies

Crowther, John & Wyer, M & Bradford, M & Kay, David & Francis, Carol. (2003). Modelling Faecal Indicator Concentrations in Large Rural Catchments Using Land Use and Topographic Data. *Journal of applied microbiology*. 94. 962-73. https://doi.org/10.1046/j.1365-2672.2003.01877.x

Kay, David & Crowther, John & Stapleton, Carl & Wyer, Mark & Fewtrell, Lorna & Edwards, A & Francis, Carol & Mcdonald, Adrian & Watkins, John & Wilkinson, Jeremy. (2008). Faecal indicator organism concentrations in sewage and treated effluent. *Water research*. 42. https://doi.org/10.1016/j.watres.2007.07.036

Kay, David et. al (2005). Decay of intestinal enterococci concentrations in high-energy estuarine and coastal waters: towards real-time T90 values for modelling faecal indicators in recreational waters. https://doi.org/10.1016/j.watres.2004.11.014

Mzyece, C.C., Glendell, M., Gagkas, Z., Troldborg, M., Negri, C., Pagaling, E., Jones, I., and Oliver, D.M. (2025). Validating a Bayesian network model to characterise faecal indicator organism loss from septic tank systems in rural catchments. *Water Research*, p.124715. https://doi.org/10.1016/j.watres.2025.124715.

UKWIR, EVALUATION OF T90 DECAY RATES FOR A RANGE OF MICROORGANISMS INDICATIVE OF SEWAGE CONTAMINATION. https://ukwir.org/eng/reports/07-WW-11-11/115248/Evaluation-of-T90-Decay-Rates-for-a-Range-of-Microorganisms-Indicative-of-Sewage-Contamination-Phase-2--Building-and-Validation-of-Predictive-Models

Wyer, M. & Kay, David & Crowther, John & Whittle, J. & Spence, A. & Huen, V. & Wilson, C. & Carbo, P. & Newsome, J. (1998). Faecal-Indicator Budgets for Recreational Coastal Waters: A Catchment Approach. Journal of the Chartered Institution of Water and Environmental Management. https://doi.org/10.1111/j.1747-6593.1998.tb00210.x