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A SOURCE-TO-SINK CONTAMINANT RISK FRAMEWORK TO SUPPORT WATER QUALITY POLICY ACROSS SCALES

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Introduction

In the wrong place, or at excessive concentrations, nutrients (nitrogen and phosphorus) and sediment become contaminants. Along with pathogens, they require reduction to improve water quality. Our Land and Water National Science Challenge (OLW NSC) and Ministry for the Environment (MfE) have commissioned a research programme 'Mapping Contaminants from Source to Sink' to inform both national and local government policy and planning on the fate of freshwater contaminants, specifically nitrogen and phosphorus species, sediment, and microbes in our environment and will be used to support the implementation of the National Policy Statement for Freshwater Management (2020).

The overall objective of this project is to produce a national landscape classification for water quality to support contaminant risk assessment for policy option development. The classification units will describe contaminant processes within parcels of land, surface water and shallow groundwater (hydrologically connected to streams and rivers).

Framework

The landscape classification provides a system for identifying and grouping individual land parcels according to their risk for water quality, applied separately for nitrogen and phosphorus species, sediment, and microbial contaminants. The water quality risk describes the intersection of three factors:

1. the *pressure* from land use and management contributing to contaminant generation,

2. the *inherent susceptibility* of the landscape to contaminant mobilisation, and

3. the *vulnerability* of downstream receiving environments to contaminant loads.

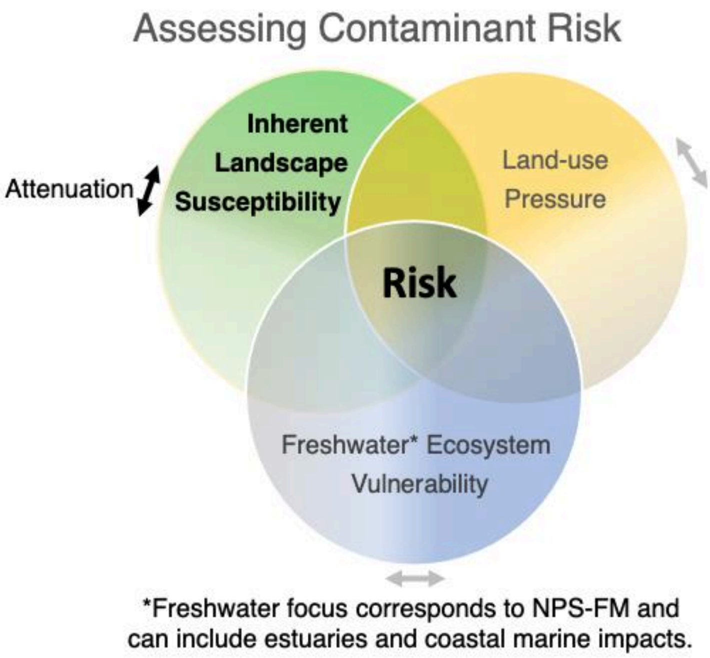

Figure 1. Contaminant risk is the intersection the inherent susceptibility of the landscape for contaminant loss, pressure from land uses, and the vulnerability of the receiving environment.

The framework draws attention to the importance of mapping and classifying inherent susceptibility of the landscape to contaminant mobilisation and delivery. It supports problem identification as part of a multi-contaminant framework considering land-use pressure in landscape units, providing consistency across scales from national policy, through regional policies and rules, to land management activity – a span of up to ~10^5. Through landscape classification, the programme builds on previously successful work (Rissmann et al., 2018; 2019), identifying the dominant processes controlling risk to water quality for each contaminant.

The approach draws on the success of *Risk = Hazard x Exposure x Vulnerability* frameworks, and its application for climate change adaption related to land and water. Realistic support for national water policy appears to benefit strongly from focus on mesoscale water governance with locally relevant land assessment (Biswas et al., 2010; Scholten et al., 2020). A landscape classification framework provides a mechanism to identify dominant processes for the key contaminants, enabling comprehensible catchment-driven focus on attributes and the development and application of appropriate models within similar landscapes, ranging from internationally accepted tools, such as eSource and SWAT, and locally adapted accounting frameworks, such as ROTAN or the methods forming the foundation for this work (Rissmann et al., 2019).

Here, the final form is expected to yield risk as probability (p) given as $p\,[S \times P \times \prod (1\text{-}A)_i < V]$, where: S is inherent susceptibility in units of contaminant load; P is land-use pressure, as a dimensionless multiplier (where 1 = reference); A is attenuation (as a fraction ≤ 1) and multiplicative in i locations along flowpaths using ∏ as the multiplicative version of summation (Σ). Notably A may occur within any of the three main compartments (Fig. 1). Finally, V = critical contaminant loading (e.g. limit). It is expected that the overall risk (p) can be evaluated with uncertainty by comparing the probability distribution function of the load, after attenuation, to the critical load estimated for the receiving environment. However, pragmatic assessment can be completed by setting V up as an additional multiplier.

The framework enables efforts to detail the role of the landscape in assessing responses to water quality issues, while retaining clear descriptions of land use pressure and vulnerability of receiving freshwater and coastal environments with a focus on ecosystem health. Focus within the project is on classification and map-based assessment of each contaminant's *inherent landscape susceptibility* to mobilisation and delivery, using a *dominant process* approach to characterise contaminant transport and attenuation to address multiple contaminants across a range of scales. The dominant processes known to drive spatial variation in water quality include climatic (e.g., orographic forcing), hydrologic (e.g., water source and pathways), redox (soil and aquifer), and physical weathering (erosion and mass wasting) categories. Other processes relevant to microbial transport and attenuation may also need to be developed. The assumption that a few dominant processes govern the response of environmental systems in any landscape is fundamental to the classification. The relationship between process response (e.g., percent overland flow of effective rainfall), and the landscape properties (e.g., slope, soil slaking and dispersion index) reduces unnecessary complexity and retains accuracy at national, catchment and farm scales.

The framework serves as a mechanism to guide, draw together, and prioritise previous work undertaken in OLW NSC and other aligned research that may be more appropriate locally, regionally or within land cases based on recognition of factors, such as dominant processes or data availability.

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