Proposed Framework for Modernizing British Columbia's Sediment Standards

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SCIENCE ADVISORY BOARD FOR CONTAMINATED SITES IN BC

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Executive Summary

This report provides a summary for Phase 1 of the Sediment Standards Project, which outlines a preliminary scientific framework for modernizing British Columbia's (BC) Contaminated Sites Regulation (CSR) Schedule 3.4 generic numerical sediment standards. The primary objective of this report is to outline a proposed scientific matrix framework for modernizing British Columbia's generic numerical sediment standards and to define the foundational data requirements needed for future phases of development.

Current sediment standards are applied across different aquatic settings (e.g., freshwater, marine, and estuarine) and differentiate between 'sensitive sediment use' and 'typical sediment use', reflecting differing protection goals. They were developed in the early 2000s and concentrate primarily on direct toxicity to amphipods, a type of benthic invertebrate. These standards do not sufficiently account for risks to other aquatic life, nor do they safeguard against toxicity from contaminants transferred through the food-chain to wildlife and humans. Furthermore, they fail to integrate current scientific knowledge regarding bioavailability or the presence of emerging contaminants. They were developed without Indigenous engagement and do not protect Indigenous uses related to traditional food consumption and cultural practices.

The proposed framework presents an initial overview of relevant scientific research, a jurisdictional scan of leading national and international approaches, and multi-faceted engagement strategy, describing the activities undertaken (an online survey, a technical session at the Canadian Ecotoxicity Workshop, and a Technical Working Group review), the diverse experts involved, and the key themes that emerged. Key findings reveal a national and global trend towards incorporating bioavailability adjustments and explicitly protecting against bioaccumulation and food transfer. Surface water and sediment quality criteria now exist for the Lower Athabasca region of Canada to protect Indigenous uses which stands out as a potential leading model for integrating Indigenous uses and Traditional Knowledge with current scientific principles. Respectful engagement will need to be carefully planned to design an overall framework that reflects the current state of the science and be technically sound/modernized, and that also places importance on integrating Indigenous Knowledge and protecting Indigenous uses.

A modernized framework is proposed that moves away from the binary 'sensitive vs. typical' site classification in favour of a more nuanced, matrix-based assessment. It recognizes the disconnect in the current generic standards that exclude consideration of protecting Indigenous uses, integrating Indigenous Knowledge, safeguarding ecological health, and protecting wildlife and human health.

The basis of the framework proposes revising the CSR Schedule 3.4 to include matrix-based standards that account for:

- Direct Protection (SedS-contact): Designed to protect ecological organisms and people from direct exposure (via separate standards for ecological and human health receptors).
- Bioaccumulation Protection (SedS-food): Designed to protect higher-trophic-level organisms (wildlife and humans) from food web transfer of contaminants, prioritizing community-specific ingestion rates for traditional foods where available.

Information that will be relied upon to derive matrix sediment standards will be incorporated into

a BC aquatic database to support all components of the proposed framework.

There are three tiers in the proposed framework which are briefly described below:

- **Tier 1 Screening**: Applying the revised BC CSR Schedule 3.4 matrix sediment standards. Deriving a SedS-contact and SedS-food standards with baseline bioavailability adjustments.
- **Tier 2 Site-Specific Screening**: Applying modified matrix sediment standards that account for site-specific factors influencing bioavailability and toxicity.
- **Tier 3 Risk Assessment**: Relies upon risk-based approaches and integrating lines of evidence, in conjunction with Tier 2 site-specific sediment standards, which may be used for delineation and screening.

This initiative aims to establish scientifically current, and holistically protective sediment standards for British Columbia's diverse aquatic resources.

Strategic Path Forward

To navigate the complexity of this modernization within the constraints of available resources, a strategic options analysis was conducted. The recommended pathway is data-driven Phased Modernization that leverages technology to build a BC-specific evidence base before calculating new numerical standards. This approach directly addresses stakeholder concerns regarding resourcing and data gaps identified during the 2025 engagement. To ensure successful adoption by industry and regulators, the roadmap treats the development of user-friendly technical procedures and training as core project deliverables alongside the scientific derivation.

A four-phase implementation roadmap is proposed for consideration, led by the Science and Standards Technical Advisory Committee (SSTAC) to support the Ministry of Environment and Parks (ENV). To maximize efficiency, Phase 2 will employ a “Smart Stagger” strategy:

- **Phase 1 (2025)**: Scoping and Framework Development (Completed). Led by the Science Advisory Board for Contaminated Sites (SABCS) and the SSTAC; this report presents their recommendations to ENV for consideration.
- **Phase 2 (2026)**: Foundational Research and Study Design. This phase prioritizes a Data Compilation Project which leverages technology to build the BC aquatic database. Technical Working Groups (TWGs) will be launched in staggered waves, beginning with Study Design and Data Compilation, followed by Bioaccumulation Classification and Matrix Standards Framework. This phase focuses on developing a probabilistic study design, creating the foundational BC aquatic database, conducting an enhanced jurisdictional scan to support drafting of a Matrix Options Paper, developing a bioaccumulation classification framework, and drafting a strategy for respectful Indigenous engagement.
- **Phase 3 (2027)**: Scientific Development and Handoff. These phases focus on mobilizing the Matrix Standards Derivation TWGs to develop technical derivation procedures, calculate draft matrix standards, and eventually deliver a comprehensive scientific recommendation package to BC ENV for policy review and consultation.
- **Phase 4 (2028+)**: Application of the Scientific Framework & Final Scientific Package. This phase involves the first application of the new procedures to develop proposed matrix standards for priority contaminants. Key activities include synthesizing TWG outputs into a comprehensive framework document, facilitating technical engagement on draft proposals, and delivering a final scientific recommendation package to BC ENV for policy review.

This roadmap ensures that the modernized standards are not only scientifically advanced and practical but are built upon a defensible, BC-specific data foundation using a fiscally responsible execution model.

A Note on the Scope of this Report and Authorship

This document is a summary of a scientific research endeavor supporting a proposed approach for updating sediment standards. All frameworks, pathways, and standards described herein are proposals for consideration. This report and its findings constitute recommendations for BC ENV. ENV, as the sole legal decision-maker, will follow its own distinct policy decision framework, including further consultation and executive approvals, before amending the CSR.

This report is an independent product of SABCS and SSTAC. It is not a publication of the ENV, does not represent ENV policy or position, and has not been prepared under, reviewed against, or approved through ENV's quality-assurance, writing, or publication standards. ENV's role in this work was that of a contributing partner providing research support, technical input, and review; that contribution is gratefully acknowledged but does not constitute authorship. All content is the responsibility of SABCS and SSTAC.

A Note on Methodology

Initial drafting of the report and the synthesis of voluminous TWG feedback (over 730 responses) were augmented using Artificial Intelligence (AI) to maximize efficiency, identify thematic trends, and assist with reference management. Following this AI-assisted synthesis, the core text underwent a comprehensive, manual rewrite and meticulous peer review by the SSTAC members and individuals listed in Acknowledgement Section who provided editorial support. This rigorous process ensured scientific accuracy, proper interpretation of data, removal of potential bias, and validity of all citations.

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Science & Standards Technical Advisory Committee (SSTAC): This project was led by the SSTAC, whose members dedicated countless volunteer hours to steering the initiative, designing the engagement process, and authoring this report.

- Jasen Nelson (SSTAC Co-Chair, ENV, SABCS)
- Dr. Shannon Bard (SSTAC Co-Chair, SABCS)
- Cara Lachmuth (ENV)
- Marc Cameron (Core6 Environmental, SABCS)
- Jennifer Trowell (Ausenco)
- Geoff Wickstrom (Craft Environmental)
- Dr. Peter Ross (Raincoast Conservation Foundation)

Note: This report was developed as an SABCS product; it was not prepared under ENV direction and does not follow ENV's writing, quality assurance, or publication requirements. Authorship and content are the responsibility of the SABCS and the SSTAC.

The Technical Working Group (TWG): We are grateful to the 39 members of the TWG who reviewed draft materials, provided detailed feedback, and stress-tested the proposed framework. This group represents a broad cross-section of professionals with deep expertise, including representatives from:

- **Consulting & Industry**: Active Earth (Lizzy Mos, Scott Steer), AtkinsRéalis (Andrea Ell, Lindsay Woof), Associated Environmental (Tyler Mehler), Ausenco (Jennifer Trowell), Azimuth (Beth Power, Ryan Stevenson, Sean Engelking), Core6 Environmental (Marc Cameron), Craft Environmental (Geoff Wickstrom), Integrated Toxicology Solutions (Mandy Olsgard), Keystone Environmental (Kevin Hall, Kevin Wong, Raminder Grewal), Millennium EMS Consulting

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- **Indigenous Nations**: Tsleil-Waututh Nation (Anuradha Rao, Melany Sanchez Solano) and Mikisew First Nation (Rachel Graham).
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Their rigorous review ensured that this framework is not only scientifically defensible but also practical for implementation in BC.

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Modernizing British Columbia's Sediment Standards

I. Introduction

A. Background and Context:

Sediment is defined as particulate organic and inorganic matter that settles to the bottom of aquatic environments. While the British Columbia Contaminated Sites Regulation (CSR) legally designates it as "particulate material that usually lies below water" (CSR, 2023), contemporary frameworks recognize sediment as a dynamic, functional matrix rather than static matter (Simpson & Batley, 2016). It acts as both a sink and source for contaminants, mediates bioavailability, and serves as a fundamental component of aquatic ecosystems, providing critical habitat for benthic organisms and influencing nutrient cycling.

Sediment is increasingly recognized not just as a sink for contaminants, but as a dynamic and integral component that sustains numerous ecosystem functions, providing benefits to both the environment and human well-being. However, over time, accumulated contaminants can be released back into the water column or taken up by organisms, acting as a secondary source of pollution and posing long-term risks to ecological and human health (Apitz, 2012).

A modern approach to sediment quality management is needed – one that uses effective tools and regulatory criteria to assess sediment quality and manage associated risks. In BC, the *Environmental Management Act* (EMA; 2003), the CSR (2023), and associated CSR Protocols determine the requirements for site remediation (BC ENV, 2023; 2025). Schedule 3.4 of the CSR provides generic numerical sediment standards, which are simply referred to herein as "sediment standards" (abbreviated as SedS in this report). These sediment standards were established to protect aquatic life and are applied across different aquatic settings – freshwater, marine, and estuarine – and differentiate between 'sensitive sediment use' and 'typical sediment use', reflecting different protection goals.

The current sediment standards are largely based on approaches and data from the late 1990s and early 2000s, detailed in technical documents such as the Ministry of Water, Lands and Parks (MWLAP, 2003) and MacDonald et al. (2003). Since their development, there have been substantial global advancements in understanding sediment toxicology including significant improvements regarding the availability of relevant data, the critical role of bioavailability, and the complex pathways of contaminant bioaccumulation and food web transfer.

B. Problem Statement/Rationale for Review:

Review and modernization of BC's sediment standards is necessary so that several key limitations can be addressed, including:

- Exclusive reliance on studies involving select benthic invertebrates.
- Exclusion of studies involving aquatic plants, algae, fish or humans.
- Lack of consideration for food web transfer (to wildlife).
- Lack of consideration for accumulation into country foods consumed by humans.
- Absence of consideration of Indigenous uses and consultation with Indigenous communities.
- Failure to capture advancements in science (bioavailability, emerging contaminants).

C. Report Objectives and Scope:

The primary objective of this report is to outline a proposed scientific matrix framework for modernizing British Columbia’s generic numerical sediment standards and to define the foundational data requirements needed for future phases of development.

The specific objectives are:

- To review the derivation and associated limitations of the current sediment standards.
- To identify and synthesize the relevant scientific concepts, techniques, and approaches for developing modern sediment standards.
- To conduct a jurisdictional scan of sediment quality management frameworks to identify best practices.
- To present the results of community and stakeholder engagement to gather input on the proposed framework.
- To propose derivation methods for modernizing sediment standards that explicitly incorporate protection of wildlife and human consumers via food-chain transfer and bioaccumulation.
- Propose strategies in the form of “an options analysis” to implement the standard derivation/framework.

The scope of work encompasses preliminary literature and jurisdictional review, planned community engagement, and the initial development of a proposed framework. It includes the protection of Indigenous uses and proposes approaches for the respectful integration of Indigenous Knowledge and Science.

A Note on the Scope of this Report: This document is a high-level summary of a scientific research endeavor. All frameworks and standards described herein are

proposals. This report and its findings constitute recommendations to BC ENV. As the sole legal decision-maker, BC ENV will follow its own policy decision framework, including further consultation and approvals, before amending the CSR.

This report is an independent product of the SABCS and the SSTAC. It is not a publication of the BC ENV, does not represent ENV policy or position, and has not been prepared under, reviewed against, or approved through ENV's quality-assurance, writing, or publication standards. ENV's role in this work was that of a contributing partner providing research support, technical input, and review; that contribution is gratefully acknowledged but does not constitute authorship. All content is the responsibility of the SABCS and the SSTAC.

D. Report Structure

This report is organized into the following nine main sections.

- Section I provides an introduction, rationale, objectives, and scope.
- Section II details the preliminary scientific research findings, including an analysis of existing BC sediment standards, a review of literature to understand scientific advancements since the existing standards were developed, and development of a preliminary framework for modernizing sediment standards (for community engagement).
- Section III presents the jurisdictional scan of sediment quality management approaches.
- Section IV outlines the completed community and stakeholder engagement activities.
- Section V describes the proposed framework and tiered approach.
- Section VI describes strategic pathways and an options analysis.
- Section VII presents conclusions and recommendations, and a tentative roadmap.
- Section VIII lists all references relied upon.
- Section IX presents appendices A to J.

II. Literature Search – Current Standards, Deficiencies and Path Forward

The following sections present a summary of existing BC Schedule 3.4 sediment standards (including their issues/deficiencies), and a high-level review of current scientific literature on sediment toxicology, bioavailability, bioaccumulation, food web modeling (FWM), and current risk assessment methodologies. See **Appendix A** for

details on the methodology used in the literature review.

A. BC CSR Schedule 3.4 Sediment Standards

Derivation Approach:

The generic numerical sediment standards in BC's CSR Schedule 3.4 were formally established based on work conducted in the early 2000s. This work culminated in key documents such as the "*Criteria for Managing Contaminated Sediment in British Columbia: Technical Appendix*" (MWLAP, 2003) and "*Development and Applications of Sediment Quality Criteria for Managing Contaminated Sediment in British Columbia*" (MacDonald et al., 2003).

The derivation approach involved several distinct steps as detailed in MWLAP (2003), and MacDonald et al., (2003)[1]:

1. **Establishment of Sediment Management Objectives (SMOs)**: Two tiers of sites were defined based on the protection levels (inferred from the SMOs) detailed within the Schedule 3.4 standards derivation:
    - **"Sensitive Contaminated Sites"** ($SedQC_{SCS}$): The SMO for these sites was to restore sediments to facilitate productive and diverse benthic macroinvertebrate communities in the near-term and to minimize risks to organisms at higher trophic levels in the food web. The aim was a low probability (approximately 20%) of observing significant observed adverse effects on growth, reproduction or mortality within the population (e.g., EC_{20}).
    - **"Typical Contaminated Sites"** ($SedQC_{TCS}$): The SMO for these sites was similar but focused on the longer-term, with a moderate probability (approximately 50%) of observing significant observed adverse effects on growth, reproduction or mortality within the population (e.g., EC_{50}).
2. **Identification of Benchmarks**:
    - **Preliminary Benchmarks**: The Canadian Council of Ministers of the Environment (CCME) Probable Effect Levels (PELs) from their 1999 guidelines (CCME, 1995; 1999a,b; 2025) were adopted as preliminary benchmarks for the BC Schedule 3.4 sediment standards. This decision was based on the general consistency of the PELs' narrative intent with the established SMOs. To refine these benchmarks, matching sediment chemistry and toxicity data were compiled, primarily from North American amphipod tests (e.g., *Hyalella azteca* for freshwater; *Ampelisca abdita* and *Rhepoxynius abronius* for marine environments). The co-occurrence data were compiled in a database referred to as the Biological Effects Database for Sediments (BEDS). Mean PEL-

[1] After the initial procedure was described, workshops were held to receive feedback. A high-level summary of the Workshop to Support the Development of Guidance on the Assessment of Contaminated Sediments in British Columbia provided by Sustainable Fisheries Foundation (2007).

quotients (PEL-Qs) were calculated for contaminant mixtures, and logistic regression models were developed to relate these mean PEL-Qs to the observed incidence of toxicity.

- **Refinement of Preliminary Benchmarks (Derivation of Numerical SedQC)**: Was completed for both sensitive and typical sites. For $SedQC_{SCS}$ (sensitive contaminated sites), the PELs for individual contaminants of potential concern (COPCs) were multiplied by the mean PEL-Q value that corresponded to a 20% probability of observing toxicity in freshwater amphipods (P_{20} freshwater = 0.62). This adjustment factor was applied to both freshwater and marine PELs because a P_{20} value for marine sediments could not be determined at the time. For $SedQC_{TCS}$ (typical contaminated sites), the PELs for individual COPCs were multiplied by the average of the mean PEL-Q values corresponding to a 50% probability of observing toxicity in freshwater and marine amphipods (P_{50} average = 1.2).

Therefore, the current sediment standards are fundamentally CCME PELs (CCME, 1995; 1999a,b; 2025) adjusted by factors derived from specific amphipod toxicity datasets to align with pre-defined risk probabilities based on adverse effects for the benthic community.

Intended Protection Level and Scope:

The existing sediment standards primarily protect benthic invertebrates (MacDonald et al., 2003; MWLAP, 2003) with the protection goal of maintaining both the diversity and abundance of the benthic invertebrate community and the food source for higher trophic levels. The derivation methodology is explicitly linked to the survival and growth responses of these sediment-dwelling organisms. While the SMOs included a general aim to minimize risks to organisms at higher trophic levels, the derivation process itself did not directly or systematically incorporate bioaccumulation pathways or specific protection goals for wildlife or human consumers of aquatic biota (MacDonald et al., 2003; MWLAP, 2003).

Consequently, the scope of the sediment standards in Schedule 3.4 is limited to direct toxicity to sediment-dwelling organisms, with separate, non-integrated Tissue Residue Guidelines (TRGs) suggested for addressing bioaccumulation concerns (MWLAP, 2003; Lachmuth et al., 2010; Arblaster et al, 2015; McTavish et al., 2024).

In 2017, the CSR Omnibus Amendment renamed the SedQC to sediment standards, but the values remained unchanged (CSR, 2017).

B. Identified Issues and Deficiencies with Existing Sediment Standards:

At the time that the 2003 standards were derived, it was acknowledged that there were limitations to the derived standards, and that gaps were present in their application. A thorough review, incorporating insights from contemporary scientific literature and regulatory advancements, revealed several issues and deficiencies with the current sediment standards:

- **Lack of Protection for Non-Benthic Receptors (via Direct Exposure)**: While designed to protect benthic invertebrates, the adequacy of the standards for safeguarding other ecological receptors, such as fish (e.g., eggs laid in sediment, demersal fish in direct contact with sediment) or sediment-associated wildlife (e.g. diving ducks, moose), from direct exposure to contaminants is not explicitly demonstrated by the original derivation method (MacDonald et al., 2003; MWLAP, 2003). Human health risks from direct contact with contaminated sediments (e.g., during recreational and subsistence activities) are also not directly addressed by these ecologically based standards. CSR Protocol 1 states the CSR soil standards for human health should be applied for direct sediment contact by people (BC ENV, 2023). However, it is worth noting that the application of soil standards in lieu of sediment standards do not take into account the differences between the two media in terms of bioaccessibility of metals, adherence of media to skin, differing exposure durations, etc. (Bright et al, 2006; Wilson et al, 2013, 2015).
- **Inadequate Consideration of Indirect Exposure Pathways (via Food Exposure)**: A significant deficiency is the absence of systematic integration of indirect exposure pathways. This particularly concerns accumulation of contaminants from sediment to benthic invertebrates and other lower trophic levels, then the food chain transfer (bioaccumulation and biomagnification) to fish, and subsequently to piscivorous wildlife as well as humans (Alava et al., 2012, 2016; Arblaster et al., 2015; BC ENV, 2017b; Lachmuth et al., 2010; US EPA, 2002; Weisbrod et al., 2007; CSAP Society, 2015). The reliance on separate TRGs, without a clear, integrated mechanism to translate these back to protective sediment concentrations within Schedule 3.4, means this critical risk pathway is not directly managed by the numerical sediment standards themselves (MWLAP, 2003). This was also a finding of the Contaminated Sites Approved Professionals (CSAP) Society's 2015 Bioaccumulation Research Project (CSAP Society, 2015). This gap is particularly critical for persistent, bioaccumulative, and toxic (PBT) substances like mercury, polychlorinated biphenyls (PCBs), and dioxins/furans (CSAP Society, 2015).
- **Limited Bioavailability Considerations**: The standards are primarily based on total bulk sediment concentrations. They do not systematically incorporate key factors known to influence contaminant bioavailability, such as sediment organic carbon (OC) content (for organic contaminants) or Acid Volatile Sulfides (AVS) and simultaneously extracted metals (SEM; for certain metals) (Allen, 2011; BCWLAP,

2003; CSR, 2023; McGrath et al., 2019; Parsons et al., 2007; Wenning et al., 2005). This can lead to inaccuracies in risk prediction, potentially resulting in under- or over-protection depending on site-specific sediment geochemistry.

- **Lack of Human Health Bioavailability Considerations:** The current standards generally assume default bioavailability (often 100%) for human exposure pathways, failing to account for matrix effects that reduce the amount of contaminant available to and absorbed by the body. This includes the reduced oral bioaccessibility of metals (e.g., arsenic, lead) in sediment (compared to the soluble salts used in toxicity studies) as well as differences in dermal absorption and skin adherence between wet sediment and dry soil. Failing to account for these relative bioavailability differences can lead to inaccurate characterization and overprediction of human health risks (Health Canada, 2017, 2018).
- **Outdated Toxicological Data & Approaches**: The underlying PELs (CCME, 1995) and the toxicity data used for deriving adjustment factors (MacDonald et al., 2003) are now over two decades old. Substantial advancements have since occurred in ecotoxicology, including improved understanding of chronic and sublethal effects, mixture toxicity, and the development of more sensitive testing protocols and endpoints (BC ENV, 2024; CCME, 1999a; Warne et al., 2018; Yan et al., 2023). Modern probabilistic approaches like Species Sensitivity Distributions (SSDs) or Benchmark Dose (BMD) modeling were not central to the original derivation (BC ENV, 2024; CCME, 1999a).
- **Emerging Contaminants**: The current list of contaminants in Schedule 3.4 does not include many substances now recognized as emerging contaminants. These include per- and polyfluoroalkyl substances (PFAS), numerous current-use pesticides, N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD), and, pharmaceuticals, personal care products, and microplastics (CCME, 1999a; USEPA, 2002; SETAC, 2021; Casado-Martinez et al., 2021; Owens, 2025; Okoro et al., 2011). The methodology previously used in the sediment standards derivations cannot be used for emerging contaminants, as the data in the BEDS database is outdated (it is no longer updated) and measures of these emerging contaminants were never included in this data set, so it is not scientifically relevant.
- **Static Nature**: BC's sediment standards have not undergone regular, comprehensive reviews and updates comparable to standards for soil and water under the CSR. This has led to a divergence from current scientific best practices and the approaches taken in other leading jurisdictions (CSAP Society, 2017; US EPA, 2005). For example, the 2017 CSR Omnibus Amendments, which updated many soil and water standards, explicitly noted that the numerical limits for sediment contaminants remained unchanged at that time (CSR, 2017).
- **Absence of First Nations Engagement in Derivation**: At the time of the derivation (2003), engagement with stakeholders, First Nations rights holders and other affected parties, was not conducted.

- **Limited Consideration for Mixture Effects**: The potential for antagonistic, synergistic or additive effects of contaminants being present in sediment (save for those present within the BEDS dataset) and their subsequent toxicity impacts of sediment-exposed receptors (either directly exposed or exposure through diet/food-web) was not considered in the derivation of the current sediment standards.

C. State of the Science for Sediment Standards Development:

Modern sediment standards, proposed to replace/update those in Schedule 3.4, should integrate contemporary scientific concepts and advanced methodologies (Chapman et al., 2002, Wenning et al., 2005; US EPA, 2002; Chapman, 1989).

Modern Scientific Concepts and Principles:

- **Equilibrium Partitioning (EqP) Theory**: This theory is foundational, positing that the bioavailability and toxicity of many contaminants to the benthic community are primarily related to their freely dissolved concentration in sediment porewater, which is assumed to be in equilibrium with sediment-bound phases (Di Toro et al., 1991; US EPA, 2003; McGrath et al., 2019). This principle underpins the United States Environmental Protection Agency's (US EPA) Equilibrium Partitioning Sediment Benchmarks (ESBs) and allows for the normalization of contaminant concentrations based on key sediment properties, such as OC content for hydrophobic organic contaminants (HOCs) and AVS/SEM ratios for certain metals (Ankley et al., 1996; US EPA, 2005).
- **Bioavailability Assessment**: Moving beyond basic EqP, a comprehensive bioavailability assessment considers the complex interactions of contaminants with various sediment phases (e.g., black carbon for polycyclic aromatic hydrocarbons (PAHs), iron/manganese oxides for metals). The use of advanced tools like passive sampling devices (PSDs) to directly measure bioavailable concentrations in porewater represents a significant advancement (US EPA, 2012; Wenning et al., 2005; Allen, 2011; Maruya et al., 2012). Mechanistic evaluations of cause-effect relationships, such as those by Fuchsman et al. (2006) for PCBs, further underscore the importance of accurate bioavailability assessments.
- **Human Health Bioavailability & Bioaccessibility:** Modern frameworks increasingly distinguish between the total bulk concentration of a contaminant present in environmental media and the fraction available for absorption by humans (bioavailability). For incidental ingestion, Relative Bioavailability (RBA) adjustments can be derived using In Vitro Bioaccessibility (IVBA) assays to estimate the fraction of contaminants (particularly metals) soluble in the gastrointestinal tract (Health Canada, 2018). For dermal exposure, assessing sediment-specific adherence factors, which often differ from dry soil due to moisture and particle size, ensures a more accurate calculation of the absorbed dose (Health Canada, 2017). When

adjusting for bioavailability to estimate an 'absorbed dose,' care must be taken to avoid disconnects with existing Toxicity Reference Values (TRVs) in risk frameworks, as many Tolerable Daily Intakes (TDIs) and oral Reference Doses (RfDs) are established based on 'administered dose' studies rather than absorbed dose.

- **Bioaccumulation Factors**: The biota-sediment accumulation factor (BSAF) should be considered for standard derivation. Application of these factors, potentially into food web models (see below) can protect all trophic level organisms along with their specific habitat or critical habitat (Alava et al. 2012; Arblaster et al., 2015). Through understanding the toxicity reference values or toxicological threshold concentrations for a contaminant for a given species of concern (e.g., apex predators such as fish-eating killer whales, harbour seals and humans, including Indigenous people heavily reliant on traditional seafoods), we can use BSAF to calculate the sediment concentration that result in an accumulated tissue concentration less that the threshold (i.e., Csediment = toxicity reference value [TRV]/ BSAF) (Alava et al. 2012; Alava et. al 2016; Arblaster et al., 2015; Gobas and Arnot, 2010).
- **Critical Body Residue (CBR) / Tissue Residue Approach**: This approach links adverse biological effects directly to the internal contaminant concentrations within organisms, rather than relying solely on external sediment concentrations. This provides a more direct measure of dose and potential risk and is particularly crucial for understanding the impacts of bioaccumulative substances (McCarty & Mackay, 1993; US EPA, 2002; CSAP Society, 2015).
- **Food Web Modeling (FWM)**: Quantitative FWMs are essential tools for assessing risks to wildlife and human consumers. These models simulate the transfer and potential biomagnification of contaminants through multiple trophic levels of an aquatic ecosystem, starting from concentrations in abiotic compartments like sediment and water (Greenfield et al., 2014; Arnot & Gobas, 2004; von Stackelberg et al., 2017)
- **Weight-of-Evidence (WoE) / Sediment Quality Triad (SQT)**: The SQT, pioneered by Chapman (1990), and broader WoE frameworks integrate multiple LOEs, typically including sediment chemistry, laboratory toxicity tests, and *in-situ* benthic community assessments (plus bioaccumulation data) to provide a more holistic assessment than chemical criteria alone (Chapman et al., 1997; Chapman et al., 2002; Wenning et al., 2005; Manfra et al., 2021).
- **Species Sensitivity Distributions (SSDs)**: SSDs are probabilistic models that describe the statistical distribution of toxicity thresholds across a diverse range of species. They allow for the derivation of protective contaminant concentrations, such as the Hazardous Concentration for 5% of species (HC_5), based on a pre-defined level of ecological protection (CCME, 2005; Posthuma et al., 2002; Warne et al., 2018; US EPA, 2016; BC ENV, 2025).

- **Adverse Outcome Pathways (AOPs)**: AOP provides a structured, mechanism-based framework or information tool that describes the linkage between a molecular initiating event (MIE) caused by a stressor and an adverse outcome relevant through a sequential series of causal key events (KEs). AOP can be applied to risk assessment (e.g., at the individual or population level). When sufficient quantitative information is available to describe dose-response and/or response-response relationships among MIEs, KEs and adverse outcomes; a quantitative AOP (qAOP) can be used to identify the point of departure that causes an adverse outcome in a dose-response assessment (Battistoni et al., 2019; Perkins et al., 2019). While AOP is still an evolving field for direct standard/guideline derivation, AOPs can help in understanding mechanisms of toxicity, selecting relevant toxicological endpoints, and identifying data gaps (Ankley et al., 2010; Chhipi-Shrestha et al., 2022).
- **Sediment-Ecosystem Regional Assessment (SEcoRA)**: Beyond traditional chemical and toxicological assessments, a modern framework should also consider the broader conceptual framework provided by the SEcoRA. This approach emphasizes understanding the dynamic interactions of sediment status, defined by its quality (e.g., composition, contaminants), quantity, transport dynamics, and location, on diverse ecological endpoints at the landscape or watershed scale. This holistic view recognizes sediments' multifaceted roles as critical habitats, valuable resources, and important indicators of ecosystem health. This holistic approach moves beyond a sole focus on contamination to integrate the broader range of ecosystem functions sediments provide (Apitz, 2012).
- **Rights-Based Protection and Indigenous Knowledge Integration:** A foundational principle for setting environmental quality standards/guideline in Canada is the recognition and protection of Indigenous rights. The WQCIU Report establishes a framework in its *Indigenous Water Use Conceptual Model* (Olsgard et al., 2023). This model, co-developed with First Nations, defines protection goals that extend beyond direct toxicity to include the safety of traditional foods and medicines, the health of culturally significant wildlife, and the overall integrity of the ecosystem as it supports traditional lifeways (Olsgard et al., 2023). It recognizes that human health and ecosystem health are inseparable. This holistic, rights-based approach represents an innovative shift for developing standards that aim to be protective of all users and uses of aquatic environments in BC.

Advanced Techniques and Methodological Approaches:

- **Advanced Toxicity Testing**: Modern approaches emphasize the use of chronic and sublethal endpoints (e.g., effects on survival, growth, reproduction, development), multi-species tests, and in-situ bioassays to provide more ecologically relevant data (US EPA, 1994, 1999, 2015). Development of standard

test methods for emerging contaminants and unique materials like sediment-associated nanoparticles is ongoing. Under the Canadian Environmental Protection Act (CEPA), Canada is moving forward with the use of new approach methods (NAM) in toxicity testing for chemical risk assessments (Government of Canada, 2025); the methods proposed here could be of use in standards/guideline development.

- **Bioavailability Measurement Tools**: Routine use of OC normalization for HOCs and AVS/SEM analysis for relevant metals is becoming standard practice (US EPA, 2005; McGrath et al., 2019; Wenning et al., 2005; Allen, 2011; Greenberg et al., 2014). Advanced tools like passive sampling devices (e.g., Solid Phase Microextraction (SPME), Polyethylene (PE) strips, Diffusive Gradients in Thin Films) for measuring freely dissolved concentrations (Cfree) in porewater offer more direct measures of the bioavailable fraction (US EPA, 2012). With passive samplers, clear standardized methods and materials will need to be developed in order to maintain analytical results consistency, as this analysis is not widely used.
- **Bioaccumulation Assessment**: This includes standardized laboratory bioaccumulation tests with relevant benthic species (e.g., ASTM, 2017), the compilation and critical evaluation of Biota-Sediment Accumulation Factors (BSAFs), and the application of dynamic or steady-state FWMs (US EPA, 2000; US EPA, 2002; Weisbrod et al., 2007; CSAP Society, 2015; Greenfield et al., 2014).
- **Benthic Community Assessment**: Beyond basic diversity indices, advanced assessments incorporate multivariate statistical analyses to discern relationships between community structure and multiple stressors and include functional endpoints such as secondary production where feasible (Chapman et al., 2002; Wenning et al., 2005).
- **Environmental DNA (eDNA)**: The use of eDNA analysis is an emerging tool for assessing biodiversity in aquatic environments (Hobbs et al. 2016; Goldberg et al. 2017). This non-invasive method can complement traditional benthic community assessments by providing broader taxonomic coverage and detecting species at low densities or in difficult-to-sample habitats (Chariton et al, 2014; Graham et al., 2019). While it holds significant promise for future ecological risk assessments and monitoring programs, the TWG review noted that methodologies are not yet fully standardized for routine regulatory use and results between labs tend to vary widely. Therefore, it is considered a long-term opportunity that requires further research and method validation.
- **Probabilistic Risk Assessment & Modeling**: The application of SSDs for guideline derivation is a key example of probabilistic modeling that is already accepted for use in standards derivation (Warne et al., 2018; US EPA, 2016). Monte Carlo simulations can be used to quantitatively incorporate uncertainty into risk assessments, and Bayesian statistical approaches (e.g., Bayesian Networks or BN) offer powerful methods for integrating diverse datasets and updating

assessments as new information becomes available (Cains and Henshel, 2021, 2024; Landis 2017, 2020; Flinders et al., 2025; Warren-Hicks & Moore, 1998; Warne et al., 2018; US EPA, 2016).

- **"Omics" Technologies**: Metagenomics and functional potential evaluation are actively utilized, present-day technologies. By sequencing the entire microbial community (microbiome) of the sediment, shifts in metabolic pathways can be detected. Algorithms can translate this data into actionable insights (e.g., confirming bioremediation is successfully breaking down toxins). Utilizing metagenomics allows practitioners to demonstrate the functional 'Restoration' of nutrient cycling, moving beyond mere chemical 'Compliance' (demonstrating low toxicity).
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Options for Incorporation into a Modernized BC Framework:

A modernized BC framework for sediment quality assessments (including sediment standards development) should aim to incorporate the strengths of identified contemporary scientific concepts and techniques. These concepts/techniques include:

- Developing sediment standards protective against the effects of direct exposure (ecological and human receptors) to contaminants.
- Developing distinct food pathway and bioaccumulation-protective sediment standards.
- Establishing a current condition screening process with triggers based on regional 'current conditions,' as pioneered in the WQCIU report, to prevent further deterioration of aquatic ecosystems (Olsgard et al., 2023).
- Expanding the existing two-tiered assessment framework (generic numerical and site-specific risk-based standards) to include a new middle tier providing the option for site-specific numerical standards. The new tier involves modifying sediment standards based on site-specific information, similar to what is specified in Protocol 2 for derivation of site-specific soil standards (e.g., bioavailability, cause and effect models, etc.).
- Expanding the list of regulated contaminants to proactively include standards or defensible assessment strategies for emerging substances of concern relevant to BC environments (CCME, 2025; SETAC, 2021).
- Establishing a regular and transparent review cycle for updating the sediment standards and the underlying framework to ensure they remain aligned with the

recently published literature and modern approaches and evolving environmental challenges (CSAP Society, 2017; Landis et al., 2016; US EPA, 2005).

These options were presented, and feedback was requested via online survey (Section IV, Part A) and at the Canadian Ecotoxicology Workshop (CEW) held in Victoria on October 7, 2025 (Section IV, Part B). After CEW, a Technical Working Group (TWG) was convened to provide further input on the development of a sediment standards derivation framework (Section IV, Part C).

III. Jurisdictional Scan

This section presents the results of how sediments are evaluated in Canadian provinces, federal Canadian agencies, the federal and state-level agencies from the United States, the European Union, Australia/New Zealand, and select countries in Asia. See **Appendix B** for the list of jurisdictions included in this jurisdictional scan.

A. Methodology

The jurisdictional scan involved a preliminary, targeted review of publicly available regulatory documents, technical guidance, and scientific literature from leading government agencies in Canada, the United States, Europe, Australia/New Zealand, and Asia. Jurisdictions were selected based on their relevance to BC's environmental context and the use of modern or innovative approaches to sediment quality management. The scope focused on how different agencies derive screening values, address bioavailability and bioaccumulation, and integrate these into regulatory decision-making. Detailed methodology for the jurisdictional review is provided in **Appendix A**.

B. Overview of Approaches in Other Government Agencies

The following sections present the findings of jurisdictional scan. For more information, including reference documents and links to primary websites, see **Appendix B**.

Indigenous-led Frameworks

Tsleil-Waututh Nation and the Province of BC: Water Quality Objectives for Burrard Inlet (səlilwət): The updated Water Quality Objectives (WQOs) for Burrard Inlet represent a historic precedent for environmental governance in British Columbia. Initiated by the Tsleil-Waututh Nation's (TWN) *Burrard Inlet Action Plan*, these objectives were co-developed and co-signed by the Nation and the Province (ENV and the Ministry of Water, Land and Resource Stewardship). This framework explicitly weaves Indigenous Knowledge with Western science, establishing objectives based on

the protection of cultural practices and the consumption of traditional seafoods (TWN, 2021; BC ENV, 2024). Key innovations include:

- **Seafood Consumption Protection:** Utilizing tissue screening benchmarks derived from health-based TRVs but adapted to reflect the higher consumption rates of Indigenous rights-holders compared to the general population.
- **Sediment Benchmarks:** The framework includes specific numerical objectives for sediment to protect benthic life and prevent bioaccumulation, explicitly noting the need for site-specific adjustments such as Total Organic Carbon (TOC) normalization for organic contaminants (e.g., PAHs, PCBs).
- **Holistic Goals:** The objectives are designed to support the TWN vision that "when the tide goes out, the table is set," ensuring the Inlet is safe for ceremonial use and subsistence harvesting.

Athabasca Chipewyan, Fort McKay, and Mikisew Cree First Nations: Water and Sediment Quality Criteria for the Protection of Indigenous Use (WQCIU): The WQCIU Report, developed for the Athabasca Chipewyan, Fort McKay, and Mikisew Cree First Nations, represents a paradigm shift in environmental standard-setting in Canada (Olsgard et al., 2023). Unlike other documents in this scan, the WQCIU framework is not merely guidance; it is a framework developed by and for First Nations to define protective conditions for their territories, reflecting their rights and traditional uses. A critical finding of this review, this framework is a leading model for integrating Indigenous rights and uses with modern science. Specifically, the WQCIU's Indigenous Water Use Conceptual Model may be helpful for defining protection goals and its Bioaccumulation Based Sediment Guideline Values (BBSGV) methodology for deriving food-web protective standards. Its placement in this scan reflects its scientific innovation and its unique legal and cultural standing.

The framework is built on a dual-derivation approach:

- **Health Risk-Based Criteria**: These are derived using a WoE approach that integrates a jurisdictional scan, spiked-sediment toxicity data, and a novel BBSGV methodology to protect human and wildlife consumers. A key innovation is the use of community-specific traditional food ingestion rates (e.g., 388 g/day for fish) gathered through a collaborative community survey, resulting in criteria that are significantly more protective than those based on general population consumption rates.
- **Current Condition Values**: These serve as anti-degradation benchmarks, established by statistically analyzing recent, seasonal monitoring data to define the existing range of water and sediment quality. The principle is to prevent any further deterioration of the environment from its current state.

Applicability to Marine Environments: It is acknowledged that the numerical criteria in the WQCIU Report were derived specifically for a freshwater riverine

system. However, the framework itself, specifically the methodology for integrating Indigenous-specific consumption rates and bioaccumulation pathways into standard derivation, is environment-neutral. This process provides a directly transferable model for developing marine and estuarine sediment standards in British Columbia, provided that marine-specific toxicity data and food web dynamics are substituted into the derivation equations.

Scope and Limitations: Users should be aware that the WQCIU criteria are explicitly derived to protect "Indigenous Use," defined here as subsistence harvesting (consumption of water, fish, wildlife, and plants) and cultural practices. Consequently, the report does not explicitly derive criteria for standard recreational scenarios (e.g., swimming, boating) or specific child exposure scenarios (e.g., incidental sediment ingestion during play) distinct from the dietary pathway. While the dietary protection derived for Indigenous adults (who typically exhibit the highest consumption rates) is likely protective of many other uses, these specific recreational and child-centric receptor/pathway combinations were not the primary drivers for the derived values and confirmation of the most sensitive receptor-exposure pathway combination should be considered in the development of future human health-protective standards.

The entire framework is guided by an Indigenous Water Use Conceptual Model, which defines four interconnected protection goals: Traditional Foods and Drinking Water, Traditional Medicines, Aquatic Ecosystem Health, and Wildlife Health (Olsgard et al., 2023). This holistic model ensures that criteria protect not just individual receptors from direct toxicity, but the entire ecosystem and the cultural practices that depend on it.

Canadian Jurisdictions (Federal, Provincial)

British Columbia (Ambient Water Quality Frameworks): While the CSR governs contaminated sites, the provincial management of ambient aquatic ecosystems relies on a distinct, policy-driven hierarchy that complements the regulatory standards (ENV, 2025).

- **Approved Water Quality Guidelines (WQGs)**: These are province-wide, science-based benchmarks for water, sediment, and biota. They are derived using rigorous protocols (often preferring Species Sensitivity Distributions) to protect the most sensitive water uses. Notable examples include recent sediment guidelines for metals that incorporate bioavailability adjustments (e.g., copper).
- **Working Water Quality Guidelines (WWQGs)**: Serving as interim benchmarks for substances without Approved WQGs, these are adopted from other

jurisdictions (e.g., CCME, US EPA) based on a strict hierarchy of preferences. The 2024 update significantly expanded the list of WWQGs for sediment, providing immediate screening values for emerging contaminants not yet listed in the CSR.

- **Water Quality Objectives (WQOs)**: These are site-specific policy benchmarks established for specific waterbodies (e.g., Burrard Inlet, Elk Valley). WQOs are derived when generic guidelines are unsuitable, allowing for the modification of benchmarks based on local background conditions, resident species, or water effect ratios. While not legally binding remediation standards in isolation, WQOs must be considered in statutory decision-making and offer a validated technical precedent for the "Tier 2" site-specific adjustments proposed in this modernization framework.

CCME: Provides national baseline guidance with Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs) derived from empirical co-occurrence data, primarily focused on benthic invertebrate protection. The CCME PELs were adopted as preliminary benchmarks in the 2003 BC SedQC development process. The derivation methodology for SQGs, focusing on direct benthic toxicity, was outlined in a 1995 protocol (CCME, 1995) and further detailed in later substance-specific documents (see the Canadian Environmental Quality Guidelines website [referenced in **Appendix B**]).

ECCC (Environment and Climate Change Canada): Develops Federal Environmental Quality Guidelines (FEQGs) for priority substances for select environmental media, sometimes including sediment, often to fill gaps or update CCME values.

Ontario MECP (Ministry of the Environment, Conservation and Parks): Employs Provincial Sediment Quality Guidelines with three tiers: No Effect Level (NEL), Lowest Effect Level (LEL), and Severe Effect Level (SEL), based on empirical data and used within a WoE framework. The NEL aims for no toxic effects and no food chain biomagnification, while LEL signifies marginal pollution and SEL indicates heavy contamination requiring management.

Quebec MELCC (Ministère de l’Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parc): Uses a five-tiered system (Rare Effect Level - REL, Occasional Effect Level - OEL, Threshold Effect Level - TEL, Probable Effect Level - PEL, Frequent Effect Level - FEL) derived from CCME's database to support sediment management decisions, including dredging. These criteria are used as screening tools, often with natural background levels and toxicity testing (Environment Canada & Ministère du Développement durable, Environnement et des Parcs du Québec, 2008).

Atlantic RBCA (Risk-Based Corrective Action): Provides Tier 1 Ecological Screening Levels (ESLs) for petroleum hydrocarbons (PHCs), incorporating EqP and OC normalization. Other contaminants often reference CCME PELs. This framework favors realistic effect thresholds (PEL-level) for Tier 1 screening. Rationale and guidance on the Atlantic RBCA framework including sediment standards is provided in Atlantic RBCA (2023).

Alberta Environment and Parks (AEP) & Alberta Energy Regulator (AER): Primarily relies on CCME SQGs for sediment, within a broader tiered framework for contaminated sites.

Selected International Jurisdictions

US EPA:

- **Equilibrium Partitioning Sediment Benchmarks (ESBs):** Mechanistically derived benchmarks for non-ionic organics (OC-normalized) and metals (AVS/SEM-based), focused on porewater exposure and direct toxicity protection. ESBs derive sediment criteria from water quality benchmarks by accounting for bioavailability. The approach does not explicitly incorporate bioaccumulation in its derivation.
- **National Contingency Plan (NCP)/ Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as "Superfund"):** Employs a risk-based approach for site cleanup, not generic SQGs, but ESBs and other screening values (e.g., Effects Range Low / Effects Range Median (ERLs/ERMs), TELs/PELs from the National Oceanic and Atmospheric Association (NOAA; 2025)) are used in initial assessments.
- **Great Lakes Water Quality Guidance Agreement (GLWQA):** Focuses on Bioaccumulative Chemicals of Concern (BCCs), with methodologies for deriving criteria protective of aquatic life, human health, and wildlife, incorporating bioaccumulation factors (BAFs)/BSAFs.

Interstate Technology & Regulatory Council (ITRC): The ITRC is a United States-based, state-led coalition that includes members from all 50 states, federal agencies, industry, and academia. It is not a regulatory agency, but a consensus-building organization focused on reducing barriers to innovative environmental technologies and promoting regulatory consistency. The ITRC develops comprehensive technical guidance documents and training on a wide array of environmental topics, including contaminated sediments, bioavailability, and risk assessment. Its guidance is highly influential in shaping state-level regulatory approaches and represents a broad consensus on best practices. Key ITRC contributions include a foundational framework for incorporating bioavailability into sediment assessments (e.g., OC and AVS/SEM normalization) for both direct benthic exposure and food-web transfer pathways, as well

as a comprehensive six-step framework for evaluating and selecting sediment remedies. ITRC resources include only guidance documents; they do not provide sediment screening values.

Washington State (Department of Ecology): The Sediment Management Standards (SMS; WAC 173-204) provide a comprehensive regulatory framework. This includes numeric chemical Sediment Quality Standards (SQSs) ("no adverse effects") and Cleanup Screening Levels (CSL) ("minor adverse effects"). Biological testing criteria (toxicity and benthic infauna) are integrated, and human health protection goals are included. OC normalization is used for some organics.

California SWRCB/OEHHA (State Water Resources Control Board/Office of Environmental Health Hazard Assessment): Employs narrative Sediment Quality Objectives (SQOs) implemented via a WoE Triad approach (chemistry, toxicity, benthic community) for aquatic life protection. Human health protection is linked to fish tissue contaminant goals (OEHHA Advisory Tissue Levels - ATLs) and bioaccumulation modeling (SWRCB, 2018).

Florida DEP (Department of Environmental Protection): Uses Sediment Quality Assessment Guidelines (SQAGs) based on TEL/PEL concepts (Minimal, Possible, Probable Effects Ranges). Includes geochemical normalization for metals and specific bioaccumulation-based SQAGs for wildlife/human health.

European Union WFD/SedNet (Water Framework Directive/Sediment Network): No European Union (EU)-wide numerical sediment standards exist. The WFD requires "good ecological and chemical status," with Member States developing national approaches. SedNet promotes integrated, risk-based sediment management using WoE. Focus is often on source control and River Basin Management Plans (EU, 2000).

Netherlands (RIVM): The National Institute for Public Health and the Environment (RIVM) follows a rigorous protocol for deriving Environmental Risk Limits (ERLs) for sediment, detailed in the *Guidance for the Derivation of Environmental Risk Limits* (RIVM, 2015).

- **Tiered Risk Framework:** The framework establishes distinct protection levels: the Negligible Concentration (NC) (representing the long-term target), the Maximum Permissible Concentration (MPC) (the standard for ecosystem protection), and the Serious Risk Concentration (SRC) (the "Intervention Value" triggering potential remediation urgency).
- **Harmonized Derivation (EqP):** To ensure consistency between water and sediment regulation, sediment standards for organic substances are frequently derived from water quality standards using Equilibrium Partitioning (EqP) theory.

This ensures that benthic organisms and water column species are protected to an equivalent level of risk.

- **Preferred Calculation Methods:** When sufficient sediment-specific toxicity data exists, the framework prioritizes the use of Species Sensitivity Distributions (SSDs) to derive the HC5 (Hazardous Concentration for 5% of species). For naturally occurring metals, an "Added Risk" approach is often used to distinguish anthropogenic pollution from background levels.
- **Bioavailability (Standard Sediment):** All numerical standards are defined for a "Standard Sediment" (10% organic matter and 25% clay). Site-specific compliance requires normalizing measured field concentrations to this standard composition, explicitly accounting for bioavailability.

Australia & New Zealand Governments (ANZG): Provides Default Guideline Values (DGVs, often TEL-based) and Guideline Values-High (GV-high, often PEL-based) (ANZG, 2019). Emphasizes WoE for exceedances and OC normalization (0.2-10%) for HOCs. SSDs are increasingly used for derivation.

China: Has a national marine sediment standard (GB 18668-2002) with three quality classes. The Ministry of Ecology and Environment (MEE) has technical guidelines for deriving Water Quality Criteria (HJ 831-2017) using SSDs, excluding bioaccumulative chemicals from this specific method.

Japan MOE (Ministry of the Environment): Focuses on water and effluent standards. Sediment management is often linked to controlling specific pollutants (e.g., mercury, dioxins) based on health risks or specific incidents, rather than a broad suite of numerical screening values.

C. Innovative or Noteworthy Approaches and Best Practices

The review of available regulatory resources provided information on the approaches and methods employed to assess and evaluate potential risks associated with contaminants in sediment. Innovative or novel approaches that were noted through the review of the above-listed references are briefly summarized, as follows:

- **WoE Integration:** Frameworks and guidance in ANZG, Ontario, Washington State, California, and the EU strongly advocate or mandate the use of WoE, combining chemistry, toxicity, and ecological data for more conclusive assessments.
- **Explicit Bioavailability Adjustments:** ECCC FEQGs (OC), US EPA ESBs (OC, AVS/SEM), ANZG (OC normalization), Washington SMS (OC normalization), and Atlantic RBCA (OC normalization for PHCs) explicitly incorporate bioavailability. The use of passive sampling methods (PSMs) for Cfree measurement is an emerging bioavailability assessment tool (US EPA, 2012).
- **Direct Linkage to Bioaccumulation and Human/Wildlife Health:** California's

SQO framework directly links sediment quality to fish tissue objectives for human health. The Great Lakes guidance (US EPA 1995, 2002) and TRG approaches (e.g., CCME) provide mechanisms to protect wildlife. Fisheries and Oceans Canada (DFO 2024) has also published A Framework for the Derivation of Environmental Quality Guidelines that Protect Apex Marine Mammals from Persistent Organic Pollutants (POPs).

- **SSDs:** Use of SSDs for deriving protective concentrations (e.g., ANZG, China's WQC guidance, increasingly in CCME/FEQGs) offers a more statistically valid and transparent method than older empirical percentile approaches.
- **Tiered Assessment Frameworks:** Many jurisdictions (e.g., ANZG, Atlantic RBCA, Ontario, Washington) use a tiered approach, starting with screening against generic guidelines and progressing to more detailed site-specific assessments if initial thresholds are exceeded. CCME soil guidelines also use a similar tiered approach.
- **Adaptive Management and Regular Review:** Some frameworks emphasize the need for periodic review and updates to guidelines to reflect new science.

D. Synthesis and Key Learnings for BC

There is a strong global trend towards incorporating bioavailability adjustments, using WoE approaches, and explicitly protecting against bioaccumulation and food web transfer risks. No single jurisdiction offers a perfect off-the-shelf model for BC, suggesting a hybrid approach is needed, adopting best-practice elements from various frameworks. The Burrard Inlet WQO and the WQCIU Reports provide recent examples of how integrating Indigenous uses with Western science and best practices can be incorporated into a modern sediment standards derivation framework.

Key elements for BC to consider include: Adopting a matrix sediment standard framework protective of human health and ecological receptors (including separate standards for direct and food pathway protection); developing procedures for deriving site-specific sediment standards based on site conditions; expanding contaminant coverage; and establishing a regular update cycle. The move towards more sophisticated assessment will require enhanced technical guidance and capacity building in BC.

A summary of select modern frameworks, including key components related to derivation methods is provided in Table 1.

Table 1. Comparison between BC's and Select Modern Sediment Regulatory Frameworks (Summary)

Feature	BC CSR Schedule 3.4 (Current)	Burrard Inlet WQOs	WQCIU (Olsgard et al., 2023)	US EPA ESBs	US EPA Superfund/ NCP	ANZG 2019	Washington State SMS	California OEHHA/ SQO
Derivation Basis	Empirical (PEL-based)	Dual: Health risk-based and empirical	Dual: Health Risk-Based (HHRA, WoE)	Mechanistic (EqP)	Risk-Based	Empirical (TEL/PEL or SSD-based)	Mixed (Empirical, WoE)	Risk-Based (Tissue) / WoE
Aquatic Settings	FW, Mar, Est	Mar	FW	FW, Mar	Site-Specific	FW, Mar	FW, Mar, Est	Mar, Est
Bioavailability	Limited (Active Zone)	Not explicitly considered	Considered via EqP in BBSGV derivation	OC norm, AVS/SEM	Site-Specific	OC norm (0.2-10%)	OC norm, AVS/SEM	FWM considers
Bioaccumulation/ Food Web	None Explicitly	Explicitly via TRG	Explicitly via BBSGV	None in Derivation	Risk Assessment	WoE includes Bioacc.	Explicit (WoE, TRG)	Explicit (FWM, HHRA link)
Human Health Path	Not Protective	Explicit	Explicit	Not Addressed	HHRA	WoE considers HH risk	HH Risk Addressed	Explicit (Fish Consumption)
Conservatism	Medium	High	High	Medium (direct tox)	Variable	Medium (DGV)	Medium (SMS/CSL)	Variable (ATL/FCG)
Update Mechanism	May be reviewed every 5 years	Iterative updates	N/A (New)	Ad hoc	Site-Specific	Ongoing Revision	Periodic Updates	Periodic Updates

Abbreviations: FW: Freshwater; Mar: Marine; Est: Estuarine; EqP: Equilibrium Partitioning; OC norm: Organic Carbon normalization; AVS/SEM: Acid Volatile Sulfide/Simultaneously Extracted Metals; WoE: Weight-of-Evidence; HH: Human Health; HHRA: Human Health Risk Assessment; TRG: Tissue Residue Guideline; FWM: Food Web Model; TEL: Threshold Effect Level; REL: Rare Effect Level; CSR: Contaminated Sites Regulation; PEL: Probable Effect Level; DGV: Default Guideline Value; SMS: Sediment Management Standard; CSL: Cleanup Screening Level; ATL: Advisory Tissue Level; FCG: Fish Contaminant Goal

IV. Community and Stakeholder Engagement

A comprehensive engagement strategy was implemented to ensure that the modernization of BC's sediment standards was informed by a diverse range of perspectives, knowledge, and practical considerations. The primary objectives of this engagement were:

- To gather input on the scientific and technical aspects of the proposed framework from the public, interested organizations and professionals involved in contaminated sites management.
- To understand potential implementation challenges and opportunities from various user perspectives (e.g., regulators, consultants, industry, First Nations, non-profit organizations).
- To build transparency and support for the updated framework.

Limitations of Engagement: It is important to acknowledge that the feedback summarized in this section reflects the perspectives of a specific subset of the professional community reached through the targeted communication channels utilized (e.g., Site Remediation News, CSAP Society mailing lists, and CEW conference attendees). Consequently, the results are subject to participation and self-selection bias. The findings presented below provide a qualitative snapshot of expert opinion from active practitioners and regulators but do not necessarily represent a statistically random sample of the broader environmental sector, the general public, or all Indigenous rights-holders.

A. Online Survey

The online survey questionnaire was designed and implemented between May 31 and July 31, 2025, and is presented in **Appendix C**.

Dissemination of the survey occurred through government websites, email distribution lists to known stakeholders (e.g., Site Remediation News, CSAP Society, industry associations, non-profit organizations), and social media. The survey was designed to be accessible and understandable to a non-technical audience where appropriate, with sections for more detailed technical input.

Participating stakeholders represented a broad cross-section of the sector, including:

- **Government Agencies:** ENV, BC Ministry of Health, Environment and Climate Change Canada (ECCC), Fisheries and Oceans Canada (DFO), and Health Canada.
- **Indigenous Nations & Organizations:** Tsleil-Waututh Nation and Mikisew First

Nation.

- **Industry & Professional Bodies:** Contaminated Sites Approved Professionals (CSAP) Society and environmental consulting firms (e.g., Active Earth, AtkinsRéalis, Associated Environmental, Ausenco, Azimuth, Core6 Environmental, Craft Environmental, Keystone Environmental, Millennium EMS Consulting, SLR Consulting, WSP).

- **Academia & Non-Profit Organizations:** Simon Fraser University, Western Washington University, Raincoast Conservation Foundation, and the False Creek Friends Society.

The feedback received from the online survey was detailed and consistent and yielded insights into stakeholder priorities concerning sediment standards. Survey results are presented in the "*What We Heard Report*", provided in **Appendix D**. The key themes that emerged from the survey included:

- Widespread dissatisfaction with the status quo and current sediment standards.
- Practical challenges in application of the current sediment standards.
- A call for a broader, more protective scope for new sediment standards.
- A mandate for a more sophisticated, science-based approach to deriving new sediment standards.
- Strong support for clear guidance and education with new sediment standards.

The survey results were instrumental for informing the refinement of the proposed framework and identifying areas requiring further communication or consideration.

Ideally, future phases of the project will significantly expand upon engagement efforts; however, the extent will ultimately be based on available resources and support from partners and volunteers.

B. Canadian Ecotoxicity Workshop Engagement

The CEW took place between October 6th and 8th, 2025. A dedicated half-day session titled "*Holistic Protection of Aquatic Ecosystems - Modern Sediment Quality Assessment*" included presentations, interactive discussions, and a poster session that was sponsored by the Science and Standards Technical Advisory Committee at the CEW. The purpose of this engagement was to solicit in-depth scientific and technical feedback on the proposed framework for modernized sediment standards from Canadian and international ecotoxicology experts, risk assessors, and regulators. Participants were primarily scientific and technical experts attending the CEW.

Guest speakers led interactive discussions covering widespread contamination

challenges, the latest in assessment science, and the critical importance of weaving Indigenous Knowledges and Science into environmental monitoring and protection frameworks.

An overview presentation covered the rationale for updating BC's sediment standards and the proposed framework presented in this report. Interactive discussions and live polling focused on specific themes such as the matrix standards, a tiered framework, and prioritization. The session concluded with presentations and a panel discussion on Weaving Indigenous Knowledges and Science. The CEW session schedule is presented in **Appendix E**, session abstracts are presented in **Appendix F**, and the results of all consultation and polling (including ranked results) are presented in **Appendix G**.

Up to 63 participants contributed to the live polling and discussions, and an additional nine TWG members, who were unable to participate in the live polling, contributed via authenticated online polling after CEW. Key take away messages included:

- Improving matrix standards to **"Distinguish 'direct toxicity' and 'food pathway toxicity' pathways explicitly."**
- **"Push guidance beyond generic numerical standards"** by developing tools and models for Site-Specific Sediment Standards (Tier 2).
- "**Resourcing**" is the greatest constraint moving forward. Many participants identified that the success of this project will be contingent upon a commitment to funding and that some level of permanent staff should be assigned to manage the multiple phases of this project.
- Bioavailability is a recognized priority and needs to be incorporated into the modernized framework.
- Indigenous Use of watersheds is an important concept that is currently missing and should be considered to move toward a **"holistic watershed level"** approach and adopt foundational concepts like **"Landscape as Kin"**.

C. Technical Working Group

With the intent of having inclusive and diverse engagement across consultants, academia and end-users, a technical working group (TWG) was formed to review a draft version (2.5) of this report. TWG members provided input on the clarity and readability of the paper as well as recommendations/edits on what additional should be included. Additionally, the TWG provided their thoughts on paths forward and prioritization objectives in multiple choice and open-ended questions; the results of this feedback are presented in **Appendix J**.

V. Proposed Framework

The following core principles should be used moving forward to guide the development of the proposed Matrix Sediment Standards Framework, forming a foundation that is protective, scientifically defensible, and practical.

- **Protection of Aquatic Health:** Standards should be fundamentally set to protect the health, diversity, and ecological function of benthic ecosystems and all sediment-associated aquatic life.
- **Protection of Wildlife:** The framework should explicitly incorporate mechanisms to safeguard wildlife associated with the bioaccumulation and trophic transfer of contaminants from sediment.
- **Protection of Human Health:** The framework should safeguard human consumers from food-web transfer of contaminants, and direct human contact will also be considered where relevant.
- **Protection of Indigenous Uses and Integration of Indigenous Knowledge**: The framework categorizes the protection of Indigenous Uses (e.g., safely fishing, hunting, and gathering traditional foods and medicines) as a distinct pathway. Furthermore, the integration of Indigenous Knowledge[2] and Science is not limited to addressing these specific traditional uses; rather, it serves as a foundational lens through which all sediment standard development, site assessment, and remediation goals may be viewed.
- **Scientifically Defensible**: Standards derived using the proposed framework should incorporate up-to-date scientific information, employing proven and transparent methodologies such as SSDs, EqP modeling, and FWMs. The framework should address legacy contaminants and prioritize the timely inclusion of relevant emerging contaminants of concern, such as PFAS and pesticides.
- **Practical and Implementable**: While ensuring adequate protection, the framework should strive for practicality in terms of sampling requirements, analytical capabilities, and remediation considerations, supported by clear guidance.
- **Transparent and Clear Communication**: The scientific basis, derivation methods, application protocols, and inherent limitations of the standards should be clearly documented and communicated to all partners and stakeholders.

A. Key Components and Structure

The proposed framework for modernized BC sediment standards should be structured

[2] **Note on Terminology (TEK vs. TK):** While the term *Traditional Ecological Knowledge* (TEK) is often used to describe specific environmental observations (e.g., fish migration timing), this framework adopts the broader terminology of **Indigenous Knowledge** or **Traditional Knowledge (TK)**. This distinction is intentional to ensure that ecological data is not treated in isolation but is understood within the holistic context of Indigenous governance, culture, spirituality, and law ("Two-Eyed Seeing").

around several key components that include understanding of background conditions, derivation of matrix sediment standards, followed by application of these revised standards using a tiered approach. These are described below.

Understanding of Background and Current Conditions

Before new standards can be effectively derived, a province-specific dataset of concentrations of constituents in sediment and other sediment quality parameters is needed. This will involve completing a desktop study to gather data from existing public reports, filling in critical data gaps on background concentrations, bioavailability parameters, and bioaccumulation factors. Compiled information is intended to be incorporated into a BC aquatic database to support development of a modernized sediment framework.

Prioritized procedures should be developed for establishing and considering local background concentrations of contaminants, particularly for naturally occurring metals and organic compounds. Standards should not typically be set below established natural background ranges for a given region or sediment type, when background has been established and can be relied upon.

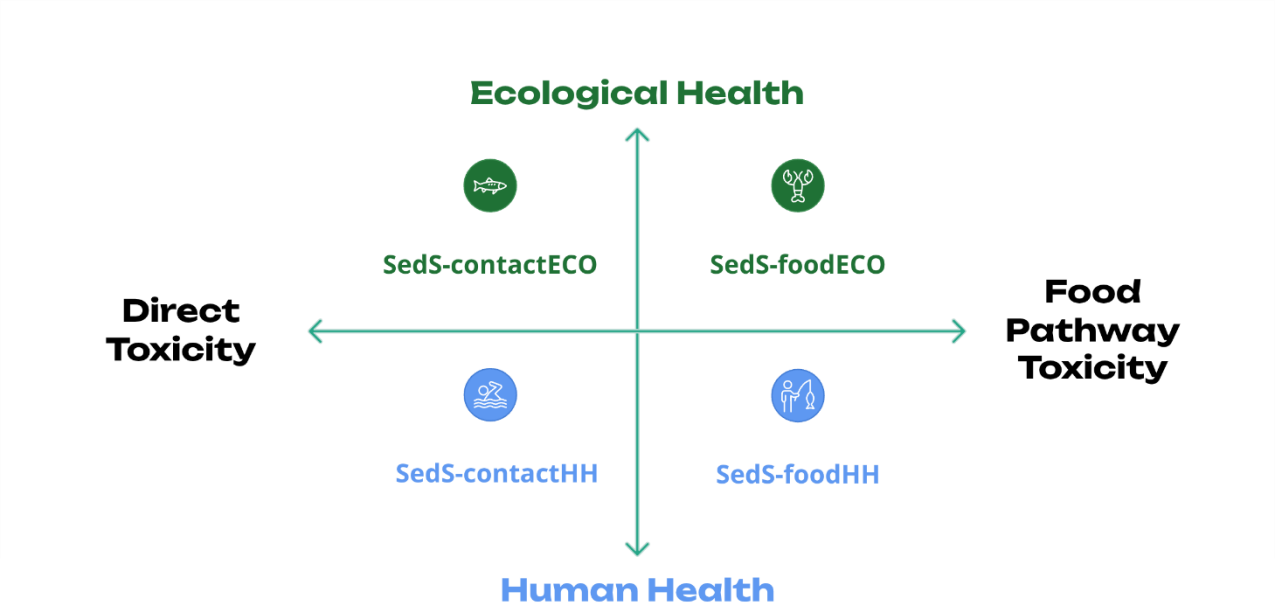
Additionally, baseline conditions and the potential for cumulative impacts on sediments need to be considered. These regional baseline conditions should be addressed at the initiation of investigations, so that a holistic and cumulative assessment can take place. This is to ensure that sediment throughout a region is protected and available for all users, including First Nations rightsholders.

Derivation of Matrix Sediment Standards

To ensure a holistic and comprehensive assessment, a Matrix Sediment Standards Framework is proposed (originally described as the “Dual Standards Approach” in the public survey). This structure organizes standards based on two distinct axes: the protection goal (Ecological Health vs. Human Health) and the primary exposure pathway (Direct Exposure vs. Food Pathway Exposure).

This approach moves beyond a single value for a contaminant, creating a matrix of standards that explicitly addresses the different ways contaminants can pose a risk to different receptors. For any given contaminant, the most stringent of the applicable matrix standards may serve as the primary screening benchmark. The components of this matrix are summarized in Figure 1.

Figure 1: The Matrix Sediment Standards Approach



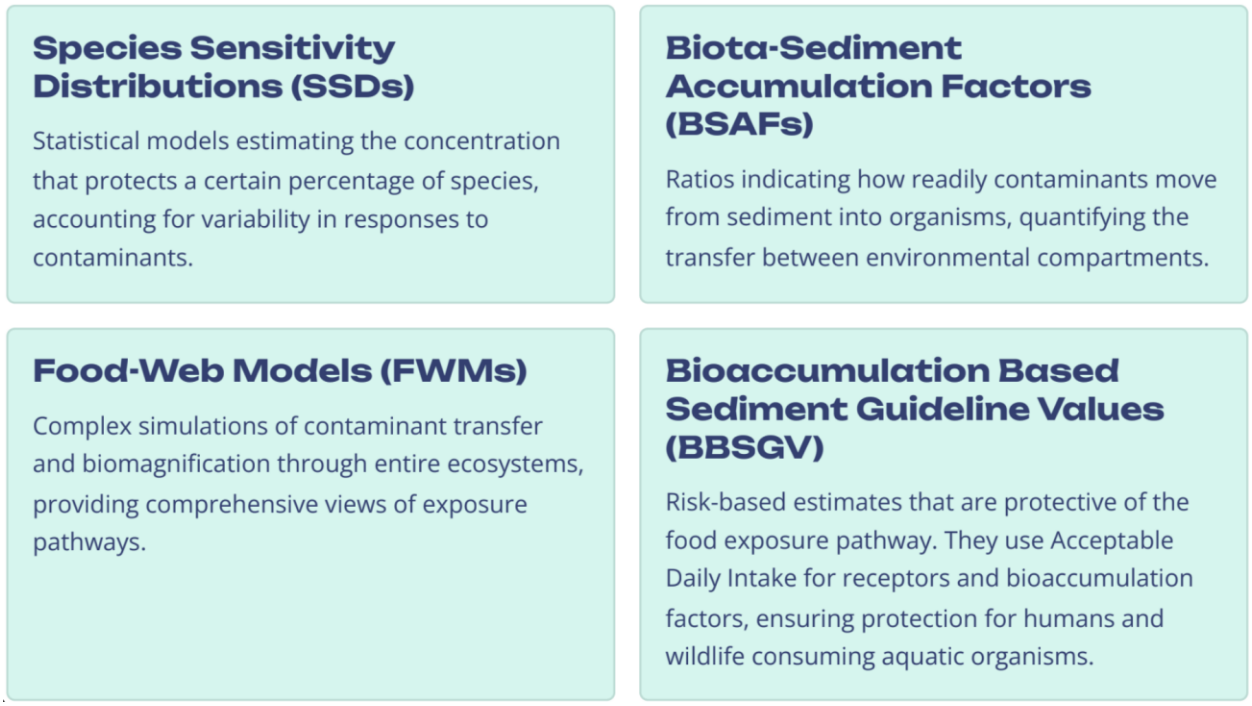
The two primary outputs of this matrix are:

1. **Sediment Standards for Direct Protection (SedS-contact)**
   This standard is designed to protect ecological organisms and people from adverse effects associated with direct exposure to contaminated sediment. Derivation will prioritize methods like SSDs based on chronic aquatic ecological toxicity data (SedS-contact$_{ECO}$) and direct contact risk assessment for human health (SedS-contact$_{HH}$).

2. **Sediment Standard for Bioaccumulation Protection (SedS-food)**
   This standard is designed to protect higher-trophic-level organisms, including piscivorous wildlife (SedS-food$_{ECO}$) and human consumers (including First Nations) of aquatic foods (SedS-food$_{HH}$), from adverse effects of contaminants through food transfer, including bioaccumulation and biomagnification of contaminants through the food web. Derivation involves linking protective TRGs or human health risk-based tissue concentrations back to sediment concentrations using scientifically validated BSAFs, FWMs, or the BBSGV (Figure 2) approach detailed in the WQCIU Report (Olsgard et al., 2023). Derivation of SedS-food$_{HH}$ prioritizes the use of community-specific ingestion rates for traditional foods where available. The inadequacy of current standards is underscored by data indicating coastal First Nations consume seafood at rates approximately 15 times higher than the average Canadian (Mos et al., 2004; Cisneros-Montemayor et al., 2016). Recent studies on 'Restorative Diets'

suggest that even these rates are suppressed baselines (Gavenus et al. 2023). Furthermore, recent research differentiates contaminant loads in 'resident' versus 'migratory' Chinook salmon (Holbert et al., 2023), confirming that near-shore sediment contamination directly drives toxicity in the primary food source for both Indigenous communities and Resident Killer Whales (Ross et al., 2000, 2013).

Figure 2 – Select Components Integrated Within the Matrix Standards



The following additional considerations are proposed to also be taken into account as part of deriving matrix sediment standards:

1. The list of contaminants with sediment standards in Schedule 3.4 is proposed to be expanded to include substances of current and emerging concern in BC. This should involve:
    a. Reviewing and updating standards for currently listed legacy contaminants (metals, PAHs, PCBs, select pesticides) using the up-to-date scientific information and derivation methods outlined. Where possible, studies will include fish and algae in addition to benthic invertebrates.
    b. Developing new guidelines for prioritized emerging contaminants such as PFAS, organotins such as tributyltin (TBT), dioxins/furans (as toxic equivalents or TEQs), relevant current-use pesticides and other emerging contaminants.
    c. Establishing a strategy for addressing micro- and nano-plastics, which may initially involve narrative standards, monitoring triggers, and a commitment to developing numerical thresholds as the science matures.
2. Prioritization Grid Classification System: To transparently manage the expanded list of contaminants, a formal prioritization grid is proposed. This system would weigh occurrence (detection frequency in BC) against hazard (toxicity, persistence, bioaccumulation). This ensures that limited regulatory resources are focused on substances that pose the highest potential risk to BC's aquatic environments, rather than simply adopting every available standard from other jurisdictions.

The grid classification system forms the foundation of the Technical Procedure for Updating CSR Standards with Values Adopted from Other Jurisdictions as “generic sediment standards” due to lack of available information necessary to derive matrix sediment standards or other considerations, which follows a three-step logic:

- Step 1 - Classification Grid: Assessing priority based on Hazard vs. Occurrence.
- Step 2 - Feasibility Assessment: Evaluating data availability, existing values in other jurisdictions, and derivation complexity.
- Step 3 - Final Decision Matrix: Synthesizing Importance (from Step 1) and Feasibility (from Step 2) to determine the regulatory path forward.

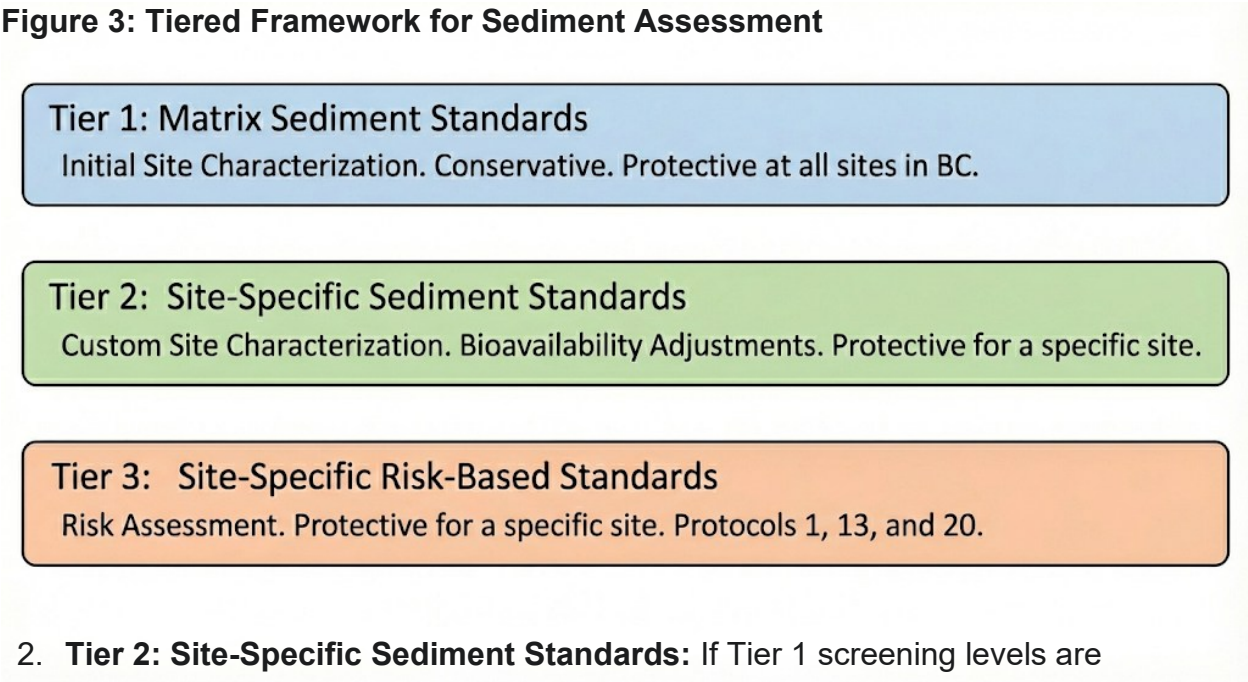
3. Refine how site-specific uses and protection goals are considered:
   a. Removing the use of the current "Sensitive" versus "Typical" use categories and replacing them so that they are linked to specific ecological receptors (e.g., critical wildlife habitats, salmon spawning areas), human uses (e.g., shellfish harvesting areas, recreational zones), or background conditions.
   b. Consider modern approaches such as protecting ecosystem functions, in addition to specific organism groups, as discussed by Apitz et al. (2012), Brown et al. (2017), and Landis et al. (2017).
   c. Ensuring that the application of SedS-contact and SedS-food appropriately reflects the designated protection goals for a given site. For instance, in areas with significant human consumption of aquatic resources or critical habitat for piscivorous wildlife, the SedS-food may be the more pertinent driver for management decisions.
4. **Baseline Bioavailability Normalization**: The derivation of matrix standards proposes integrating a baseline normalization for bioavailability, specifically normalizing for TOC for non-ionic organic contaminants. This establishes a "reference" standard (e.g., normalized to 1% TOC) for Tier 1 screening, which can then be adjusted using site-specific data in Tier 2.

Implementation of a Tiered Assessment Approach

A tiered approach to sediment quality assessment would be implemented to allow for efficient use of resources while maintaining protective outcomes:

1. **Tier 1: Screening:** Site-specific sediment chemistry data would be compared against the matrix standards (SedS-contact and SedS-food for both human and ecological health, as applicable) with baseline bioavailability assumptions. Sites where all contaminant concentrations are below these screening standards would generally be considered of low concern, potentially requiring no further action or only baseline monitoring.

Figure 3: Tiered Framework for Sediment Assessment



2. **Tier 2: Site-Specific Sediment Standards:** If Tier 1 screening levels are exceeded, a more detailed investigation may be undertaken incorporating site-specific information and bioavailability adjustments such as TOC (for organic contaminants), grain size, SEM/AVS (for metals), and human health exposure factors (e.g., oral bioaccessibility, dermal adherence) (McGrath et al., 2019; Allen, 2011; Greenberg et al., 2014). As part of the frameworks for standards derivation, the requirements, procedures, and accepted models for measuring/modelling bioavailability should be specified in Protocols, while clear guidance on site-specific data collection (e.g., Total OC, AVS, SEM) should be developed.

3. **Tier 3: Risk Assessment:** If Tier 2 screening levels are exceeded, a risk assessment may be needed, in accordance with either Protocols 1 or 13. This tier often involves the collection and integration of multiple LOEs within a structured WoE framework. This approach is consistent with the comprehensive understanding of 'sediment status' (quality, quantity, location, transport) advocated by frameworks like SEcoRA, allowing for a more complete picture of impacts on diverse ecological endpoints (Apitz, 2012). Relevant LOEs may include:
    - Consideration of the extent and magnitude of contamination (i.e., area impacted, magnitude of exceedances) in the context of habitat availability and quality in the impacted area.
    - Advanced, site-specific bioavailability assessments (e.g., use of PSDs for measuring Cfree, refined partitioning studies).
    - Sediment toxicity testing using appropriate acute and chronic bioassays with relevant species.
    - Benthic invertebrate community assessments (e.g., analyzing species diversity,

abundance, presence of sensitive taxa, community structure indices, eDNA).
    - Measurement of contaminant concentrations in the tissues of local biota (invertebrates, fish, algae, plants).
    - Application of site-specific or refined FWMs and BSAF determinations.

B. How the Proposed Framework Addresses Identified Gaps

This modernized framework is designed to directly address the key deficiencies identified in the current sediment standards listed in Schedule 3.4 of the CSR, including:

- **Protection of Non-Benthic Receptors and Indirect Exposure Pathways**: The introduction of the SedS-food, derived through TRGs, BSAFs, and FWMs, explicitly addresses the risks to wildlife and human consumers via food web transfer, a critical pathway not covered by the current benthic-focused standards (US EPA, 2002; CSAP Society, 2015; BC ENV, 2024).
- **Inadequate Bioavailability Considerations**: Systematically incorporating OC normalization and AVS/SEM assessments at Tier 2 and allowing for advanced tools like PSDs in higher tiers, systematically integrates bioavailability into the assessment process, leading to more accurate risk predictions than bulk sediment comparisons alone (McGrath et al., 2019; Allen, 2011; Greenberg et al., 2014).
- **Outdated Toxicological Data and Approaches**: The framework prioritizes the use of the best available and current toxicological data and modern derivation methodologies (e.g., SSDs, mechanistic models) rather than relying on adjusted historical PELs (BC ENV, 2024; Warne et al., 2018; Greenfield et al., 2014).
- **Emerging Contaminants**: The framework includes a process for prioritizing and developing standards for emerging contaminants of concern (PFAS, micro- and nano-plastics, etc.), ensuring the standards remain relevant to contemporary environmental challenges (CSR, 2023; SETAC, 2021).
- **Static Nature of Standards**: The guiding principle of adaptive management, with a commitment to a regular review and update cycle, ensures that the sediment standards will evolve with scientific advancements and changing environmental priorities (CSAP, 2017; US EPA, 2005).
- **Weight-of-Evidence**: Prioritizing a tiered approach that progresses towards WoE assessments for more complex sites and moves beyond a simple numerical comparison, allowing for more holistic and scientifically defensible decision-making (Chapman et al., 2002; Ontario MECP, 2008; Greenfield et al., 2014).

C. Implementation Considerations and Challenges

The successful implementation of this modernized framework requires careful planning and addressing the following considerations and potential challenges:

- **Data Requirements and Availability:**

    - Challenge: Deriving defensible SedS-contact using SSDs and SedS-food using FWMs and TRGs requires substantial, high-quality toxicological and bioaccumulation data, which are limited for some contaminants or BC-specific species.
    - Consideration: Phased implementation, starting with contaminants with more extensive datasets. Investment in targeted research to fill critical data gaps for BC-relevant species and ecosystems. Development of clear guidance on data quality requirements.
- **Technical Capacity and Expertise:**
    - Challenge: The application of advanced concepts like bioavailability modeling, FWMs, SSDs, passive sampling, eDNA, and probabilistic risk assessment methods require specialized expertise, necessitating further development for regulators, consultants, and laboratories.
    - Consideration: Development of comprehensive technical guidance and training, while fostering collaboration between government, academia, and consulting sectors.
- **Laboratory Capabilities and Analytical Methods:**
    - Challenge: Measurement of emerging contaminants (e.g., PFAS at very low ng/g levels), specialized bioavailability parameters (e.g., AVS/SEM, Cfree via PSDs), and conducting relevant chronic toxicity tests may require upgrades to laboratory analytical capabilities and standardization of methods across BC. However, local laboratory capacity may be limited.
    - Consideration: Engage with analytical laboratories to understand current capabilities and future needs. Early engagement with analytical laboratories, perhaps using BCELTAC committee as a forum supplemented by direct consultations with labs to inventory current capabilities, define minimum performance objectives, and co-develop standardized methods. Support method development and validation for new parameters. Establish clear analytical Quality Assurance/Quality Control (QA/QC) requirements.
- **Cost and Timelines for Site Assessments:**
    - Challenge: More comprehensive assessments, particularly at Tier 3 involving multiple LOEs, may increase the cost and time required for site investigations compared to the current simpler screening approach.
    - Consideration: The tiered approach is designed to focus intensive efforts on sites warranting them. Clear guidance on when and how to apply higher-tier assessments can optimize resource allocation. Long-term cost savings may be realized by avoiding unnecessary remediation or by more effective risk management.
- **Regulatory Integration and Clarity:**
    - Challenge: Clearly integrating the proposed matrix standard system, tiered assessment framework, and AOP/BN/WoE principles into the existing CSR

legal and procedural structure would be critical. Definitions (e.g., for site use categories if retained), compliance metrics, and roles/responsibilities (e.g., for Approved Professionals) would need to be clearly articulated.
    - Consideration: Iterative development of regulatory language with legal review. Extensive stakeholder consultation during the drafting of new regulations, protocols, and technical guidance.
- **Engagement:**
    - Challenge: Effectively communicating the scientific basis and practical implications of the new, more complex framework to a diverse range of stakeholders (industry, public, environmental groups) and First Nations rights holders would be essential for acceptance and successful implementation.
    - Consideration: Develop a clear communication strategy. Provide accessible summaries and educational materials. Engage partners and stakeholders throughout the development and rollout process to address concerns and build consensus.

Addressing these challenges proactively through strategic planning, investment in capacity building, phased implementation where appropriate, and ongoing stakeholder engagement would be key to the successful modernization of BC's sediment standards.

VI. Strategic Pathways and Options Analysis

The clear mandate for reform of the CSR's sediment standards, identified through preliminary research and stakeholder engagement, necessitates a strategic analysis of the available options for constructing a new, modernized framework for the review and development of standards. This requires an evaluation of recognized methods for deriving a complete set of matrix sediment standards protective of both ecological organisms and humans (through direct and indirect exposure pathways), and a clear assessment of the implementation models available to the province.

A. Scientific Approaches for Sediment Standard Derivation

Drawing on the findings of this project, the following scientific approaches are recommended for deriving of Matrix Sediment Standards. These standards will serve as the Tier 1 screening benchmarks, providing a scientifically defensible foundation for the initial assessment of contaminated sites:

1. **Direct Exposure Protection (SedS-contact):** To protect organisms and people from adverse effects associated with direct contact with contaminated sediment.
   a) **Ecological Protection (SedS-contact$_{ECO}$):** Based on protecting benthic organisms using an SSD approach. An SSD is a statistical tool that models the variation in sensitivity across a range of different species to a specific contaminant (Posthuma et al., 2002; Warne et al., 2018). By compiling available, high-quality toxicity data, a cumulative distribution can be plotted from which a protective concentration is derived, typically the Hazardous Concentration for 5% of species (HC_5), which is the concentration at which 95% of species in the ecosystem are expected to be protected (CCME, 2005; US EPA, 2016). The SSD approach is more scientifically defensible and transparent than older methods because it is based on a comprehensive view of toxicological data and provides a clear, probabilistic statement of the intended protection level (BC ENV, 2025a).
   b) **Human Health Protection (SedS-contact$_{HH}$)**: To protect people from direct contact with sediment during recreational or harvesting activities. Derivation involves standard human health risk assessment (HHRA) methodologies, considering exposure from incidental ingestion and dermal contact (Health Canada, 2017). Critically, this requires adapting exposure parameters for unique aquatic scenarios. For example, as noted by survey respondents, dermal adherence rates[3] for contaminants can be significantly higher in wet, intertidal sediments compared to the terrestrial soils for which standard factors are typically developed (Health Canada, 2017).
2. **Food Web Protection (SedS-food):** To protect higher-trophic-level organisms, including wildlife and human consumers, from the adverse effects of contaminants transferred through the food web:
   a) **Ecological Protection (SedS-food$_{ECO}$):** To protect aquatic and marine wildlife, this

[3] Health Canada (2017) presents available dermal adherence factors from three studies. If newer studies exist, then these should be included in the derivation of matrix standards for this pathway.

standard links protective TRGs for key receptor species (e.g., eagles, killer whales) back to corresponding sediment concentrations. This translation is achieved using tools such as BSAFs, which are empirically measured ratios of contaminant levels in tissue versus sediment, or more complex, mechanistic FWMs that simulate the movement and magnification of contaminants through an entire ecosystem (Arnot & Gobas, 2004; CSAP Society, 2015; Greenfield et al., 2014; US EPA, 2000; Weisbrod et al., 2007).

b) **Human Health Protection (SedS-food$_{HH}$):** To protect human consumption of fish and shellfish, a back-calculation approach is used. The process begins by establishing a safe tissue concentration that can be consumed based on human health toxicological reference values and key exposure parameters, most notably the consumption rate (BC ENV, 2023; US EPA, 2015). It is important that consumption rates are protective of all populations, including Indigenous communities that may have significantly higher consumption of traditional foods than the general population. This safe tissue level is then translated back into a protective sediment concentration using validated BSAFs or models.

While modern derivation methods are necessary, the framework should effectively utilize global scientific data. Prior to initiating *de novo* calculations, the strategy promotes a meta-analysis of existing, scientifically defensible standards from other jurisdictions to determine if they can be adopted or adapted for BC. The choice of these modern derivation methods carries significant long-term implications for data management and institutional capacity. Adopting SSDs and BSAF/FWM-based approaches is not a one-time exercise in calculation; it necessitates a sustained commitment to ongoing ecotoxicological research, monitoring, and data compilation. A critical and cost-effective first step to address this data gap is to conduct a preliminary desktop study to compile readily available BC-specific data from the hundreds of publicly available reports already submitted to the government. This approach would provide a foundation for the development of updated matrix sediment standards. Also, this data would support the development of protocols for customizing those Tier 1 Matrix Standards to Tier 2 Site-Specific Standards. The data from the desktop study would directly support the application of probabilistic approaches to integrate models like equilibrium partitioning and biotic ligand models. Without this investment in data, starting with what is already available, the new, more sophisticated framework would be built on an unstable foundation, limiting its scientific defensibility and effectiveness.

B. Strategic Options for Framework Implementation

With a clear understanding of the desired architecture and the scientific methods to build it, the final strategic choice involves selecting an implementation pathway. The options (or pathways) present themselves, each with distinct trade-offs in terms of speed, cost, complexity, and alignment with the expert mandate.

- **OPTION 1: Data-Driven Foundational Research:** This option re-frames the initial phase of the project to focus exclusively on a comprehensive desktop research study and

collaborative research. Instead of making rapid regulatory changes, this approach prioritizes the SABCS-led compilation of existing BC-specific data from publicly available reports. The goal is to build the essential scientific foundation required to support the subsequent development of the full multi-component framework. This includes developing the scientific basis for deriving matrix sediment standards, creating a protocol for deriving site-specific standards (i.e., bioavailability data for adjustments, etc.), and collaboratively establishing a framework for classifying and prioritizing substances. Examples of data to be collected include background concentrations, occurrence of detectable concentrations (to identify new priority contaminants), bioavailability and bioaccumulation data, among other data endpoints.

- **OPTION 2: Phased Modernization:** This approach would adopt the full, integrated framework as the end goal but implement it in sequential phases over several years. Early phases could deliver "early wins" by initiating a data compilation project (described in Option 1), expanding the contaminant list, and developing a procedure implementing bioavailability adjustments within the existing regulatory structure. Subsequent phases would then focus on developing and consulting on the proposed derivation approaches for matrix standards, with development and submission of deliverables supporting the full implementation, including proposed values for prioritized substances in a later phase. This approach balances the need for comprehensive reform with pragmatic considerations of resource allocation and regulatory development timelines.
- **OPTION 3: Comprehensive Overhaul:** This approach would involve developing and implementing the fully integrated, tiered, matrix standard framework, supported by bioavailability tools and modern derivation methods, as a single, cohesive regulatory package. While this represents the highest upfront investment in terms of complexity and resources, it is the option that most directly and completely responds to the holistic vision for reform articulated by the expert community. It avoids the potential for creating interim, partially effective regulations and delivers the full benefits of a modernized system in a single step.

Within each option, there will be staged implementation and concrete milestones with clear decision gates with which to measure progress. Table 3 provides a comparative analysis of these three implementation options.

Table 3 – Comparative Analysis of Implementation Options

Implementation Options	Description	Alignment with Expert Mandate	Scientific Robustness	Implementation Complexity & Cost	Regulatory Flexibility*	Key Advantages	Key Disadvantages
Option 1: Data-Driven Foundational Research	Focuses on a desktop study and collaborative research to build the scientific foundation for a new framework, including protocols for standard derivation and substance prioritization.	**High**	**Very High (for the research component)**	**Low-to-Medium (focused on research)**	**Low (no immediate regulatory change)**	Builds a strong, BC-specific scientific basis; highly cost-effective due to volunteer support and use of modern technology such as Artificial Intelligence; directly addresses identified data gaps.	Delays implementation of new protective standards; does not provide immediate regulatory updates; with long timelines, previously completed work "becomes stale", leading to cost inefficiencies.
Option 2: Phased Modernization	Implements the full framework in sequential stages over several years, starting with high-priority items.	**High**	**High (at completion)**	**Medium (spread over time)**	**Medium (initially)** **to** **High (finally)**	Delivers incremental improvements and early wins; manages complexity over time.	Creates interim regulatory stages; delays full benefits of the integrated system, longer timelines stretch out political goodwill.

Option 3: Comprehensive Overhaul	Develops and implements the full, integrated tiered, matrix standard framework as a single package.	**Very High**	**Very High**	**High (upfront)**	**High**	Fully addresses all identified deficiencies; delivers a cohesive, modern system.	Requires significant upfront investment of resources and time; more complex to develop and roll out, allocation considerations to avoid implementation delays.

Notes:

***** - Refers to the ability to manage the pace of change, adapt to new information without locking into rigid legislation immediately, and avoid "regulatory shock" for stakeholders.

Some aspect of Option 1 may be required to ensure that Option 2 or 3 proceeds effectively, i.e., there is a need to invest in desktop data compilation prior to initiating regulatory work.

It is recommended to establish a formal governance structure for cross-agency collaboration, regardless of the option selected.

Preferred Strategic Option: A Hybrid Approach

While a Comprehensive Overhaul (Option 3) aligns with the holistic vision, the expert community at CEW overwhelmingly identified 'resourcing' as the single greatest constraint to advancing sediment protection. Therefore, the preferred strategic option is a combination of Option 1 (Data-Driven Foundational Research) with Option 2 (Phased Modernization).

Attempting to derive standards without first securing the data foundation (Option 1) limits the ability to develop standards that are scientifically valid and account for BC's unique geochemical landscape. By adopting the "Smart Stagger" strategy – where foundational research and data compilation are prioritized in 2026 using technological tools – the province can mitigate the risk of "regulatory shock." This approach ensures that when the comprehensive regulatory drafting begins in subsequent phases, it is supported by a BC aquatic database and a probabilistic study design, ensuring both scientific defensibility and fiscal responsibility.

VII. Conclusions and Recommendations

The preliminary literature and jurisdictional reviews and stakeholder engagement activities detailed in this report provide an unambiguous and compelling case for reform. This collaborative project has clearly identified critical gaps in the current sediment standards and proposes a preliminary roadmap to address outstanding gaps. Translating this strategic vision into a concrete plan requires a clear prioritization of reforms and a logical, phased implementation schedule.

A. Data Compilation as the Foundation for Modernization

The community engagement data provides a clear hierarchy of needs that can guide the allocation of resources. The following priorities represent a logical sequence to support the proposed framework, starting with the most urgent and foundational elements.

- **Priority 1 - Data Compilation Project:** Before new standards can be effectively derived, a representative, province-specific dataset is needed and was deemed a key technical priority during stakeholder engagement. This will involve completing a desktop study to gather data from existing publicly available reports to begin filling critical data gaps on background concentrations, bioavailability parameters, and bioaccumulation factors. This data is also required to develop clear guidance for bioavailability and tiered assessments, which expert feedback also prioritized.
- **Priority 2 - Develop and Implement the Matrix Standard Approach:** While critical for addressing all direct contact and bioaccumulation problems, its development and implementation depend on the other pieces, particularly the expanded contaminant list and the tiered structure, being in place.
- **Priority 3 - Formally Incorporate Bioavailability Adjustments:** Considers natural site-specific variation and is essential for the functioning of a tiered system.

Table 4 summarizes the proposed actions and the rationale supporting the development of these three key priorities, which is based on the multi-faceted engagement results compiled

in **Appendices D (Survey), G (CEW),** and **J (TWG)**. Timelines are critical to successfully develop and implement the below proposed actions, presented in Table 4. Details regarding priority and framework timelines are included in the "Scoping Plan", under separate cover.

Table 4 – Rationale for Prioritization - Survey Results

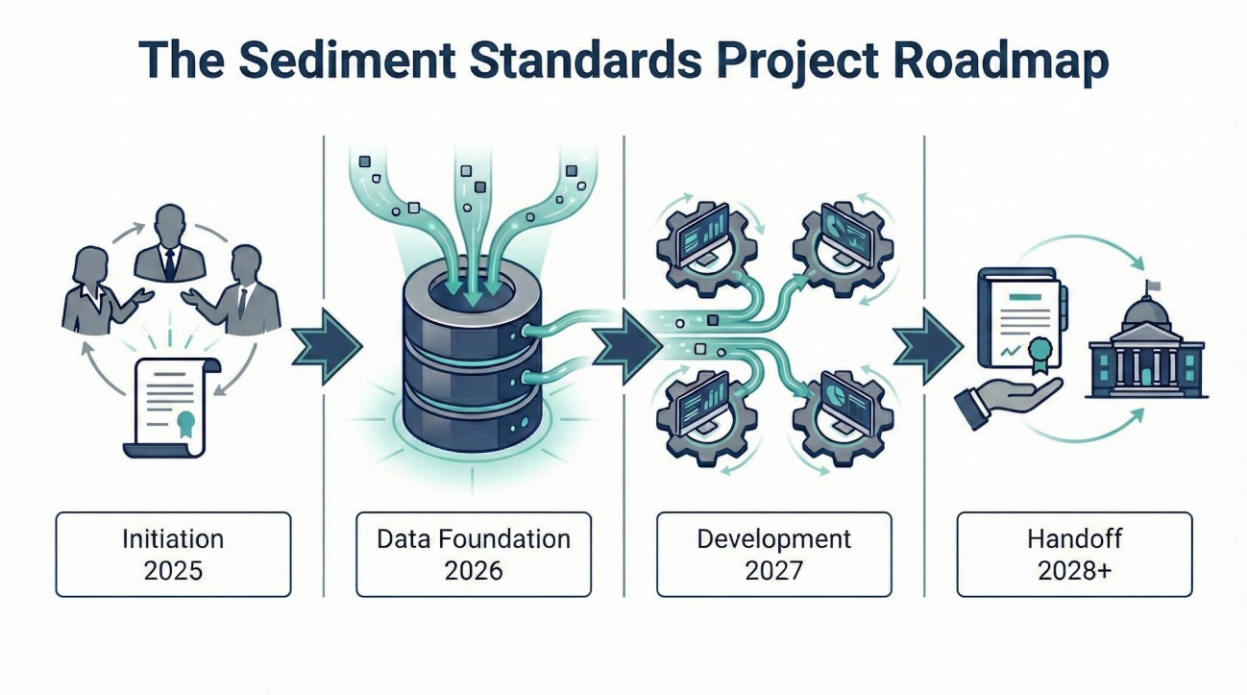
Proposed Action	Survey Support (% "Essential" / "Very Important" / "Beneficial")	Expert (CEW & TWG) Consensus	Strategic Impact	Implementation Complexity
Launch Desktop Data Compilation	(Addresses universally identified data gaps)	Ranked #1 Research Priority (TWG)	Very High	Low-to-Medium
Expand Contaminant List	95%	Top Priority for Mercury & PFAS (TWG)	High	Medium
Incorporate Bioavailability	91%	"High Priority Near-Term" (CEW) Top Tier 2 Priority (TWG)	High	Medium
Expand Tiered Framework	86%	Ranked #2 Framework Priority (TWG)	High	High
Develop Matrix Standards	83% (Necessary/ Beneficial)	Ranked #1 Framework Priority (TWG) "High Priority Near-Term" (CEW)	High	High
Provide Comprehensive Guidance	(Universal Qualitative Support)	Ranked #1 Focus for Holistic Management (CEW)	High	High

B. Proposed Phased Implementation Plan ("Roadmap")

Based on the prioritization above, a logical, multi-year implementation plan is proposed. This plan is intentionally structured to be led by SSTAC, leveraging its network of volunteer experts

and access to modern technological tools (e.g., Artificial Intelligence) to complete the foundational scientific work efficiently. This approach is designed to be streamlined and efficient, providing a scientifically defensible package for BC ENV to review, consider, and move forward through its own distinct policy, consultation, and legal processes. The project roadmap contains four phases, including the completed initiation and scoping phase (1), the data foundation and research phase (2), the scientific development and derivation phase (3), and the framework execution & handoff phase (4) (see Figure 4).

Figure 4. Proposed Phased Implementation Plan for the Sediment Standards Project ("Roadmap")



Phase 1 (2025): Project Initiation and Scoping (Completed)

This phase established the scientific rationale and community mandate for reform. Key activities included a preliminary literature review, a jurisdictional scan of international best practices, and targeted engagement via an online survey and a technical session at the Canadian Ecotoxicity Workshop (CEW). The primary deliverables were this White Paper (outlining the preliminary scientific framework) and a detailed Scoping Plan to guide future research.

Phase 2 (2026): Foundational Research & Study Design

This phase focuses on the foundational, high-priority actions that volunteer-led SSTAC Technical Working Groups (TWGs) can initiate. To address resource constraints and manage volunteer capacity, this phase utilizes a "Smart Stagger" strategy and a task-based advisory model, launching TWGs in sequential waves rather than concurrently. This phase is scoped to be executable within the confirmed SABCS baseline budget ($23,000), while remaining scalable

for potential Ministry partnership.

Technical Working Groups (TWGs)

- **Wave 1 (Design & Data):** The first wave of experts will focus on developing the study design and building the BC aquatic database.
    1. **Study Design TWG (Bioavailability):** Tasked with evaluating all available approaches (including probabilistic models) to develop a research plan for creating BC-specific bioavailability tools. This plan will be critically linked to the bioavailability (and other) data compiled from the Data Compilation Project to ensure it is rooted in BC-specific environmental conditions. This research may also identify key gaps where new data collection is required.

       They will define the data compilation strategy, data acceptance criteria, and watershed prioritization scheme required to develop regional bioavailability models (e.g., Bayesian Network Relative Risk Models). Their output guides the Data Compilation TWG.

    2. **Data Compilation TWG:** Tasked with designing the database architecture and data extraction methodology, setting up the BC aquatic database, and overseeing the execution, analysis, and reporting of the Data Compilation Project.

- **Wave 2 (Classification & Scoping):** Once data collection is underway, the second wave focuses on categorizing contaminants and evaluating derivation methods.
    1. **Bioaccumulation Classification TWG:** Tasked with developing a framework for classifying bioaccumulative substances for food pathways. This group's work will support the Substance Prioritization TWG and the Matrix Standards Framework TWGs by providing a consistent method for categorization.

    2. **Matrix Standards Framework TWG:** In 2026, a single Matrix Standards Framework TWG is proposed to conduct an enhanced jurisdictional review and develop a Matrix Options Paper. This work involves a meta-analysis of recent derivations from leading jurisdictions (e.g., SSD, EqP methods) to evaluate the merits of direct adoption, modification, or *de novo* derivation, ultimately recommending the most scientifically defensible and efficient strategy for BC.

Deliverable

- **BC Aquatic Database:** This is the highest-priority action. A SSTAC-led Data Compilation Project to compile and analyze readily available BC-specific data.
    1. **Objective:** To gather data from existing reports (e.g., Environmental Assessment applications, Site Remediation reports) for critical data on background concentrations, bioavailability parameters (e.g., TOC, AVS/SEM), and accumulation factors (e.g., BSAFs) to support a BC-specific framework.

2. **Methodology:** The project leverages the expertise of SSTAC volunteers and technological tools to conduct a probabilistic study (described in a Study Design Document) for identifying key sites and associated high-value reports. It will also seek partnerships with other organizations (e.g., DFO, ECCC) to incorporate their datasets. A key component will be outreach to local communities and organizations to find available reports that can enhance the understanding of local environmental conditions and historical/current sources.

3. **Resources:** This project is designed to be driven primarily by SSTAC volunteer effort, utilizing low-cost technology infrastructure, with BC ENV subject matter experts participating as liaisons.

Indigenous Engagement Support: In 2026, the SSTAC will prepare a proposed strategy for supporting respectful and appropriate Indigenous engagement throughout the scientific development process. This may involve a "soft launch" of the BC aquatic database to select Indigenous communities, demonstrating the value of regional data layers relevant to their territories as a possible step toward information-sharing and collaboration.

Phase 3 (2027): Scientific Development and Derivation

This phase utilizes the BC aquatic database and the Matrix Options Paper delivered in Phase 2 to begin developing a Detailed Derivation Approach, Updated Scientific Framework Document, and Technical Procedures, and establish Wave 3 TWGs.

Technical Working Groups

- **Establish Matrix Standards Derivation TWGs:** Four separate TWGs (e.g., for SedS-contact$_{HH.}$ SedS-contact$_{ECO,}$ SedS-food$_{HH.}$ and SedS-food$_{ECO}$) will be established. Their primary task is to develop the proposed scientific framework for deriving each standard type. This involves in-depth research and evaluation of which scientific models (e.g., SSDs, EqP, BLM, FWMs) are most appropriate for different substances, receptors and pathways.
- **Establish Substance Prioritization TWG:** Tasked with developing a Prioritization Grid Classification System as part of the Technical Procedure for Updating CSR Standards with Values Adopted from Other Jurisdictions.
- **Develop a Detailed Derivation Approach:** The Matrix Standards Derivation TWGs will draft a detailed, transparent approach (the "how-to" guides) for deriving standards using the modern scientific methods selected in Phase 2 (e.g., procedures for developing SSDs, applying FWMs).
- **Develop Draft SSTAC Technical Procedures:** To ensure consistency in their own work, the Study Design (Bioavailability) and Substance Prioritization TWGs will draft internal technical procedures for applying the derivation protocols. These serve as the

SSTAC's internal "standard operating procedure" for developing the draft standards.

- **Technical Procedure for Bioavailability Adjustment of Sediment Standards**: Potential interim deliverable for submission to BC ENV for consideration.

- **Technical Procedure for Updating CSR Standards with Values Adopted from Other Jurisdictions**: Potential interim deliverable for submission to BC ENV for consideration.

  A grid classification system (developed by Substance Prioritization TWG) forms the foundation of **Technical Procedure for Updating CSR Standards with Values Adopted from Other Jurisdictions** white paper**.** These adopted standards would be “generic sediment standards” due to lack of available information necessary to derive matrix sediment standards or other considerations.
  The Prioritization Grid Classification System follows a three-step logic:
  - Step 1 - Classification Grid: Assessing priority based on Hazard vs. Occurrence.
  - Step 2 - Feasibility Assessment: Evaluating data availability, existing values in other jurisdictions, and derivation complexity.
  - Step 3 - Final Decision Matrix: Synthesizing Importance (from Step 1) and Feasibility (from Step 2) to determine the regulatory path forward.

  This procedure (the Prioritization Grid Classification System) is a structured decision matrix for classifying legacy and emerging contaminants based on the intersection of **Hazard** (toxicity, persistence, bioaccumulation potential) and **Occurrence** (frequency and magnitude of detection in BC). This system would sort substances into clear management categories (e.g., "Immediate Standard Development," "Watch List/Monitoring," or "No Action Required").

Phase 4 (2028+): Application of the Scientific Framework & Final Scientific Package

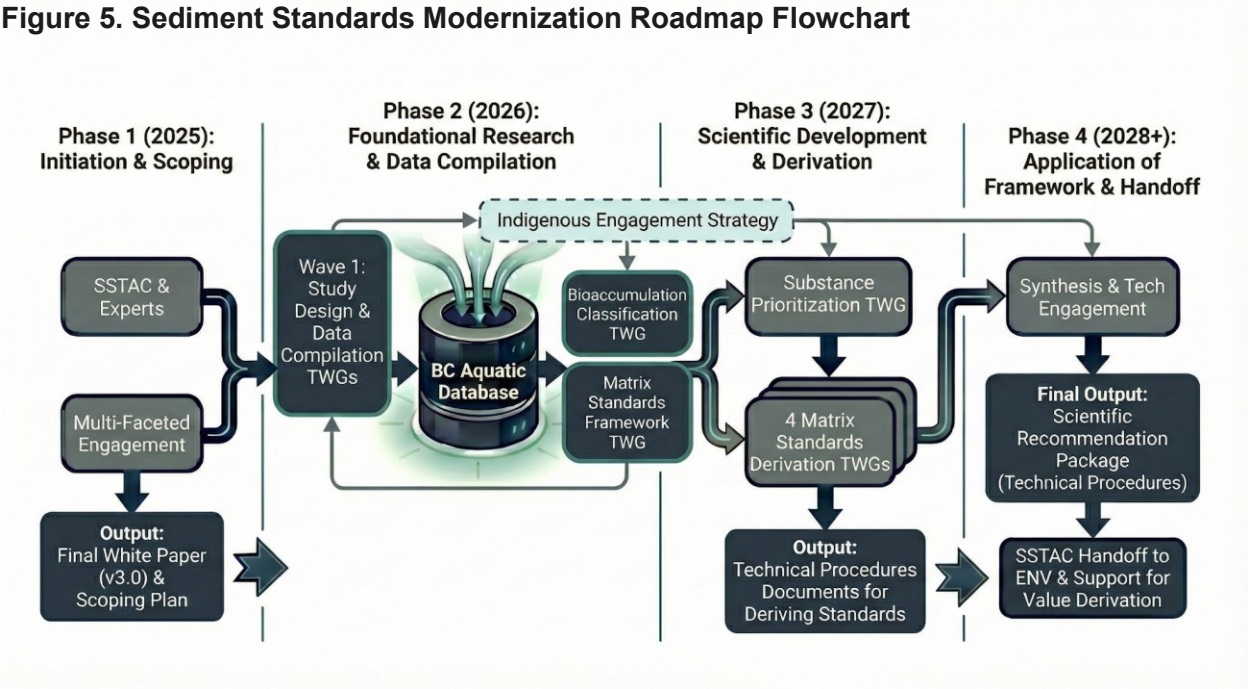
This phase involves the first application of the new procedure to develop proposed standards and finalize the scientific package for handoff.

- **Draft the Updated Scientific Framework Document:** The SSTAC-led collaboration will synthesize the work of all TWGs into a single, comprehensive scientific framework document detailing the tiered assessment process, the matrix standard approach, and the scientific rationale for each component.
- **Draft Proposed Numerical Standards:** Using the approved derivation approaches, the TWGs will undertake the significant effort of developing draft proposed matrix standards for the priority list of contaminants. This work will be iterative and depend on data availability (from Phase 1) and substance-specific complexities. This work would be conducted in collaboration with and/or with the approval of ENV.
- **Collaborate on Technical Engagement:** SSTAC will seek to support ENV, and other organizations, to co-facilitate technical engagement with experts and stakeholders on the draft scientific proposals (e.g., the framework and draft standards), gathering feedback to refine the package.

- **Compile Final Recommendation Package:** All draft documents will be compiled into a single, comprehensive scientific recommendation package.

Figure 5 pictorially represents the phased approach for the Sediment Standards Modernization, including when TWGs will be formed and when deliverables will be produced.

Figure 5. Sediment Standards Modernization Roadmap Flowchart



C. The Critical Path to Success: Investing in Guidance, Data, and Training

The survey respondents and CEW technical experts sent a powerful and unanimous message: new rules alone are not enough. The success of this scientifically advanced framework is ultimately determined by its usability. Experts at CEW and in the TWG confirmed this, ranking 'Push guidance beyond generic numerical standards' as the top focus for providing value. Furthermore, the significant expert debate on the current feasibility of bioavailability adjustments has indicated that failure to invest in clear guidance is a primary risk to the project.

The demand is not for generic support but for specific, practical tools. Respondents universally called for comprehensive and accessible guidance documents that go beyond simply stating the rules, specifically requesting "decision trees, flowcharts, and worked examples" to navigate the new tiered framework, as well as transparent documentation on how the new standards were derived (**Appendix D**). This highlights a critical lesson from past regulatory initiatives: Inadequate investment in implementation support can cause a scientifically valid framework to fail in practice. Therefore, the strategic plan for modernizing the sediment standards must treat developing user-friendly guidance, a dedicated data generation strategy (beginning with the high-priority desktop compilation project) and comprehensive guidance and training materials as a core project component with a dedicated budget, on par with the scientific work of deriving the

standards themselves. This investment is not an ancillary cost; it is the essential insurance policy for the success of the entire initiative.

D. Conclusion: Seizing an Opportunity for National Leadership

A pathway forward to updated sediment quality standards has been proposed in this paper. This proposed path forward involves:

- Derivation of a matrix standard approach that explicitly protects against both direct toxicity and food-web bioaccumulation;
- The systematic incorporation of bioavailability to ensure that both matrix standards and implementation of assessments (Tiers 1 to 3) are based on relevant exposure levels rather than total concentration; and
- An expanded tiered framework, with site-specific numerical sediment standards, provides regulatory flexibility and focuses resources where they are most needed.

In undertaking this reform, the BC ENV and the SABCS have an opportunity that extends beyond necessary regulatory maintenance.

By embracing this comprehensive vision, BC has the opportunity to move beyond simply catching up with modern science and instead to demonstrate leadership. This initiative can establish one of the most advanced, scientifically defensible, and practical sediment management frameworks in North America, setting a new national standard for environmental protection. Seizing this opportunity will not only ensure the long-term health of British Columbia's invaluable aquatic environments but will also position the province as a leader in next-generation environmental regulation.

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IX. Appendices

Appendix A. Detailed Methodology for Scientific Literature Review

The scientific and grey literature review for this report was conducted as a high-level scan designed to set the foundation and inform the strategic scoping and development of the proposed modernization framework. It was not a systematic, exhaustive meta-analysis but rather an enhanced preliminary review intended to identify the limitations of the current BC standards and synthesize available science and leading regulatory practices as of 2025. This foundation will support more in-depth, topic-specific reviews in subsequent phases of the project.

The methodology involved several parallel streams:

1. **Foundational Document Analysis:** A detailed review of the derivation and limitations of the existing BC CSR Schedule 3.4 sediment standards was conducted. This included an analysis of the original technical documents (e.g., MWLAP, 2003; MacDonald et al., 2003) and subsequent reviews (e.g., CSAP Society, 2015).
2. **Peer-Reviewed Literature Scan:** A targeted search of academic databases (including Google Scholar and Web of Science) was performed to identify key advancements in sediment quality assessment. Searches focused on publications from the last 15-20 years, with a focus on journals such as *Environmental Toxicology and Chemistry*, *Integrated Environmental Assessment and Management*, and *Science of the Total Environment*. Key search topics included:
    a. **Derivation Methods:** "Species Sensitivity Distributions (SSDs)", "Equilibrium Partitioning (EqP)", "Adverse Outcome Pathways (AOPs)", and "Weight-of-Evidence (WoE)".
    b. **Exposure Pathways:** "Bioavailability" (including "Organic Carbon", "AVS/SEM"), "Bioaccumulation", "Food Web Models (FWMs)", and "Biota-Sediment Accumulation Factors (BSAFs)".
    c. **Emerging Contaminants:** "PFAS sediment", "6PPD sediment", and "microplastics sediment".
    d. **Holistic Frameworks:** "Sediment-Ecosystem Regional Assessment (SEcoRA)".
3. **Jurisdictional Grey Literature Review:** A scan of publicly available regulatory documents, technical guidance, and scientific reports was conducted for the jurisdictions listed in **Appendix B**. This search, conducted primarily via Google and government agency websites, was essential for fulfilling the "Jurisdictional Scan" objective. This review is described in Section III of this report.
4. **Supplemental Source Identification:** Key sources from professional organizations (e.g., SETAC, ITRC) and foundational reports identified in the reference lists of primary articles were also compiled. Many of these, while not cited directly in the main body, were considered during framework development

and are listed in **Appendix I**.

This multi-faceted approach allowed for the synthesis of information from academic, regulatory, and professional sources to build the scientifically defensible and practical framework proposed in this report.

Appendix B. List of Jurisdictions Included in the Scan

The following jurisdictions were reviewed to identify established practices, innovative approaches, and best practices in sediment quality guideline development and application. This review was conducted using publicly available information accessible via internet searches, primarily using Google.

Indigenous-led Frameworks

- **British Columbia Ministry of Environment & Climate Change Strategy and Tsleil-Waututh Nation**
  - **Key Documents:** *Water Quality Objectives for Burrard Inlet* (includes sediment quality objectives)
  - **Primary Website:** https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-objectives/bc_twn_burrardinlet_wqo.pdf
- **Athabasca Chipewyan, Fort McKay, and Mikisew Cree First Nations**
  - **Key Documents:** *Water and Sediment Quality Criteria for the Protection of Indigenous Use (WQCIU Report)* (Olsgard et al., 2023).
  - **Primary Website:** https://acfn.com/wp-content/uploads/2023/10/wqciu_report.pdf

Canadian Jurisdictions

Federal

- **Canadian Council of Ministers of the Environment (CCME)**
  - **Key Documents** (including select constituents)**:**
    - *Canadian Environmental Quality Guidelines (CEQGs)* (CCME, 2025)
    - *Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life* (CCME, 1995)
    - *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life - DDT, DDE, and DDD* (CCME, 1999a)
    - *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life - Lead* (CCME, 1999b)
  - **Primary Website:** Canadian Environmental Quality Guidelines (CEQGs)
- **Environment and Climate Change Canada (ECCC)**
  - **Key Documents:**
    - ECCC. *Federal Environmental Quality Guidelines (FEQGs)*. (This is the main landing page explaining the purpose of FEQGs. Includes 40 water, 17 sediment guidelines, 11 fish tissue, and other guidelines). (ECCC, 2024a)
    - ECCC. *Federal environmental quality guidelines - Lead*. (This is an example of a specific FEQG that includes sediment values). (ECCC, 2024b)
  - **Primary Website:** Federal Environmental Quality Guidelines (FEQGs)

Provincial

- **Ontario MECP (Ministry of the Environment, Conservation and Parks)**
  - **Key Documents:**
    - *Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario* (Ontario MECP, 2008)
    - *Guidelines for the protection and management of aquatic sediment quality in Ontario* (Ontario MOEE, 1993)
    - **Primary Website:** Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario
- **Quebec MELCC (Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parc)**
  - **Key Documents:** *Criteria for the Assessment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation* (Environment Canada & MELCC, 2007)
  - **Primary Website:** Sediment Quality Criteria
- **Atlantic Provinces (Atlantic RBCA)**
  - **Key Documents:**
    - *Ecological Screening Protocol for Petroleum Impacted Sites in Atlantic Canada: Scientific Rationale* (Atlantic PIRI, 2012)
    - *Atlantic RBCA Environmental Quality Standards Rationale and Guidance Document* (Atlantic PIRI, 2023)
  - **Primary Website:** Atlantic RBCA
- **Alberta Environment and Parks (AEP) & Alberta Energy Regulator (AER)**
  - **Key Documents:**
    - *Environmental Quality Guidelines for Alberta Surface Waters* (AEP, 2018)
    - *Contamination Management Policy And Guidelines* (AER, 2025a)
    - *Manual 021: Contamination Management* (AER, 2025b)
  - **Primary Website:** Alberta Tier 1 soil and groundwater remediation guidelines

Selected International Jurisdictions

United States

- **U.S. Environmental Protection Agency (US EPA)**
  - **Key Documents:**
    - **ESBs:** *Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: PAH mixtures* (US EPA, 2003)
    - **CERLA/NCP:** *Sediment Risk Management Principles* & *Contaminated Sediments: Control, Treatment, and Remediation* (US EPA, 2017; 2005)
    - **GLWQI:** Code of Federal Regulations. *40 CFR Part 132 -- Water Quality Guidance for the Great Lakes System* (US EPA, 1995; 2002)
  - **Primary Websites:**
    - Equilibrium Partitioning Sediment Benchmarks (ESBs) (The principles page often links to technical resources like ESBs)
    - Superfund: Contaminated Sediments (https://www.epa.gov/superfund/superfund-contaminated-sediments)
    - Great Lakes Water Quality Guidance (GLWQI)

- **Interstate Technology & Regulatory Council (ITRC)**
  - **Key Documents:**
    - ITRC. (2011). Incorporating Bioavailability Considerations into the Evaluation of Contaminated Sediment Sites. CS-1. Washington, D.C.: ITRC Contaminated Sediments Team.
    - ITRC. (2014). Contaminated Sediments Remediation: Remedy Selection for Contaminated Sediments. CS-2. Washington, D.C.: ITRC Contaminated Sediments Team.
  - **Primary Website:** https://itrcweb.org/
- **Washington State (Department of Ecology)**
  - **Key Documents:**
    - Washington Administrative Code. *Chapter 173-204 WAC: Sediment Management Standards* (Washington State DEP, 2013a)
    - *Sediment Cleanup Users Manual II (SCUM II): Guidance for Implementing the Sediment Management Standards* (Washington State DoE, 2013b)
  - **Primary Website:** Sediment Cleanups
- **California (SWRCB/OEHHA) State Water Resources Control Board/Office of Environmental Health Hazard Assessment:**
  - **Key Documents:**
    - *A Tiered Assessment Framework to Evaluate Human Health Risk of Contaminated Sediment* (Greenfield et al., 2014)
  - **Primary Websites:**
    - OEHHA Fish Advisories and Guidelines
    - SWRCB Sediment Quality Objectives (SQOs)
- **Florida (Department of Environmental Protection)**
  - **Key Documents:**
    - *Approach to the Assessment of Sediment Quality in Florida Coastal Waters* (Florida DEP, 1994)
    - *Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters* (Florida DEP, 2003)
  - **Primary Website:** Sediment Guidelines

Europe

- **European Union (WFD/SedNet)**
  - **Key Documents:**
    - *Directive 2000/60/EC (Water Framework Directive)* (European Parliament, 2000)
    - *Sediment management in the context of the EU Water Framework Directive* (SedNet, 2004)
    - *Integrated sediment management Guidelines and good practices...* (European Commission, 2022)
  - **Primary Websites:**
    - EU Water Framework Directive
    - SedNet (The European Sediment Network)

Australia & New Zealand

- **Australia & New Zealand Governments (ANZG)**
  - **Key Documents:**
    - *Technical rationale for changes to the method for deriving Australian and New Zealand water quality guideline values for toxicants*. (Batley et al. 2014).
    - *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018a)
    - *Revised method for deriving Australian and New Zealand water quality guideline values for toxicants* (Warne et al., 2018)
    - *Toxicant default guideline values for sediment quality* (ANZG, 2018b)
- **Primary Website:** Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Asia

- **China (Ministry of Ecology and Environment)**
  - **Key Documents:**
    - *Marine Sediment Quality standard (GB 18668-2002)* This is the national standard, often cited in research papers). (Yang et al., 2022)
    - *Chinese Technical Guideline for Deriving Water Quality Criteria for Protection of Freshwater Organisms* (Describes the SSD-based methodology for water, HJ 831-2017) (Yan et al., 2023)
  - **Primary Website:** Ministry of Ecology and Environment of the People's Republic of China
- **Japan (Ministry of the Environment)**
  - **Key Documents:**
    - MOE. *Conservation of the Water Environment*. (This provides an overview of their water quality standards). (MOE Japan, 1997)
    - MOE. *National Effluent Standards*. (Shows their focus on controlling discharges). (Japan MOE, 2015)
    - US Army Engineer Waterways Experiment Station. (1987). *Management of Bottom Sediments Containing Toxic Substances: Proceedings of the US/Japan Experts Meeting*. (Shows historical engagement on the topic). (US Army Engineers, 1985, 1987)
  - **Primary Website:** Ministry of the Environment, Government of Japan

Appendix C. Sediment Standards Project – Survey

The following is a copy of the survey question disseminated for public input.
Section 1: Background

This survey is brought to you by the Science and Standards Technical Advisory Committee (SSTAC), established by the Science Advisory Board for Contaminated Sites (SABCS), in partnership with the BC Ministry of Environment and Parks (ENV).

Instructions: This 25-question survey (10-30 minutes) aims to gather feedback from scientists, researchers and managers on the British Columbia's Contaminated Sites Regulation (CSR) sediment quality standards and potential updates. Your input is valuable for guiding the review process. Please answer based on your professional knowledge and experience. Individual responses will be kept confidential. Responses are not required, so you can skip responding to questions if you like.

The following question provides you with an opportunity to go directly to the last section of the survey called "Sediment Standards Project & Future Participation" which provides information on the project, opportunities for participation and contact information.

Section 2: Proposed Approaches for Updating BC CSR Sediment Standards

Part 1: Background

British Columbia's current Schedule 3.4 sediment standards, in the Contaminated Sites Regulation (CSR), were derived by multiplying a probable effect level (PEL) for a substance from the Canadian Council for Ministers of the Environment, 1999, Environmental Quality Guidelines, by a defined probability of observing adverse effects to 20% of a population of organisms (i.e., EC20), in selected toxicity tests. Selected toxicity tests included a 28 to 42-day test for the freshwater amphipod, *Hyalella azteca*, and 10-day tests for the marine amphipods *Ampelisca abdita*, and *Rhepoxynius abronius*. The probability is dependant on sediment use, resulting in the following use-specific criteria:

1. Generic numerical sediment standards, for sensitive sediment: a 20% probability of observing an EC20 (P20) (equal to 0.62 for freshwater, none derived for marine), and
2. Generic numerical sediment standards, for typical sediment: a 50% probability of observing an EC20 (P50) (equal to 1.2 for both freshwater and marine).

Sediment standards are derived based on exposure scenarios for benthic ecological organisms and do not address the potential for bioaccumulation, not the associated effects on those species that consume aquatic organisms (e.g., wildlife and humans). The existing CSR sediment standards were not developed for the purpose of protecting human health, so they do not consider direct contact exposure pathways between people and contaminated sediment, such as incidental ingestion and dermal contact.

Recent scientific advancements and societal interests highlight the need for updates to better protect aquatic ecosystems, wildlife, and human health. The SSTAC is developing a scientific framework for modernizing the CSR sediment standards, incorporating international best practices, and we want to hear your views with respect to factors you believe should be considered within the framework that BC ENV will consider in revising existing sediment standards and developing new sediment standards. Here's a summary of proposed approaches to sediment standards development we're considering and the problems they address:

1. Dual Standard Approach (Benthic & Bioaccumulation/Food):

- **Approach**: Consider developing two separate standards for each contaminant where applicable: one to protect sediment-dwelling organisms from direct toxicity (Benthic) and another to protect wildlife and humans from contaminants in food, which may accumulate in the food web (Bioaccumulation and Food).
- **Problem Solved**: The current standards do not explicitly protect against bioaccumulation or food transfer risks, which is a major pathway for harm from persistent contaminants like mercury and polychlorinated biphenyls (PCBs). This approach directly addresses the risk of contaminants transferring up the food chain.

2. Incorporate Bioavailability Adjustments:

- **Approach**: Consider requiring mandatory measurement of sediment properties like Total Organic Carbon (TOC) and Acid Volatile Sulfide/Simultaneously Extracted Metals (AVS/SEM). Use standardized methods (like OC-normalization for organics, AVS/SEM assessment for metals) to adjust contaminant measurements before comparing them to standards. Promote advanced tools like passive samplers in higher-tier assessments.
- **Problem Solved**: Contaminant toxicity heavily depends on how much is available for uptake by organisms (bioavailability), which varies greatly with sediment type. Current standards use bulk concentrations, which may not reflect actual impact in all cases. This approach makes risk assessments more scientifically accurate and aligns better with international best practices.

3. Update Standard Derivation Methods:

- **Approach**: Consider modern methods like Species Sensitivity Distributions (SSDs) based on chronic toxicity data to derive benthic toxicity standards where possible. For bioaccumulation standards, use validated Biota-Sediment Accumulation Factors (BSAFs) or Food Web Models (FWMs) to link protective Tissue Residue Guidelines back to sediment screening levels.
- **Problem Solved**: The current method relies on adjusting older empirical values with known limitations. SSDs offer a statistically stronger basis for direct toxicity protection. BSAF/FWM approaches provide a mechanistic link for bioaccumulation protection.

4. Expand Contaminant Coverage:

- **Approach**: Develop standards for priority emerging contaminants relevant to BC, including PFAS families, current-use pesticides, organotins, and dioxins/furans. Address microplastics through monitoring and risk assessment frameworks.
- **Problem Solved**: The current contaminant list is outdated and misses many substances now recognized as potential risks.

5. Implement Tiered Assessment & Weight-of-Evidence (WoE):

- **Approach**: Consider a tiered system (e.g., Tier 1 uses guidelines for screening; exceedances trigger Tiers 2/3, requiring site-specific information and other lines of evidence (chemistry, toxicity testing, bioaccumulation, benthic community analysis) integrated using a WoE framework. Develop specific BC guidance.
- **Problem Solved:** Provides a more flexible yet rigorous approach. Allows efficient screening but ensures thorough, ecologically relevant assessments for complex sites using multiple data types. Aligns with international best practice.

Part 2: About You

1. Does your professional work involve protecting human health or the environment from pollution and/or contamination? (Multiple Choice)
2. Does your professional work involve assessing or managing sediment quality? (Multiple Choice)

Section 3: Current BC CSR Sediment Standards (Schedule 3.4)

3. How familiar are you with the current BC CSR Schedule 3.4 numerical sediment standards? (Rating-scale)
4. In your experience, how effective are the current BC CSR sediment standards at protecting benthic organisms (e.g., worms, clams, insects living in sediment)? (Rating-scale)
5. In your experience, how effective are the current BC CSR sediment standards at preventing harmful bioaccumulation of contaminants in the aquatic food web (e.g., accumulation in fish, wildlife)? (Rating-scale)
6. How practical are the current BC CSR sediment standards to apply in site assessments and management? (Rating-scale)
7. Which aspect of the current BC CSR sediment standards presents the biggest challenge in your work? (Multiple Choice)
8. Please elaborate on the biggest challenge you identified in the previous question, or describe any other significant challenges you face when applying the current BC CSR sediment standards. (Open-ended)
9. Can you provide examples from your experience where the current standards may have been under-protective or over-protective? Please

provide the context. (Open-ended)

10. What specific data gaps have you encountered when assessing sediment quality relative to the current BC standards? (Open-ended)

Section 4: Proposed Approaches for Updating Standards

11. The proposed update includes a 'Dual Standard' approach (separate values for benthic protection and bioaccumulation protection). How necessary do you think this approach is for improving sediment management in BC? (Rating-scale)
12. How important is it to systematically incorporate bioavailability adjustments (e.g., using Organic Carbon, AVS/SEM) into the routine application of BC sediment standards? (Rating-scale)
13. Which method for deriving benthic protection standards do you think is most appropriate for BC, considering data availability and scientific robustness? (Rating-scale)
14. How important is it to expand the list of regulated contaminants in BC sediment standards to include substances like PFAS, current-use pesticides, and organotins? (Rating-scale)
15. How beneficial would a formal, tiered assessment framework incorporating multiple lines of evidence be for complex sediment site assessments in BC? (Rating-scale)
16. What are your thoughts on the proposed 'Dual Standard' approach? What potential benefits or challenges do you foresee in its implementation? (Open-ended)
17. What are the key considerations for formally linking sediment quality assessment to Human Health Risk Assessment (HHRA) in BC, particularly regarding fish/shellfish consumption? (Open-ended)
18. Regarding a Tiered Approach (e.g., Tier 1 generic numerical; Tier 2-3 site-specific numerical): What site-specific information and lines of evidence (beyond chemistry) are most critical to include? (Open-ended)
19. Do you have experience with sediment quality frameworks from other jurisdictions (e.g., US EPA, Ontario, Washington State)? Are there specific elements from elsewhere that BC should consider adopting or adapting? (Open-ended)
20. Please provide any other comments or suggestions regarding the scientific basis, policy implications, or practical application of potential updates to BC's sediment standards. (Open-ended)

Section 5: Methodological Preferences & Data Needs

21. When assessing direct toxicity risk to benthic organisms, which assessment tool(s) do you find most reliable? (Rating-scale)
22. When assessing bioaccumulation risk from sediments, which assessment tool(s) do you find most reliable? (Rating-scale)
23. What type of sediment toxicity testing provides the most valuable information for site assessment in BC? (Rating-scale)
24. How can sediment standards better account for the cumulative effects of multiple contaminants often found at sites? (Open-ended)
25. From a regulatory science perspective, what are the key factors for ensuring updated sediment standards are implementable, enforceable, and achieve the desired environmental protection outcomes? (Open-ended)

Section 6: Sediment Standards Project & Future Participation

Healthy sediments are the foundation of thriving aquatic ecosystems—yet BC's current sediment-quality standards are decades old. The Science Advisory Board for Contaminated Sites (SABCS), in partnership with and supported by the BC Ministry of Environment & Parks (ENV), launched a fast-tracked, 10-month initiative to develop a roadmap for modernizing sediment standards. The Science & Standards Technical Advisory Committee (SSTAC), co-chaired by Jasen Nelson and Dr. Shannon Bard (SABCS), is leading the Sediment Standards Project, which includes:

- Preliminary research and jurisdictional scan;
- Designing and conducting this survey (June through July 2025);
- Preparing an interactive session at the Canadian Ecotoxicology Workshop (CEW) in Victoria this October; and
- Developing a scoping plan for modernizing sediment standards.

Findings from the preliminary research and jurisdictional scan will be documented, along with insights from community engagement activities, in a white paper which will inform the scoping plan for future phases of the Sediment Standards Project.

We are inviting collaborators to participate in our:

- **Online survey**: Share this survey with your colleagues so they can share their perspectives are on issues with sediment standards and possible solutions;
- **Technical Working Group**: Provide volunteer support for priority research

topics;

- **Session at CEW**: Submit your sediment assessment-related presentation abstract to our session and/or participate in our moderated workshop discussions focused on key sediment issues and proposed solutions.

Share your expertise to ensure best available science, best practices and diverse perspectives are included in our collaborative Sediment Standards Project.

By contributing, you will help inform our proposed scientific framework and support our inclusive community engagement process, which will be published as an SABCS white paper. Getting involved in our project will build your network with like-minded experts into the next stages of standards development. Whether you have sediment-toxicity data, modelling insight, or assessment experience, your voice can steer this initiative toward practical, science-based outcomes.

Interested in contributing your perspective? Reach out to SABCS to express interest in the Sediment Standards Project.

To learn more, send us an email at: info@sabcs.ca. Let's raise the bar for sediment management in BC, together!

Appendix D. Sediment Standards Project Survey: What We Heard

SCIENCE ADVISORY BOARD FOR CONTAMINATED SITES IN BC

September 2025

Executive Summary

Purpose

The Science Advisory Board for Contaminated Sites (SABCS), in partnership with the British Columbia (BC) Ministry of Environment and Parks (the Ministry), has launched the first phase of a multi-year effort to modernize Contaminated Sites Regulation (CSR) sediment standards. This work is SABCS-led; the Ministry participates as a contributing partner and retains sole regulatory authority. The initiative will develop a transparent, risk-based scientific framework that incorporates bioavailability, contaminant mixtures, and cumulative-effects endpoints to allow for holistic protection of aquatic ecosystems, including the wildlife and people who depend on them.

In April 2025, the SABCS initiated the Sediment Standards Project to develop a scoping plan for reviewing and updating the CSR sediment standards. The SABCS established the Science and Standards Technical Advisory Committee (SSTAC) to oversee and directly support the Sediment Standards Project, including a multi-faceted public engagement process. On May 30, 2025, the public survey was started to gather feedback on the effectiveness and practicality of the current CSR Schedule 3.4 sediment standards from those who work with them most closely. The feedback from the public survey will be used to inform the next phase of public engagement, which is a half-day session at the Canadian Ecotoxicity Workshop in Victoria on October 27, 2025.

Engagement Method

An online survey was distributed to SSTAC members and other qualified environmental professionals between May 30 and July 31, 2025. This report summarizes the feedback received from respondents (43 complete and 18 additional partial responses), representing a cross-section of expert opinion from environmental consultants, industry representatives, academics, non-government organizations, and government regulators.

Key Themes

The feedback received was detailed and consistent, coalescing around several critical themes:

- **Widespread Dissatisfaction with the Status Quo:** A strong consensus emerged that the current standards are outdated and not sufficiently protective of the environment. A striking 73% of respondents rate the standards as "Not Effective" or "Slightly Effective" at preventing harmful bioaccumulation. A significant concern is their failure to address this pathway, which can lead to contaminants moving up the

food chain and posing a risk to wildlife and human health.

- **Practical Challenges in Application:** Respondents highlighted significant difficulties in applying the current standards. Common issues include a limited list of regulated contaminants that omits substances of emerging concern, ambiguity in the classification of "typical" versus "sensitive" sediments, and the standards' failure to account for the bioavailability of contaminants in different environmental settings.
- **The Call for a Broader, More Protective Scope:** Respondents overwhelmingly advocate for a framework that is more comprehensive and protective. This is most evident in the demand to expand the list of regulated contaminants, which 95% of respondents rated as "Essential" or "Very Important." Furthermore, the need to address bioaccumulation was a critical concern, with 68% viewing a "Dual Standard" approach as "Very Necessary" or "Essential."
- **A Mandate for a More Sophisticated, Science-Based Approach:** There is a strong desire to move beyond simple, conservative "bright-line" standards towards a more nuanced, evidence-based system. This is supported by 91% of respondents who see incorporating bioavailability adjustments as "Essential" or "Very Important," and 86% who believe a formal, tiered assessment framework would be beneficial.
- **Strong Support for Clear Guidance and Education:** Participants emphasized that new standards, particularly if more complex, must be accompanied by clear, comprehensive guidance documents, standardized methodologies, and accessible training programs to ensure consistent and effective implementation by regulators and practitioners.

Conclusion

The feedback gathered provides a clear mandate and a well-defined direction for updating the BC CSR sediment standards. This input will be instrumental in developing a modernized framework that is more protective of the environment and human health, and more practical for regulators and practitioners to implement across BC's diverse aquatic ecosystems.

1. Introduction

1.1 Background

BC’s diverse aquatic ecosystems, from its rugged coastline and intricate fjords to its thousands of freshwater rivers and lakes, are invaluable ecological, cultural, and economic resources. Sediments form the foundation of these aquatic environments, providing critical habitat for a wide range of organisms. However, sediments can also act as a sink for contaminants, accumulating pollutants over time. These contaminants can then be released back into the water or enter the food web, posing risks to aquatic life and human health.

To manage these risks, the province established sediment standards under the CSR. The CSR defines "sediment" as particulate material that usually lies below water. These standards are intended to be used in the assessment and remediation of contaminated sites to ensure the protection of both environmental and human health. The current sediment standards, found in Schedule 3.4 of the CSR, have been in place since 2003. In that time, scientific understanding of sediment toxicology, contaminant fate and transport, and human and ecological risk assessment has advanced significantly.

1.2 Purpose of Engagement

Recognizing the need to ensure the provincial regulatory framework reflects current science, the SABCS is undertaking a comprehensive review of the CSR sediment standards. A key component of this review is engagement with the professionals who apply these standards in their daily work.

The primary objective of this engagement was to gather expert feedback from environmental consultants, industry representatives, government regulators, academics, non-government organizations and other qualified professionals. The survey sought to understand their perspectives on the effectiveness and practicality of the existing sediment standards and to solicit recommendations for improvement.

1.3 Methodology

An online survey was conducted for two months between May 30 and July 31, 2025. The survey was posted online and distributed to members of the SSTAC to reach and other professionals identified as having expertise in the field of contaminated sites and sediment quality assessment. The survey was advertised using a variety of channels including the Ministry’s Site Remediation News service, the SABCS website, LinkedIn posts and direct email to contacts who may not be included in the channels used for

advertising the survey.

A total of 61 partial and 43 complete responses were received and analyzed. The analysis involved quantitative summaries of multiple-choice questions and a qualitative thematic analysis of open-ended responses to identify key issues, common challenges, and preferred approaches for modernizing the sediment standards.

1.4 About This Report

This "What We Heard" report presents a neutral summary of the feedback received during the engagement period. The views and opinions expressed are those of the survey respondents and do not necessarily represent the position of the SABCS or the Government of BC.

The report is organized into key themes that emerged from the survey data. Direct, anonymized quotes are used throughout to illustrate the perspectives shared by participants. Results from this report will directly inform the project's next phases.

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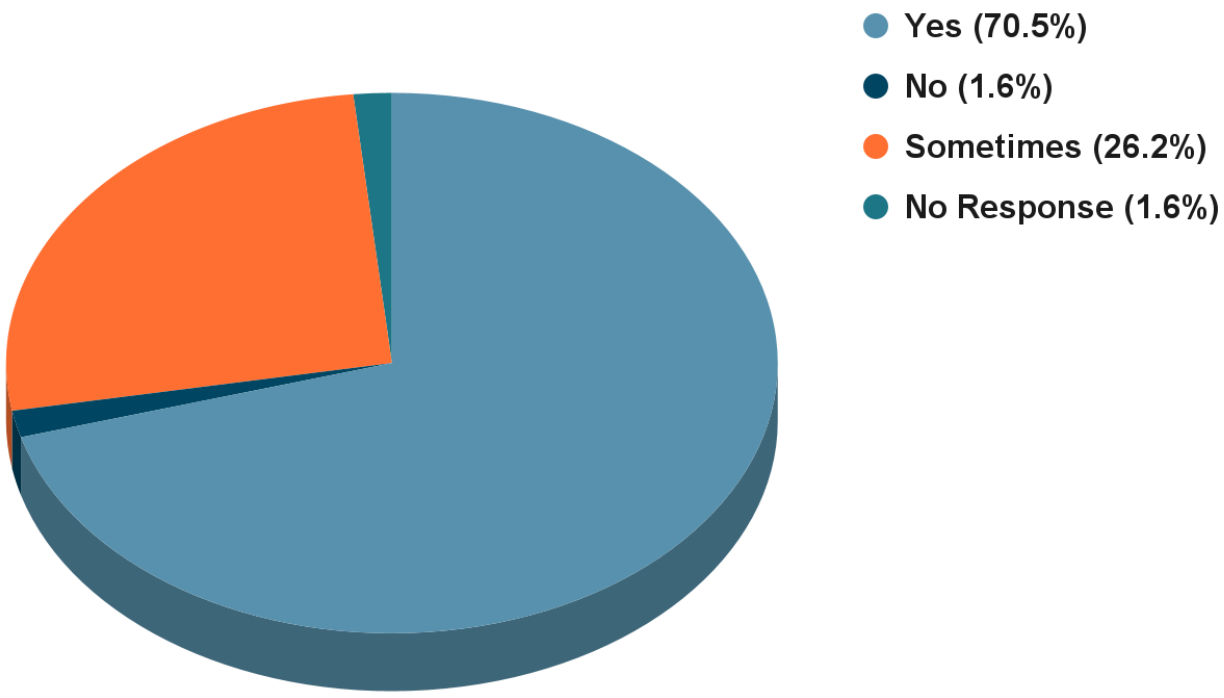
2. Overview of Respondents

The survey successfully reached a targeted audience of highly experienced professionals who work directly with the BC CSR sediment standards. The quality and depth of the responses reflect a strong collective expertise in contaminated sites management, environmental science, and regulatory compliance.

Professional Involvement

The vast majority of respondents are actively engaged in work that involves assessing or managing sediment quality. This direct, hands-on experience provides a valuable, practice-based perspective on the strengths and weaknesses of the current regulatory framework. As shown in Figure 1, 64% of respondents indicated that their professional work involves assessing or managing sediment quality, with an additional 21% reporting they sometimes engage in this work.

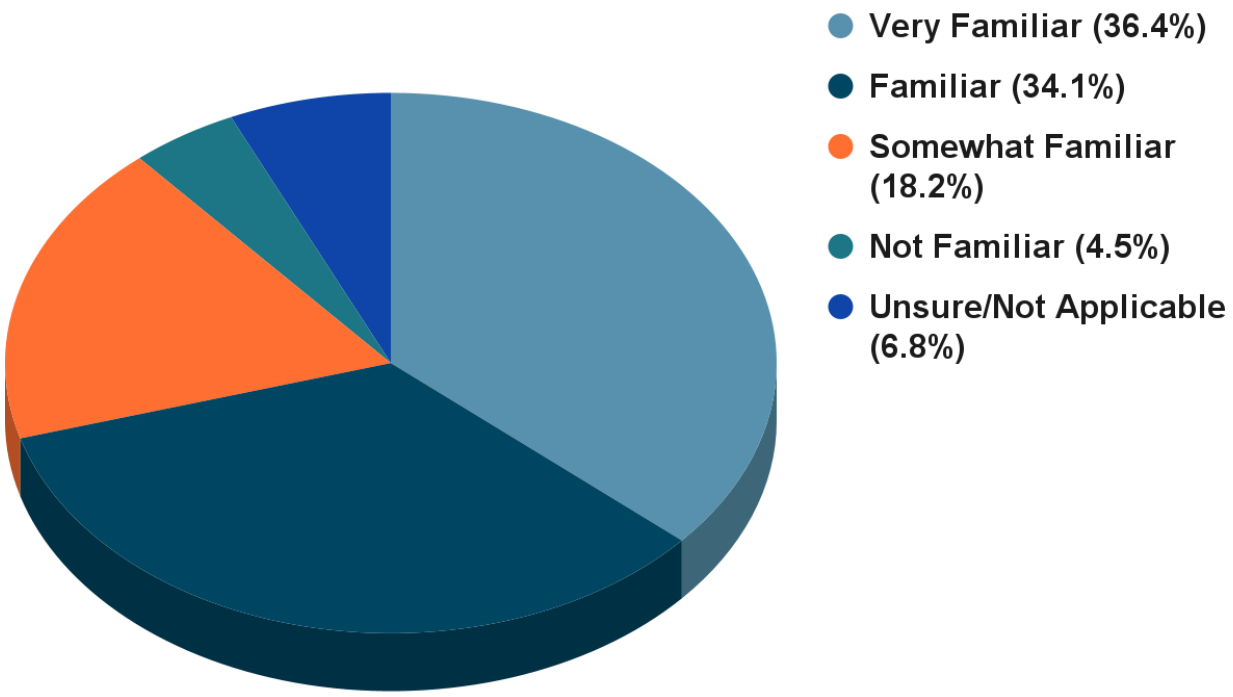
Figure D-1: Does your professional work involve assessing or managing sediment quality? (n=61)



Familiarity with Current Standards

The feedback received is from a well-informed audience. Over 70% of respondents described themselves as "Very Familiar" or "Familiar" with the current BC CSR Schedule 3.4 numerical sediment standards. This high level of familiarity ensures that the critiques and suggestions provided are not based on speculation, but on years of practical application.

Figure D-2: How familiar are you with the current BC CSR Schedule 3.4 numerical sediment standards? (n = 61)



The professional background of respondents was diverse, including environmental consultants, representatives from industry, academics, non-government organizations and regulators from various levels of government. This mix of perspectives provides a balanced and comprehensive overview of how the standards are used and perceived across different sectors. The strong consensus on key issues that emerged from this diverse group underscored the validity of their shared concerns and recommendations.

3. Summary of Feedback: Key Themes

3.1 Theme A: Effectiveness of Current Standards

A predominant theme throughout the survey responses is that the current sediment standards are outdated and not sufficiently protective of the complex aquatic ecosystems in BC. While some respondents see value in the standards as a basic screening tool, the majority believe they fail to address key risk pathways, particularly the bioaccumulation of contaminants.

Figure D-3: Perceived Effectiveness for Protecting Benthic Organisms (n = 59)

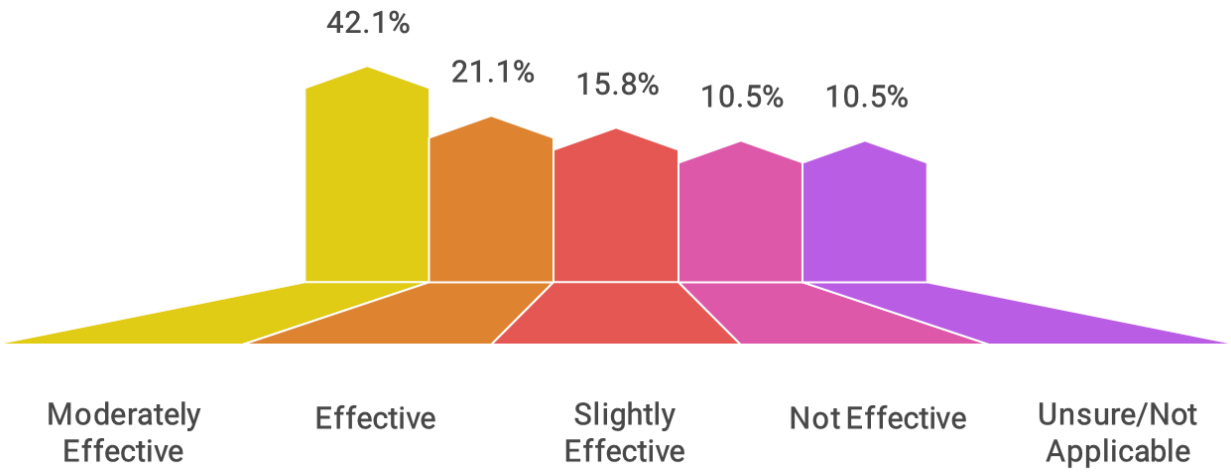
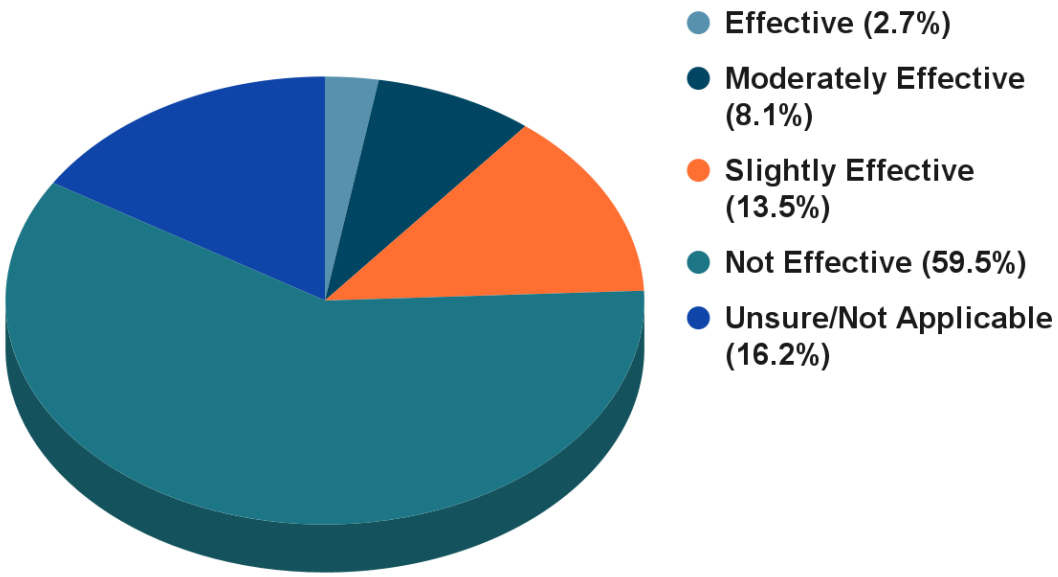


Figure D-4: Perceived Effectiveness for Preventing Harmful Bioaccumulation (n = 59)



As illustrated in Figures 3 and 4, there is a stark contrast in how respondents view the standards' ability to protect different parts of the ecosystem. While over 60% of respondents believe the standards are at least "moderately effective" at protecting benthic organisms, this confidence plummets when considering the broader food web. A

striking 73% stated the standards are "Not Effective" or "Slightly Effective" at preventing harmful bioaccumulation. This points to a critical gap: the standards are perceived as focusing on direct toxicity to sediment-dwelling organisms while largely ignoring the transfer of contaminants up the food chain to fish, marine mammals, and ultimately humans.

This concern was frequently articulated in the written comments, where participants highlighted the limitations of a framework that does not explicitly account for bioaccumulation risks.

> *"The BC CSR sediment standards are not appropriate or adequate to protect upper trophic level organisms, apex predators and humans at the top of foodwebs, as these sediment standards were or are designed for the protection of low tropic level species and benthic organisms."* - Survey Respondent

> *"No bioaccumulation protection is also a scary consideration, resulting in the need to clean up to levels below standards but having a challenging time making a convincing argument."* - Survey Respondent

This lack of bioaccumulation standards was cited as a direct cause of under-protection. One respondent noted an experience where contaminant levels were below the numerical standards, yet tissue sampling revealed that contaminants were accumulating in organisms at levels above critical thresholds. Another pointed out that the standards are not protective enough for Indigenous communities that rely on traditional seafood harvesting, where bioaccumulation poses a direct human health risk.

Conversely, several respondents argued that in certain situations, the standards are *over-protective*. This occurs most often in areas with naturally high background concentrations of metals, where the generic, province-wide standards are lower than what is found in undisturbed local sediment.

> *"I know that there have been instances where arsenic and copper concentrations in the Fraser River are naturally higher than the standards, so this would be an example of overprotectiveness."* - Survey Respondent

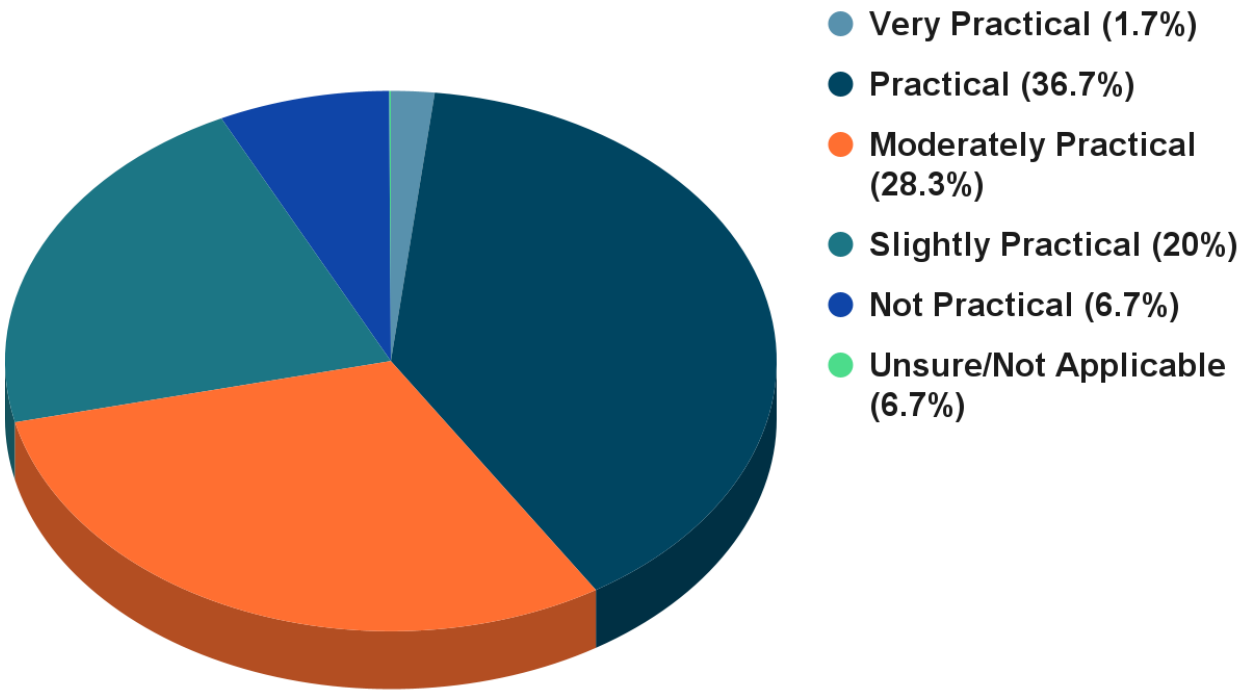
This "one-size-fits-all" approach can lead to unnecessary and costly investigations or remediation efforts at sites where the elevated concentrations are natural and pose no additional risk to the environment or human health.

3.2 Theme B: Practicality and Challenges of Application

While the current standards are seen as relatively simple to apply - comparing an

analytical chemistry result to a number in a table - respondents identified significant practical challenges that undermine their utility and scientific defensibility.

Figure D-5: Practicality of Applying Current Standards (n = 60)



The feedback indicates that the perceived practicality of the standards is largely due to their simplicity, but this simplicity comes at a cost. The most significant challenges identified by respondents relate to the limited scope of the standards, ambiguity in their application, and a lack of scientific transparency.

Issues with Specific Parameters and Contaminants

A major and recurring criticism is that the list of regulated contaminants in Schedule 3.4 is insufficient and outdated.[6] Professionals frequently encounter substances for which no provincial standard exists, forcing them to rely on guidelines from other jurisdictions or conduct costly, site-specific risk assessments.

> *"The CSR list of sediment standards is surprisingly short."* - Survey Respondent

> *"There are numerous COCs [contaminants of concern] that are not within Schedule 3.4 including TBT. Additionally, there are no human health considerations for sediments."* - Survey Respondent

Respondents specifically highlighted the need for standards for emerging contaminants like per- and polyfluoroalkyl substances (PFAS), current-use pesticides, organotins (e.g., tributyltin), microplastics, and petroleum hydrocarbons (PHCs). The lack of PHC standards was noted as a particular deficiency, with one respondent describing the existing federal models as "too low (not realistic)" for BC conditions.

Methodological and Interpretive Challenges

Beyond the contaminant list, respondents expressed frustration with the methodology and interpretation of the existing standards.

- **Typical vs. Sensitive Sediments:** The distinction between "typical" and "sensitive" sediments was a common point of contention. The definition of a "sensitive" sediment is seen as overly broad and restrictive, resulting in its default application to nearly all sites, including industrial harbours and marinas. This negates the purpose of having a two-tiered system and can lead to the application of overly stringent standards that may not be achievable or necessary.

  "The typical vs sensitive approach is a bit clunky. At the very least, the terms don't seem appropriate. Benthic organisms in Industrial harbours may still be sensitive even if there's a lower protection goal allowed for those environs." - Survey Respondent

- **Bioavailability:** A fundamental scientific criticism is that the standards are based on total contaminant concentrations and do not account for bioavailability—the portion of a chemical that is actually available to be taken up by organisms. This can lead to a mischaracterization of risk.

  "The bioavailability in sediment helps us understand not just how much contaminant is present, but whether it is causing harm or influencing environmental processes. This distinction is required to make informed decisions in managing contaminated sites." - Survey Respondent

- **Lack of Transparency:** Many professionals noted that the scientific basis and derivation documents for the current standards are not readily available. This makes it difficult to understand the level of protection the standards are intended to provide and to justify site-specific modifications when appropriate.

3.3 Theme C: The Need for New and Revised Standards

Given the perceived shortcomings of the current regulations, there is overwhelming support among survey respondents for a comprehensive update. This support is not merely for adjusting existing values but for developing a fundamentally new, more

scientifically robust framework for assessing sediment quality.

Figure D-6: How necessary is the proposed 'Dual Standard' approach? (n = 60)

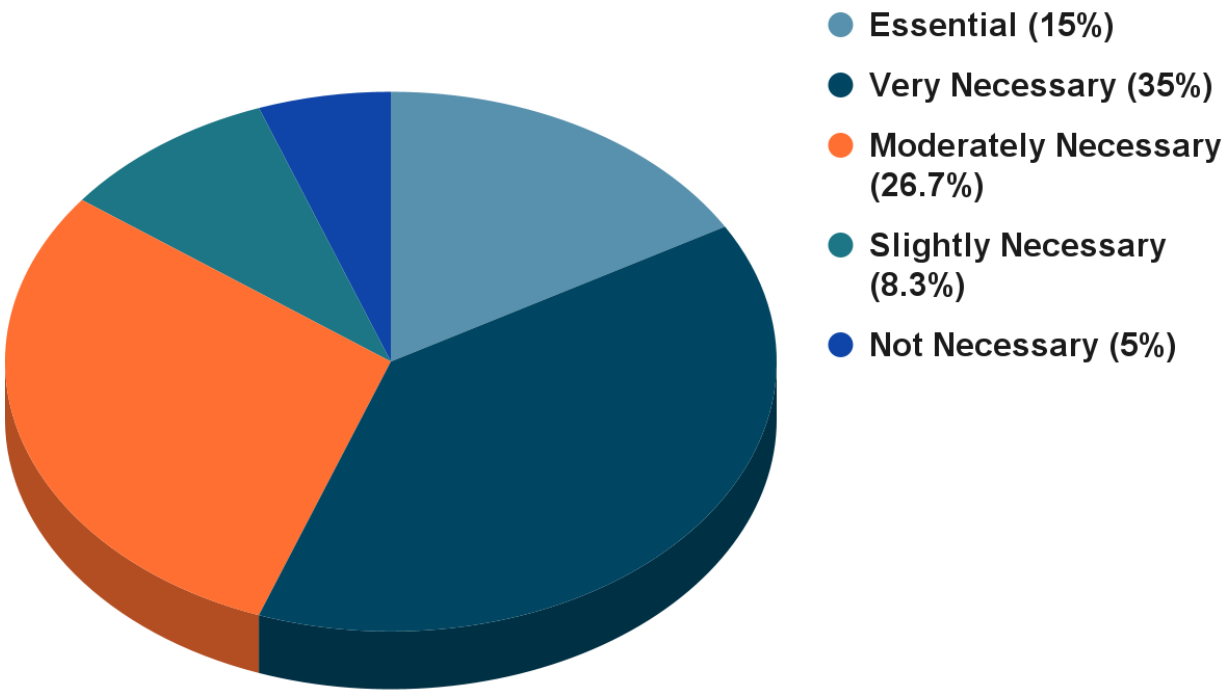


Figure D-7: How important would a formal, bioavailability adjustment option within the tiered framework be? (n = 59)

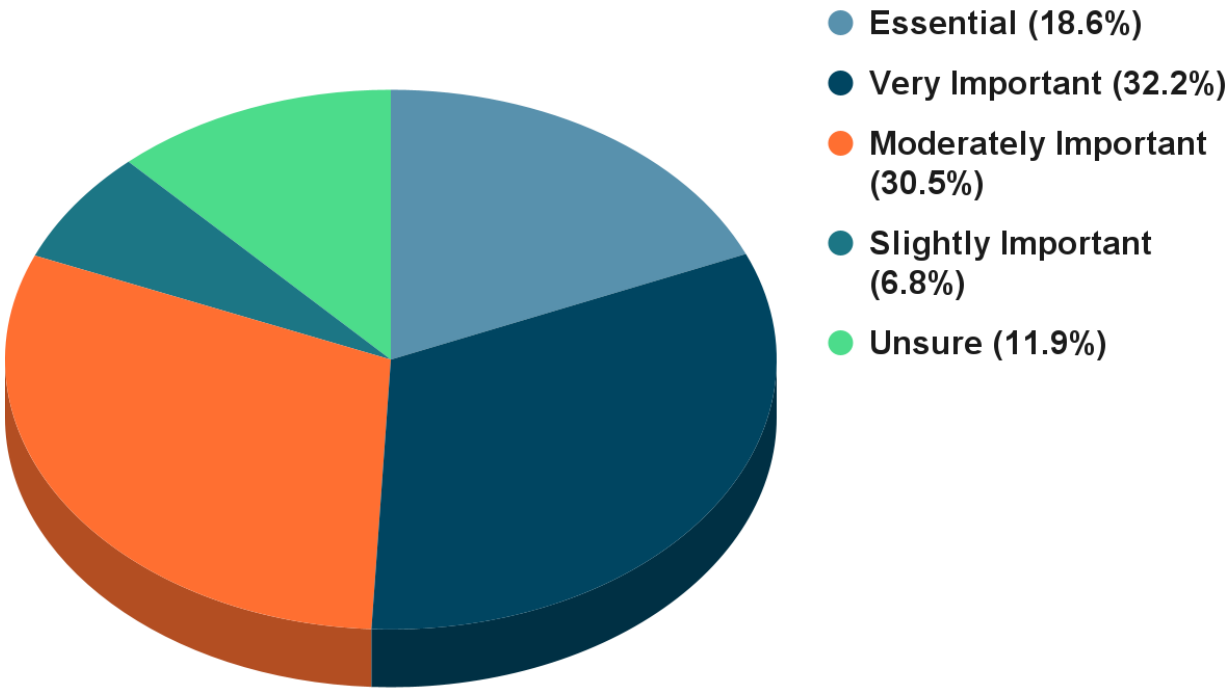
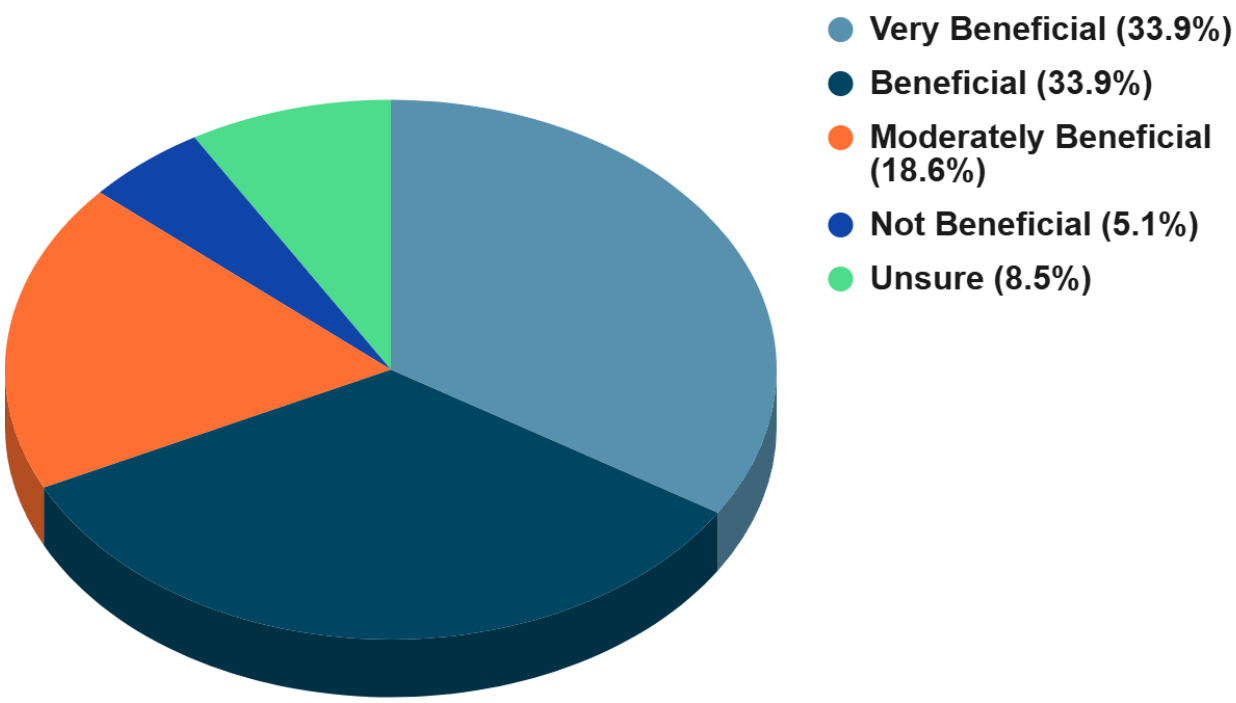


Figure D-8: How beneficial would a formal, tiered framework be? (n = 59)



The desire for a modernized framework is clear, with a strong mandate coupled with clear preferences for the *form* these new standards should take.

Key Suggestions for New Standards

Respondents provided specific, constructive suggestions for developing a more effective and scientifically defensible sediment standards framework.

- **Dual-Standard Approach:** There is strong support for developing separate standards for the protection of benthic organisms (direct toxicity) and for the protection against bioaccumulation (food web effects). This "dual standard" approach is seen as a critical step to address the primary weakness of the current regulations. As one respondent noted, this approach would *"address more receptors (i.e., not just focus on benthic invertebrates)"* and provide a more holistic assessment of risk.
- **Incorporate Bioavailability:** A clear majority of respondents (over 88%) believe it is "Essential" or "Very Important" to systematically incorporate bioavailability adjustments into the standards, using metrics such as Total Organic Carbon (TOC) and Acid Volatile Sulfides/Simultaneously Extracted Metals (AVS/SEM). This would allow for a more accurate assessment of risk by considering the fraction of a

contaminant that is actually available to cause harm, rather than relying solely on total concentration.

- **Tiered, Risk-Based Framework:** There is broad agreement (over 86% see it as "Beneficial" or "Very Beneficial") that a formal, tiered assessment framework would improve sediment management in BC. Such a framework would allow for simple screening at Tier 1 using conservative numerical standards, with options for more complex, site-specific investigations at higher tiers. This could include tools like:
    - Food Web Models (FWMs) to simulate contaminant transfer through the food chain.
    - Biota-Sediment Accumulation Factors (BSAFs) to quantify the relationship between contaminant levels in sediment and in organisms.
    - Toxicity Testing to directly measure the effects of contaminated sediment on aquatic life.

    "I believe this [a tiered framework] can be extremely beneficial, especially when combined with a tiered assessment framework." - Survey Respondent

This approach would provide the flexibility needed to manage the wide variety of sites and conditions found across the province, from remote, pristine environments to complex, industrialized harbours.

3.4 Theme D: Data, Guidance, and Implementation

While there is strong enthusiasm for new, scientifically advanced standards, respondents were equally clear that new rules alone are not enough. The success of a modernized framework depends on robust data, clear guidance, and comprehensive training to support its implementation.

Data Gaps

A significant barrier to effective sediment quality assessment is the lack of critical data. Respondents identified several key areas where more information is needed:

- **Emerging Contaminants:** The most frequently cited data gap is the absence of standards for contaminants of emerging concern such as PFAS, current-use pesticides, organotins, microplastics, and PHCs.
- **Background Concentrations:** There is a need for provincially or regionally established background concentration data for metals and other substances. This would help distinguish between natural and anthropogenic sources of contamination and prevent the misclassification of sites.
- **Bioaccumulation Factors:** To properly assess bioaccumulation risk, BC-specific data is needed, including Biota-Sediment Accumulation Factors (BSAFs) for local species and information on their dietary habits.
- **Sampling and Analysis:** Respondents also called for better guidance on sampling density and methodologies, and improved laboratory analytical methods and lower detection limits to support advanced assessments.

Guidance and Training

Respondents universally agreed that any new framework must be accompanied by clear, accessible, and practical guidance. There is a strong desire for transparency in how the new standards are developed and how they are intended to be used.

> *"Provide decision trees, flowcharts, and worked examples in guidance documents. Integrate chemistry, toxicity tests, and benthic community data in a weight-of-evidence (WOE) approach."* - Survey Respondent

> *"That would be dependent on what the future framework is, but at the bare minimum there needs to be a presentation on what was done and how the standards were derived."* - Survey Respondent

Specific requests included webinars, detailed technical documents, and training sessions for both regulators and consultants to ensure the new framework is applied consistently and correctly across the province. This emphasis on implementation support highlights a key lesson from past experience: without proper guidance, even the most scientifically sound regulations can be difficult to apply in practice.

3.5 Theme E: Noteworthy Insights

Beyond the major themes, respondents provided several specific and forward-thinking suggestions that warrant consideration in the standards review process:

- **Human Health Dermal Exposure:** One respondent highlighted a potential gap in human health risk assessment, noting that the rate at which contaminants adhere to skin can be significantly higher in wet, intertidal sediments compared to standard terrestrial soils. This could lead to an underestimation of risk for people using these areas for recreation or harvesting.
- **Future-Proofing for Climate Change:** A novel suggestion was to consider incorporating a temperature factor into the standards. The respondent noted that warmer water temperatures, a consequence of climate change, can increase both the toxicity of certain contaminants and the susceptibility of organisms to them.
- **A "One Health" Approach:** One expert advocated for framing the project through a "One Health" lens, which recognizes the interconnectedness of environmental, wildlife, and human health. This approach would align the updated standards with broader goals of ecological and community well-being.

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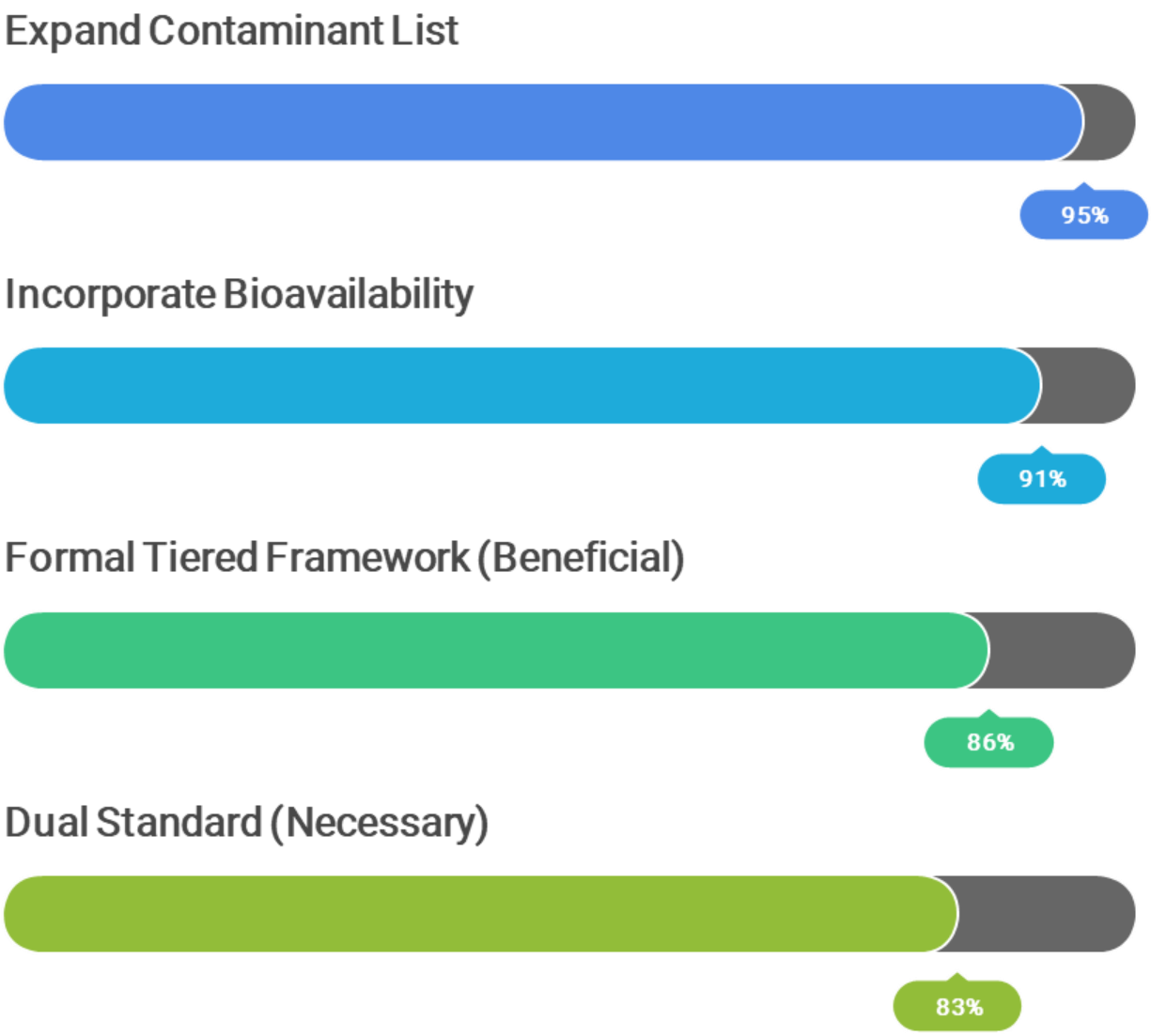
4. Respondents' Preferred Actions & Approaches

The survey responses provide a clear roadmap for modernizing BC's sediment standards. The feedback moves beyond identifying problems to proposing a suite of preferred actions and approaches. The central theme is a shift from a simple, prescriptive system to a more sophisticated, flexible, and scientifically robust framework that better reflects the complexities of aquatic ecosystems.

Based on an analysis of the survey data, the most frequently recommended actions and approaches are summarized in Figure D-9.

Figure D-9: Respondents' Most Recommended Approaches (n = 60, 59, 59, 60)



- **Develop Bioaccumulation-Based Standards:** This was the most prominent recommendation. Experts strongly advocate for a "dual standard" approach, with one set of values to protect benthic organisms and another to protect higher trophic levels (including wildlife and humans) from the effects of bioaccumulation. This addresses the most significant perceived weakness of current regulations.
- **Incorporate Bioavailability Adjustments:** There is a strong consensus that standards should not be based solely on total contaminant concentrations. Respondents want a system that accounts for site-specific factors like organic

carbon content and AVS, which control how much of a contaminant is actually available to cause harm.

- **Expand List of Regulated Contaminants:** The current list of substances is seen as inadequate. Respondents urged the development of standards for a wider range of chemicals, including emerging contaminants like PFAS, modern pesticides, and PHCs.
- **Establish a Tiered, Weight-of-Evidence Framework:** Professionals support a move towards a more flexible assessment framework. This would allow for simple screening at low-risk sites, while providing clear pathways for more detailed, multi-faceted investigations (e.g., combining chemical analysis with toxicity testing and biological community surveys) at more complex sites.
- **Provide Clear Implementation Guidance:** The call for clear, comprehensive, and practical guidance was universal. This includes the need for transparent documentation on how standards are derived, and decision trees, case studies, and training to ensure consistent application by both industry and regulators.
- **Develop Regional Background Concentrations:** To address the issue of standards being lower than natural levels in some areas, respondents recommended the development of regional background values. This would provide a more realistic baseline for assessing contamination and prevent unnecessary remediation efforts.

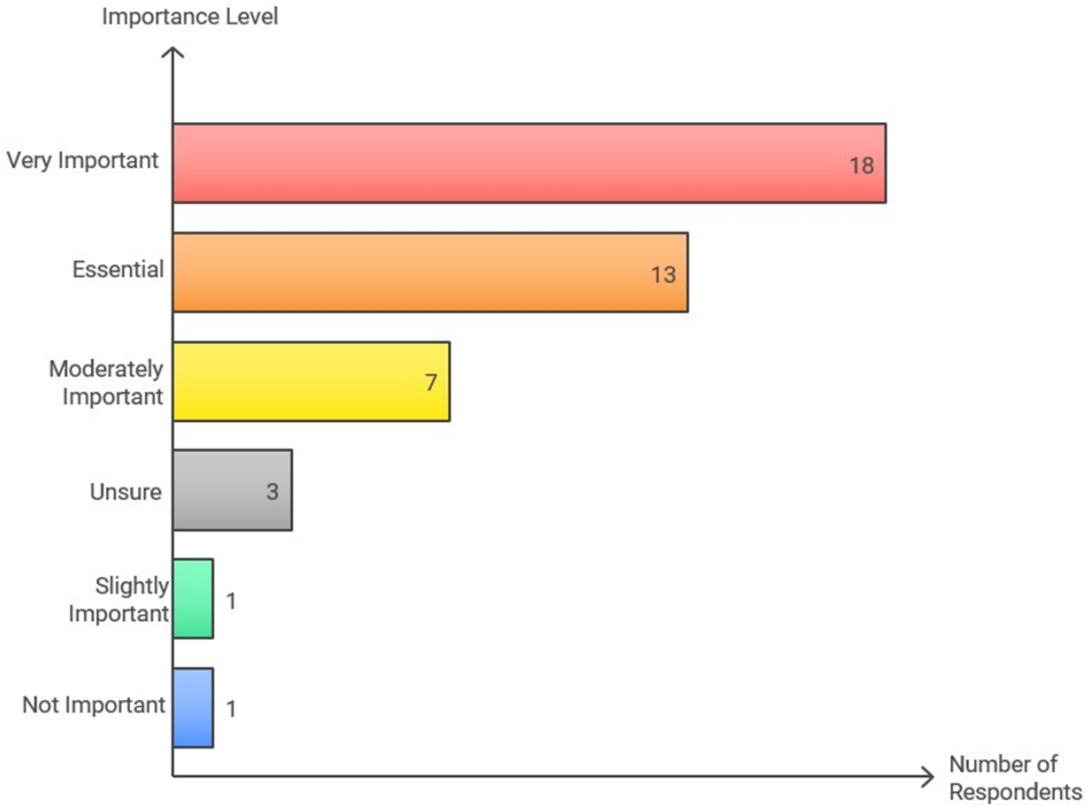
5. Summing It Up

The survey engagement process for the Sediment Standards Project has yielded a clear and compelling message from the community of professionals who work with these regulations daily. The feedback demonstrates a strong consensus on the need for change and provides valuable, constructive direction for developing a modernized sediment standards framework for BC.

Are we on the right track?

The overwhelming response from stakeholders confirms that the initiative to review and update the sediment standards is not only welcome but essential. When asked about the necessity of developing new numerical standards, 88% of respondents identified it as either "Essential", "Very Important" or “Moderately Important.” This represents a powerful mandate for reform.

Figure D-10: Is it Important to Develop New Sediment Standards? (n = 43)



This strong support indicates that the professional community is ready and willing to embrace a new, more scientifically advanced approach to sediment management. The issues raised, from the lack of bioaccumulation standards to the need for clear guidance, are not minor critiques but point to fundamental gaps in the current system that must be addressed.

The input gathered through this survey will be invaluable in guiding the next phase of the Sediment Standards Project. The feedback highlights a clear path forward: developing a robust, tiered framework that includes separate standards for benthic and bioaccumulation protection, incorporates bioavailability, addresses emerging contaminants, and is supported by clear guidance and training. By incorporating this expert feedback, the SABCS and the Ministry can develop sediment standards that are both scientifically defensible and practically applicable, ensuring the long-term health of BC's aquatic environments.

6. Appendices

Appendix A: Survey Questions

1. Does your professional work involve protecting human health or the environment from pollution and/or contamination? (Multiple Choice)
2. Does your professional work involve assessing or managing sediment quality? (Multiple Choice)
3. How familiar are you with the current BC CSR Schedule 3.4 numerical sediment standards? (Rating-scale)
4. In your experience, how effective are the current BC CSR sediment standards at protecting benthic organisms (e.g., worms, clams, insects living in sediment)? (Rating-scale)
5. In your experience, how effective are the current BC CSR sediment standards at preventing harmful bioaccumulation of contaminants in the aquatic food web (e.g., accumulation in fish, wildlife)? (Rating-scale)
6. How practical are the current BC CSR sediment standards to apply in site assessments and management? (Rating-scale)
7. Which aspect of the current BC CSR sediment standards presents the biggest challenge in your work? (Multiple Choice)
8. Please elaborate on the biggest challenge you identified in the previous question, or describe any other significant challenges you face when applying the current BC CSR sediment standards. (Open-ended)
9. Can you provide examples from your experience where the current standards may have been under-protective or over-protective? Please provide the context. (Open-ended)
10. What specific data gaps have you encountered when assessing sediment quality relative to the current BC standards? (Open-ended)
11. The proposed update includes a 'Dual Standard' approach (separate values for benthic protection and bioaccumulation protection). How necessary do you think this approach is for improving sediment management in BC? (Rating-scale)
12. How important is it to systematically incorporate bioavailability adjustments (e.g., using Organic Carbon, AVS/SEM) into the routine application of BC sediment standards? (Rating-scale)
13. Which method for deriving benthic protection standards do you think is most appropriate for BC, considering data availability and scientific robustness? (Rating-scale)
14. How important is it to expand the list of regulated contaminants in BC sediment standards to include substances like PFAS, current-use pesticides, and organotins? (Rating-scale)

15. How beneficial would a formal, tiered assessment framework incorporating multiple lines of evidence be for complex sediment site assessments in BC? (Rating-scale)
16. What are your thoughts on the proposed 'Dual Standard' approach? What potential benefits or challenges do you foresee in its implementation? (Open-ended)
17. What are the key considerations for formally linking sediment quality assessment to Human Health Risk Assessment (HHRA) in BC, particularly regarding fish/shellfish consumption? (Open-ended)
18. Regarding a Tiered Approach (e.g., Tier 1 generic numerical; Tier 2-3 site-specific numerical): What site-specific information and lines of evidence (beyond chemistry) are most critical to include? (Open-ended)
19. Do you have experience with sediment quality frameworks from other jurisdictions (e.g., US EPA, Ontario, Washington State)? Are there specific elements from elsewhere that BC should consider adopting or adapting? (Open-ended)
20. Please provide any other comments or suggestions regarding the scientific basis, policy implications, or practical application of potential updates to BC's sediment standards. (Open-ended)
21. When assessing direct toxicity risk to benthic organisms, which assessment tool(s) do you find most reliable? (Rating-scale)
22. When assessing bioaccumulation risk from sediments, which assessment tool(s) do you find most reliable? (Rating-scale)
23. What type of sediment toxicity testing provides the most valuable information for site assessment in BC? (Rating-scale)
24. How can sediment standards better account for the cumulative effects of multiple contaminants often found at sites? (Open-ended)
25. From a regulatory science perspective, what are the key factors for ensuring updated sediment standards are implementable, enforceable, and achieve the desired environmental protection outcomes? (Open-ended)

Appendix B: Survey Methods and Constraints

Methodology

The online survey used Google Forms and was anonymous.

The analysis involved two components:

1. **Quantitative Analysis:** Responses to multiple-choice and rating-scale questions were tallied and are presented as percentages and charts throughout this report to illustrate the distribution of opinions on specific topics.
2. **Qualitative Analysis:** Responses to open-ended questions were compiled and systematically analyzed to identify recurring themes, key issues, and specific recommendations. Direct, anonymized quotes have been selected to provide context and depth to the quantitative findings.

Limitations

The findings of this report should be considered within the context of the following limitations:

- **Targeted Audience:** The survey was not distributed to the general public but to a specific group of technical experts. As such, the results reflect the views of this professional community and are not necessarily representative of the broader public or Indigenous Peoples.
- **Sample Size:** While the respondents are highly knowledgeable, the sample size of 43 complete responses is relatively small, but there were an additional 18 responses for some questions, which brings the total participants up to 61. The findings represent a valuable snapshot of expert opinion but may not capture the full spectrum of views within the environmental industry. Numerous organizations indicated that they completed the survey as a team or elected a team member to complete the survey on behalf of the organization.
- **Self-Selection:** Participation in the survey was voluntary, which may introduce a self-selection bias. It is possible that individuals with stronger opinions or specific concerns about the current standards were more likely to respond.

Appendix C: Survey Responses

Section 2: Proposed Approaches for Updating BC CSR Sediment Standards

Part 1: Background

British Columbia's current Schedule 3.4 sediment standards, in the Contaminated Sites Regulation (CSR), were derived by multiplying a probable effect level (PEL) for a substance from the Canadian Council for Ministers of the Environment, 1999, Environmental Quality Guidelines, by a defined probability of observing adverse effects to 20% of a population of organisms (i.e., EC20), in selected toxicity tests. Selected toxicity tests included a 28 to 42-day test for the freshwater amphipod, *Hyalella azteca*, and 10-day tests for the marine amphipods *Ampelisca abdita*, and *Rhepoxynius abronius*. The probability is dependant on sediment use, resulting in the following use-specific criteria:

1. Generic numerical sediment standards, for sensitive sediment: a 20% probability of observing an EC20 (P20) (equal to 0.62 for freshwater, none derived for marine), and
2. Generic numerical sediment standards, for typical sediment: a 50% probability of observing an EC20 (P50) (equal to 1.2 for both freshwater and marine).

Sediment standards are derived based on exposure scenarios for benthic ecological organisms and do not address the potential for bioaccumulation, not the associated effects on those species that consume aquatic organisms (e.g., wildlife and humans). The existing CSR sediment standards were not developed for the purpose of protecting human health, so they do not consider direct contact exposure pathways between people and contaminated sediment, such as incidental ingestion and dermal contact.

Recent scientific advancements and societal interests highlight the need for updates to better protect aquatic ecosystems, wildlife, and human health. The SSTAC is developing a scientific framework for modernizing the CSR sediment standards, incorporating international best practices, and we want to hear your views with respect to factors you believe should be considered within the framework that BC ENV will consider in revising existing sediment standards and developing new sediment standards. Here’s a summary of proposed approaches to sediment standards development we're considering and the problems they address:

1. Dual Standard Approach (Benthic & Bioaccumulation/Food):

- **Approach**: Consider developing two separate standards for each contaminant where applicable: one to protect sediment-dwelling organisms from direct toxicity (Benthic) and another to protect wildlife and humans from contaminants in food, which may accumulate in the food web (Bioaccumulation and Food).
- **Problem Solved**: The current standards do not explicitly protect against bioaccumulation or food transfer risks, which is a major pathway for harm from persistent contaminants like mercury and polychlorinated biphenyls (PCBs). This approach directly addresses the risk of contaminants transferring up the food chain.

2. Incorporate Bioavailability Adjustments:

- **Approach**: Consider requiring mandatory measurement of sediment properties like Total Organic Carbon (TOC) and Acid Volatile Sulfide/Simultaneously Extracted Metals (AVS/SEM). Use standardized methods (like OC-normalization for organics, AVS/SEM assessment for metals) to adjust contaminant measurements before comparing them to standards. Promote advanced tools like passive samplers in higher-tier assessments.
- **Problem Solved**: Contaminant toxicity heavily depends on how much is available for uptake by organisms (bioavailability), which varies greatly with sediment type. Current standards use bulk concentrations, which may not reflect actual impact in all cases. This approach makes risk assessments more scientifically accurate and aligns better with international best practices.

3. Update Standard Derivation Methods:

- **Approach**: Consider modern methods like Species Sensitivity Distributions (SSDs) based on chronic toxicity data to derive benthic toxicity standards where possible. For bioaccumulation standards, use validated Biota-Sediment Accumulation Factors (BSAFs) or Food Web Models (FWMs) to link protective Tissue Residue Guidelines back to sediment screening levels.
- **Problem Solved**: The current method relies on adjusting older empirical values with known limitations. SSDs offer a statistically stronger basis for direct toxicity protection. BSAF/FWM approaches provide a mechanistic link for bioaccumulation protection.

4. Expand Contaminant Coverage:

- **Approach**: Develop standards for priority emerging contaminants relevant to BC, including PFAS families, current-use pesticides, organotins, and dioxins/furans. Address microplastics through monitoring and risk assessment frameworks.
- **Problem Solved**: The current contaminant list is outdated and misses many substances now recognized as potential risks.

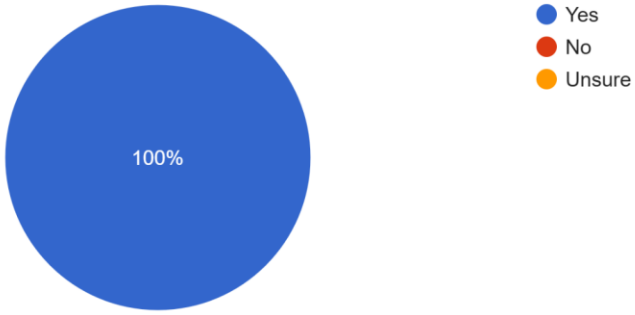
5. Implement Tiered Assessment & Weight-of-Evidence (WoE):

- **Approach**: Consider a tiered system (e.g., Tier 1 uses guidelines for screening; exceedances trigger Tiers 2/3, requiring site-specific information and other lines of evidence (chemistry, toxicity testing, bioaccumulation, benthic community analysis) integrated using a WoE framework. Develop specific BC guidance.
- **Problem Solved:** Provides a more flexible yet robust approach. Allows efficient screening but ensures thorough, ecologically relevant assessments for complex sites using multiple data types. Aligns with international best practice.

Part 2: About You

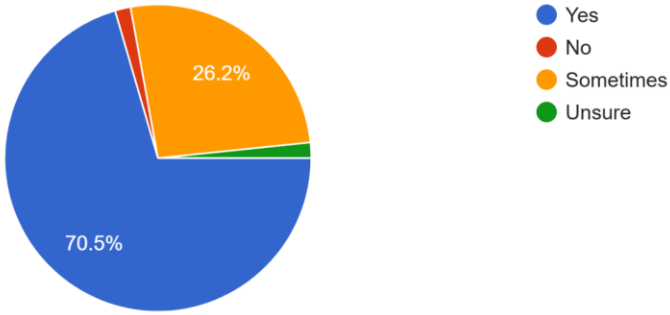
1 - Does your professional work involve protecting human health or the environment from pollution and/or contamination?

61 responses



2 - Does your professional work involve assessing or managing sediment quality?

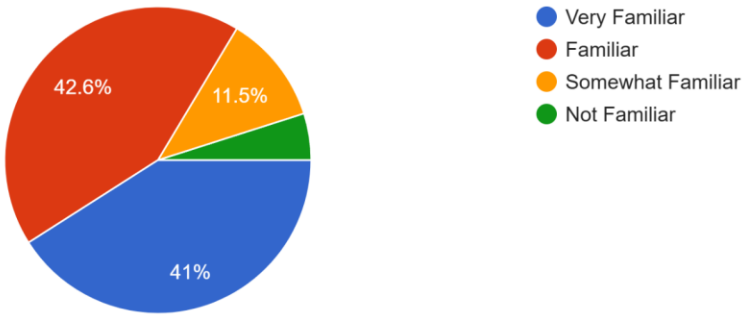
61 responses



Section 3: Current BC CSR Sediment Standards (Schedule 3.4)

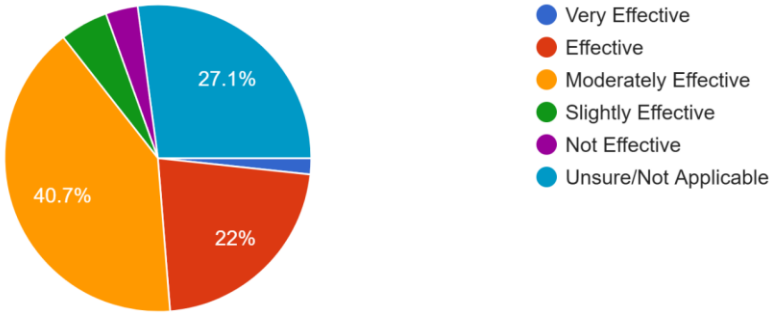
3 - How familiar are you with the current BC CSR Schedule 3.4 numerical sediment standards?

61 responses



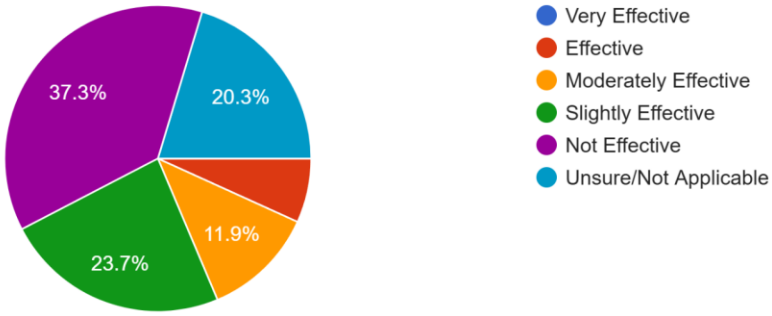
4 - In your experience, how effective are the current BC CSR sediment standards at protecting benthic organisms (e.g., worms, clams, insects living in sediment)?

59 responses



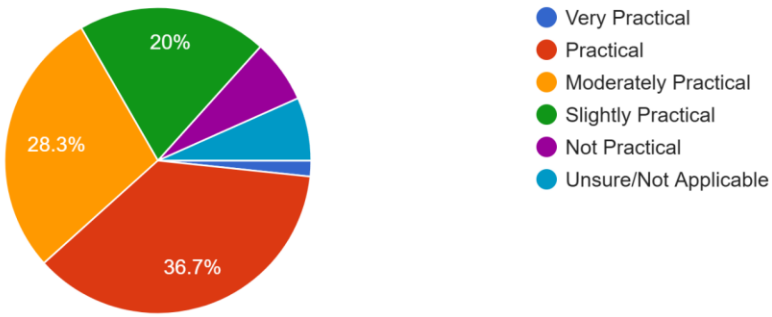
5 - In your experience, how effective are the current BC CSR sediment standards at preventing harmful bioaccumulation of contaminants in the aquatic food web (e.g., accumulation in fish, wildlife)?

59 responses



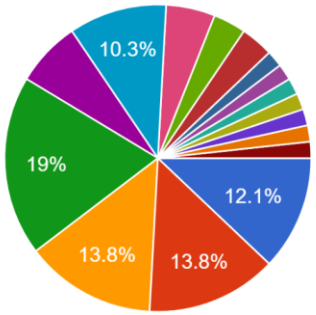
6 - How practical are the current BC CSR sediment standards to apply in site assessments and management?

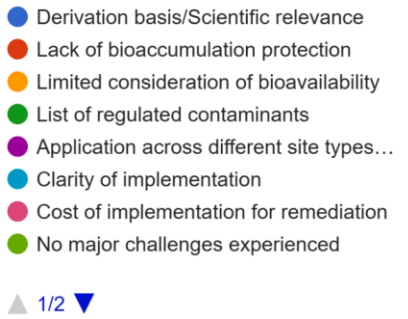
60 responses

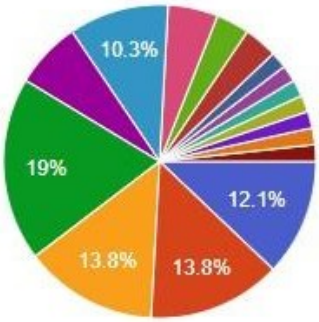


7 - Which aspect of the current BC CSR sediment standards presents the biggest challenge in your work?

58 responses







Other responses included:

- All
- Limited disposal options
- Sediment standards are applied to a discrete area; but sources are often associated with the region or waterbody rather than the direct upland parcel. Sediment transfer through a waterlot or other temporal conditions are not considered within the simple 'typical/sensitive' framework.
- Several of above. The original sediment criteria derivation documents were removed from the BC ENV website and should be re-posted or alternatively post a good description of their basis similar to what is at the start of this survey. The current definition of substances that are bioaccumulative (e.g., BCF > 2000) is not that protective. No consideration of % organic carbon although BC Working sediment guidelines have incorporated that for PAHs. Lack of standards for petroleum hydrocarbons (diesel/F2) given how common a contaminant this is.
- We do not use BC sediment standards in our work, but our understanding is that the basis of the derivation is old and does not consider bioaccumulation.

- Other: Only useful if < SedQC, otherwise need ERA

8 - Please elaborate on the biggest challenge you identified in the previous question, or describe any other significant challenges you face when applying the current BC CSR sediment standards. (54 responses)

- three issues: the standards are outdated and the list is limited, the standards should consider bioaccumulation for substances that bioaccumulate (but only where there is a receptor - I am worried that there may be applying bioaccumulation in non fish-bearing streams), Bioavailability can be considered, but is it only for site specific consideration (e.g. in a DERA)
- Exceeding a standard for a particular substance is almost irrelevant without the context of bioavailability (eg. AVS/SEM, organic carbon)
- Many industrial sites alongside waterbodies have wharves and docks. Sediments in the vicinity of these structures are often contaminated with PAHs from creosote pilings and potentially metals from vessel antifouling paint or hydrocarbons from vessel bilge water, fueling spills, etc. Wharves and creosote pilings are not a CSR Schedule 2 use. Perhaps they should be, in order to officially trigger the need for sediment investigation specific to these structures/use.
- In order of priority, I believe the list of contaminants needs to be greatly expanded beyond the 32 standards, especially as many jurisdictions are focusing energies on newer/emerging contaminants in sources such as CSOs and WWTP discharges. The standards should also be considerate of bioaccumulation -- with particular emphasis on those contaminants where there is obvious evidence of bioaccumulation, with less emphasis on substance where the evidence for bioaccumulation is limited. I think worrying about bioavailability falls in the "additional study" category, or risk assessment, and it may be a slippery slope to try and consider bioavailability given the number of variables affecting it.
- Clarity of implementation. Secondly how determine contamination impacts from the site, background or off-site sources.
- The CSR has long been flawed regarding handling standards which are less than common background concentrations in soil and groundwater. Arsenic in soil is the classic example, along with manganese and iron in groundwater in the interior, particularly near reducing environments such as wetlands. The use of the 95th percentile to calculate background concentrations leads to a background less than the highest background concentrations, meaning that some amount of remediation or risk assessment is almost inevitable. For a new sediment regime, these issues should be

avoided through widespread sampling to better capture and understand of the variability of metals concentrations across the province, and more flexible and realistic background concentration calculations. Consideration should be made for biological processes that can accumulate metals (eg, iron reducing bacteria near a spring). Finally, excavation of sediment from wetlands and lakes will lead to habitat loss, as the difficulty of restoring these habitats means that leaving the contaminant might be less harmful to ecosystems than removing it.

- True sediment COCs are not always identified as bioaccumulation is not considered at the investigation stage. This is because bioaccumulation is generally not considered with respect to standards development.
- We are very interested in path-way specific screening criteria for application in risk assessments
- It's difficult to know how the standards were derived, so it's impossible to tease apart the tox data involved to verify the validity to a particular site. It's understood that the tox data is protective of benthic invertebrate community, but nowhere is the level of protection provided. No bioaccumulation protection is also a scary consideration, resulting in the need to clean up to levels below standards but having a challenging time making the convincing argument.
- I agree with ENV's desire to include TOC and AVS-SEM to adjust SedQC in T1 for relevant contaminants (before moving to T2/T3 ERA) and also agree that SedQC for bioaccumulation would be helpful for a subset of contaminants (not necessary for all)
- The standards only being protective of benthic organisms and not higher trophic levels is a huge limitation and leaves much of the ecosystem unprotected.
- the schedule is limited in chemicals and application across different sites
- Clarity between sensitive and typical use
- Marine sediment standards are not available for many chemicals and there is no requirement that the freshwater values must apply in their absence.
- sensitive site use definition is too broad which prevents typical site use standards from being used at more urban sites like marinas, ports, industrial waterfronts. also there are no background concentrations for sediment which should be considered in urban environments.
- The bioavailability in sediment helps us understand not just how much contaminant is present, but whether it is causing harm or influencing environmental processes. This distinction is required to make informed decisions in managing contaminated sites, protecting public health, and maintaining environmental sustainability.
- The two biggest challenges are with Clarity of Implementation and Derivation

basis/Scientific relevance, in particular clarity and rationale for when to apply typical versus sensitive standards. In the original derivation (early 2000s) it was understood that typical standards applied at most contaminated sites and the sensitive standards apply under specific situations (refer to Schedule 2 of Criteria for Managing Contaminated Sediment in British Columbia - Technical Appendix. However more recently, BC ENV has indicated that the sensitive standards apply at almost all contaminated sites, but no scientific basis or rationale has been provided. In my experience and from discussions with colleagues, the sensitive standards are overly conservative and don't provide an accurate screening tool. Often background concentrations exceed the sensitive standards. Also, effects in lab testing or in situ are typically not observed until the typical (not sensitive) standards are exceeded at a meaningful level. This means that screening with sensitive standards at all sites as the default requirement, does not contribute meaningfully to the understand of potential sediment risks.

- Other challenges are the lack of sediment standards for multiple contaminants and the lack of bioaccumulation protection - usually we have to select or own sediment screening values (e.g., apply soil standards or get from other jurisdictions) for non-scheduled contaminants and do some sort of food chain assessment.
- The BC CSR sediment standards are not appropriate or adequate to protect upper trophic level organisms, apex predators and humans at the top of foodwebs, as these sediment standard were or are designed for the protection of low tropic level species and benthic organisms.
- currently the contaminant list is limited. needs expansion
- limited list of regulated parameters and no sediment background
- There are currently sediment standards for 31 parameters, including 7 metals. This makes it more difficult to interpret the results of toxicity tests and benthic invertebrate community surveys. It also leaves open the possibility that sediment impacts go unremediated. To me the first priority should be expanding the number of regulated parameters...including emerging and common parameters. Second priority should be development of standards for bioaccumulative substances for consumer protection
- Unless you do risk assessment work, the current system skews to classifying wide areas of sediment without any way of refinement to reduce, target "hot spots" thus inflating remedial costs to treat a large area.
- limited list of contaminants in 3.4 standards.
- Limited disposal options for material making appropriate disposal cost prohibitive thus leading to illegal dumping
- I think the scientific relevance and the bioavailability concerns both usually warrant discussion when working with various stakeholders. When dealing with a "hard" value it is 'easy' to poke holes in the standards or in other cases rely too heavily on them.

Adding context to the values (through evaluations of bioavailability, understanding the basis (and limitations) of the standards, etc) - I feel is the only way to get more scientific clarity as to actual risk.

- The removal of contaminated sediment from one location in the sea (ie boat launch) and then the requisite need for laborious time consuming permitting and sampling program to meet a 'disposal at sea' standard ' is pretty haywire.
- Very little petroleum hydrocarbon F3/F4/HEPH standards in Canada. Current standards for PHCs are in Marine Canada using petrotox model (fugacity model) are too low (not realistic) and poorly resolve natural (organic matter in sediment) vs anthropogenic.
- Multiple aspects listed above present challenges. The "Criteria for Managing Contaminated Sediment in British Columbia" (circa 2004) is undated and appears to no longer be available. All sites seem to meet the definition of "sensitive". Schedule 3.4 is limited to 31 substances - bioaccumulation is not addressed, nor is human health protection (except to the extent that the default is to apply soil standards based on soil ingestion). The current standards lack ecological relevance beyond benthic invertebrates. The current standards do not account for physical variables such as grain size, or porewater concentrations (which speaks to bioavailability). Requirements for submissions made to ENV for review have been inconsistent, and the need for and extent of weight of evidence approaches and food chain modelling seem to be dependent on who the ENV case worker is.
- Sediment standards are applied as "bright lines" and {likely} conservative in most situations - these factors, combined with the high costs of triad-type analysis stall out attention to contaminated sediments. As a result, responsible parties tend to avoid these liabilities unless forced otherwise. Consideration could be given to better guidance on methods to assess bioavailability through both desktop (OC, modeling, AVS, grain size, etc.) and field methods (benthos, tox testing, tissue concentrations, etc.). Much of this guidance ALREADY exists, so I would argue to liaise with others on this - like Suzanne Agius at Environment Canada or what the Australians just put out https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants
- n/a
- The standards do not really take into account when Groundwater/Surface water moves from above "an area" could be a project area (stripped? Mined? Borrowed from?) through to the bottom side of "an area" say a project area. Water quality can be taken at a snapshot in time to determine if sediment studies need to be taken however there is not a real road map as to when this may need to occur?

- Lack of criteria for many contaminants, lack of studies to update SSDs, need bioaccumuation approach
- Clarity of implementation which results in cost increase
- one significant challenge is the inconsistent application of sensitive vs typical across practitioners
- A significant challenge in applying the BC CSR sediment standards is deciding between sensitive and typical sediment use at sites with creeks and ditches. These areas can serve both ecological and functional purposes, creating ambiguity. Clearer guidelines or examples would help in making consistent and effective decisions in these mixed-use environments.
- The NSTP approach used in the derivation of CCME sediment quality guidelines (which were used in the development of the B.C. sediment standards) is outdated. Better sediment toxicity data is now available for most contaminants, which allows for the use of better, more modern methods of guideline derivation such as species sensitivity distributions.
- emerging contaminants
- The biggest challenge is the reliance on co-occurence based approaches to derivation, essentially adopting CCME values that have a high percentage of false positives in practical application (this is different than the statistical procedures used to to process BEDS data). For some chemicals, the standards align reasonably well with field validations (e.g., total PAH) whereas other cases yield high numbers of exceedances that do not validate for the stated protection goals (e.g., several individual PAHs, total PCBs). The fundamental problem is derivation of individual benchmarks using data based on mixtures. I have other concerns, but the questions identified in the survey suggest that they have been identified (e.g., missing substance groups, discernment between direct contact and bioaccumulation pathways, toxicity modifying factors). I will add one new issue here, specifically the role of individual versus substance groups (individual PAH, HPAH/LPAH, total PAH, mixture-based metrics like narcotic and bioavailability metrics), because the standards have inconsistent use of group subtotals.
- Substances encountered on a regular basis are not regulated
- Application of Typical vs. Sensitive Criteria. Current definitions are overly restrictive and impractical for sites that are working harbours and will remain as such.
- River sediments adjacent to an upland contaminating facility; initial samples indicate some CSR standard exceeded; subsequent evaluation indicates that the sample represents the sediment travelling downstream rather than impact from the upland facility.

- Remediation of Sediment is a difficult and rather unregulated body of work with limited access to professionals experienced in that form of remediation and quite costly, especially on large-scale projects. Another significant challenge is the applicability of the regulations to sediment across different ecosystems. Many polycyclic aromatic hydrocarbons occur naturally in sediment containing high decomposing plant materials, and such may occur in higher concentrations in wetlands or in shallow waters with deadfall as opposed to a flowing stream.
- Like the concept of tiered sedQGs or requiring analyses of parameters that can be used to evaluate uptake potential…whether that leads to modified guidelines or sediment LOEs beyond sedQGs.
- Application of sensitive and typical
- Sediment types vary widely
- I selected 'Limited consideration of bioavailability' above, but the challenge I see is that the concentration of a contaminant in bulk, dried sediment is often a pore indicator of the degree of harm that the contaminant is doing. For small organisms that spend time in the sediments but that don't consume significant volumes of sediment, contact and/or ingestion of pore water is the dominant exposure pathway. A Tiered approach, that recommends investigation of pore water quality for substances known to partition into pore water would be helpful.
- While typical sediment standards are provided, they are essentially prohibited from use. Clear and applicable freshwater and marine sediments would be relatively easy to apply yet remain flexible and appropriate to the primary sediment environments. Estuarine standards could be defined as the most stringent of both regimes for each substance.
- very limited list of contaminants - missing most current use pesticides, sewage related contaminants (personal care products and pharmaceuticals)
- Certain chemicals may simply be screened out in an RA as the standards don't trigger inclusion, and as such, the risk to higher trophic level species may be missed. Lack of bioavailability may result in excessive extra work addressing chemicals that simply may not be as bioavailable and could be screened out. The typical vs sensitive approach is a bit clunky. At the very least, the terms don't seem appropriate. Benthic organisms in Industrial harbours may still be sensitive even if there's a lower protection goal allowed for those environs. Like the soil quality standards, perhaps BCENV might designate 'broader areas' in the province with certain protection goals. A shaded map that acknowledges broader zones with lower protection goals perhaps due to accepted impacts from other beneficial use by humans? How would this fit with federal management responsibilities, aboriginal rights and title, etc. These provide challenges to

the practical application of sediment standards. Something that meshes better with federal jurisdiction would be VERY helpful. Less overlap.

- Tributyltin/Organotins are a major contaminant in marinas/harbours/shipyards. High priority to develop either a sediment-based guideline or other risk-based media concentration limit.
- Other challenges include the protection of food-web exposures.
- One more challenge is the PROTECTION OF HUMAN HEALTH via INCREASED dermal adherence rates to intertidal sediments. Adherence rates can approach 10x higher than terrestrial soil dermal adherence rates. I've identified unacceptable human health risks through cross media exposures via this method. This is a gap in the regulations.
- Funding to conduct a benthic survey of False Creek's seabed.
- There are numerous COCs that are not within Schedule 3.4 including TBT. Additionally, there are no human health considerations for sediments.
- The CSR list of sediment standards is surprisingly short.
- Protocol 1 indicates that in an HHERA we need to consider the potential for bioaccumulation/biomagnification. If we determine that a COPC has the potential to bioaccumulate (per the definition provided in Protocol 1), then we have to compile lines of evidence or complete a full food chain model to determine risk. It would be nice to have a screening tool (like a sediment standard protective of potential bioaccumulation) as a first pass to focus on more detailed assessments of the risk-driving COPCs.

9 - Can you provide examples from your experience where the current standards may have been under-protective or over-protective? Please provide the context. (44 responses)

- n/a
- In instances where the csr does not have a sediment standard e.g. tributyltin
- Several metals exceedances that had to be further investigated with AVS/SEM to learn they weren't bioavailable (ie. standards were over protective). Extra resources were used to prepare a risk assessment that would not have been necessary if that information could have been used from outset of investigation.
- Under protective - absence of standard for diesel/F2. I have seen amphipod toxicity/lethality in the range of 1000 ppm F2 that didn't appear to be PAHs related. Over protective - possibly the sensitive standards for metals in particular some of the metals that are more natural (CCME ISQG), rarely do laboratory toxicity tests show >EC20 effects for a slight to moderate exceedance of sensitive/ISQG.
- This question seems specific to the numerical values themselves. As these values are

not protective of bioaccumulation, there are projects where contaminant concentrations were below standards but tissue data suggested contaminants were accumulating in tissues above critical tissue levels.

- sometimes background sediment metal concentrations are higher than than the standards.
- unable to do so for sediment. I have quite a few examples of soil and groundwater standards being overprotective, and would rather see those problems avoided.
- Not sure if totally relevant, but the definition of a sensitive site is very stringent thus most sites have to have sensitive standards applied. To me, this is overprotective in a number of cases and can result in physical remediation, which may actually be more harmful...
- There has been some recent ambiguity around whether the change in wording on the provincial website meant that CSR supported the application of sensitive criteria at a working harbour or other commercial/light industrial waterlots
- It's difficult to know if they are over or under protective when derivation methods and data isn't available to evaluate. I know that there have been instances where arsenic and copper concentrations in the Fraser River are naturally higher than the standards, so this would be an example of overprotective.
- Mostly over-protective; ERA often indicates neg-low risk (acceptable) even though contaminants > SedQC
- Whenever the standards are applied, they are not protecting higher level species, and this occurs every time they are relied on.
- under-protective in that not all potential contaminants are listed compared to those for water and soil
- With the current definitions sensitive use standards are being applied in almost all scenarios because the definition is so broad and the definition for typical is just “not sensitive”
- Iron is problematic when it migrates to the marine environment due to the precipitate that forms, but not iron standard exists for marine sediment, or for the precipitate. Since legally, this is not an exceedance, it is difficult to get RPs to address it.
- Over-protective - sites in Burrard Inlet, small craft harbour marinas. Since the standards currently are generic they are protective and most risks assessments would develop higher risk based numbers.
- North coast of BC where D&F at moderate to low levels in sediment were causing significant concern to local community. Detailed bioaccumulation assessment and tissue

residue analysis demonstrated that the substances were not bioavailable.

- Even the typical standards are almost always overpredictive. I can think of multiple examples for freshwater and marine assessments where the typical standards were exceeded but there was little or not toxicity and little and not measureable effects to benthos in situ. For example at a current marine site I am working at near Nanaimo we have up to 8-fold exceedance of chromium, copper and lead typical standards - however we have only mild uncertain sublethal responses in test organisms and only a limited response in benthic community at one station. None of the lab effects or in situ responses correspond to concentrations of these metals suggesting they are not the cause of effects.
- The best example as showcase is the lack of protection and under-protective approach for endangered Southern Resident Killer Whales (SRKWs) and Chinook salmon in their critical habitats an home ranges in British Columbia. Please, see Alava et al. (2012; https://doi.org/10.1021/es303062q), in which we provide the rationale to address this issue with current Sediment Quality Guidelines (SDG) at the provincial and federal level to contribute to the derivation of sediment quality criteria and tissue residue guidelines that protect biota of high trophic levels under various PCB management scenarios. The results further demonstrated that current PCB sediment quality and prey tissue residue criteria for fish-eating wildlife are not protective of killer whales and are not appropriate for assessing risks of PCB-contaminated sediments to high trophic level biota.
- no
- where parameters exceed soil standards in the uplands but there are no applicable sediment standards; we get forced into risk assessment which is expensive
- Mercury - probably protective of benthos but unlikely protective of consumers; Total PAH - not clear how total PAH can have a higher standard than individual PAHs
- Woodfibre - LNG Plant assessment where the extent of impact was very extensive and there was no way to differentiate between pre-existing sediment impacts given the proximity of the project to the Squamish estuary impacts to the north or to create/describe "background" sediment quality.
- I have worked on numerous projects where it is likely the risk of certain sediments we’re overestimated. This was really only evident when using other metrics (toxicity testing, passive samplers, bioaccumulation assays etc). However the concept and use of these techniques are still quite novel, expensive, and the overall usefulness can be somewhat limited or difficult to convey to the general public. As a consultant, it does feel like a bit

guilty to proven innocent when a standard is exceeded (and understandably so). Further work to better understand what these exceedances mean and weight of evidence approaches to better that characterize that risk would be useful.

- A recent boat basin collects river sediments and these become fouled by permitted pleasure craft docking and launching. It seems a bit silly to permit this activity but then punish the operator/owner through onerous sediment sampling, testing and disposal at sea requirements. Its not like anyone is eating benthos at the location, and even were sport fish preying on benthos, the risk of bioaccumulation would appear to be small.
- Sediment in freshwater creek near an upstream oil and gas wellsite in NE BC.
- The standards for Total PAHs exceed the sum of the thirteen individual PAHs and thus, one or more individual PAHs always exceed before Total PAHs exceed (i.e., what purpose do the Total PAH standards serve?). The assumption is that all individual PAHs exhibit the same adverse effect (narcosis) and are weighted equally, which is overly simplistic. There is also an issue of the "rounding rule". There continue to be challenges with toxicity equivalency for dioxins/furans and PCBs (e.g., BC Lab manual approved methods may not achieve the lab detection limits for some individual congeners that are needed to properly assess the TEQ sums), and thus the level of protection afforded and conclusions regarding adverse effects are unclear. Cumulative/additive effects of metals, pesticides, etc. are not addressed by the current standards. CSR sediment standards are commonly not in sync with the BC Water Quality Guidelines values (i.e., Water Quality Branch "Working Sediment Quality Guidelines") and it is unclear why they differ (other than policy decisions from different branches of ENV). Schedule 3.4 only includes 7 metals vs. several other CSR substances prescribed in other media than sediment that have Working Sediment Quality Guidelines (e.g., iron, manganese, molybdenum, nickel, silver).
- Without getting into site-specific data and conducting primary data analysis, I think it is difficult to respond accurately to this question. The fact that most well-done sediment quality triad assessments result in reducing the areas requiring remediation indicates that the current standards are a screening step -- labeling that as under or over protective isn't helpful framing...
- Standards could be overprotective in natural settings that will remediate themselves over time. Sometime clean-up causes more harm than good. Standards may not be robust enough in cases where a long term project is taking place with different substances being used at different times for different durations. more stringent standards could

potentially be effective in this scenario.

- Over-protective for metals commonly found in natural geology of the area, particularly copper and arsenic
- In our recent work at the National Guidelines and Standards Office (ECCC) in sediment guideline derivations, we used both an NSTP approach and an SSD approach. The different approaches resulted in guideline values that were different by several orders of magnitude with the NSTP values being under protective for the one chemical trialed thus far.
- Most experience is over-protection, although not to same degree as CCME ISQG (one advantage of BC guidelines, along with total PAH standards). I have too many experiences to recount here, but over time it has become evident that the standards are often too low for direct contact pathway. This is by design, in order to screening data for subsequent investigation, for some cases yield "exceedances" under near-background conditions, leading to inefficiency. On the flip side, the absence of standards for some groups (PBDEs, organotins, etc.) means that those groups get less attention than warranted (i.e., implicitly underprotective if they do not exist). In working harbour assessments, the federal government has adopted the Tier 2 (PEL equivalent) for screening, which seems to work effectively, so I like the idea of keeping multiple tiers. The challenge seems to be more for remote or sensitive environments where the preliminary screening often identifies multiple substances that create appearance of hazard, when such is an artifact.
- Generally overprotective
- Under-protective as many parameters regulated under Schedules 3.1 and 3.2 do not have sediment standards and aren't necessarily included in RA in BC. Bioaccumulative parameters - what is the list specific to marine vs. freshwater, standards to not account for aquatic wildlife ingestion and uptake for bioaccumulative and non-bioaccumulative parameters.
- See previous question. Sediment standards for PAHs over-protective in some cases where natural decomposition occurs at a rapid rate.
- Generally, current sedQGs are likely overprotective but all are weak and have high uncertainty.
- Using sensitive standards for highly industrialized areas
- overly protective as not bioavailable at the site.
- Under-protective often due to the small number of substances included.

- Looking at country foods consumption of crabs under indigenous rights and title with respect to harvesting allowance, crab consumed at regulatory default consumption rates from a major BC harbour would result in unacceptable risk levels in humans. As such, the sediment standards alone do not appear to be sufficiently protective of people if they wish to exercise their full rights.
- See #8 for human health. Context is a small craft harbour boat grid. Dermal exposures to arsenic in intertidal sediments using the default terrestrial soil adherence rate (1E-07 to 1E-08 kg/cm2-event, Health Canada 2024 PQRA Guidance) did not result in unacceptable risks. However, assuming "wetted" sediment adherence rates(6.3E-07 to 6.6E-07 kg/cm2) resulted in unacceptable risks and the requirement for risk controls.
- See above
- Both have been true in different scenarios. I think understanding the limitations of the standards and carrying forward that uncertainty for further evaluation in a risk assessment is key to determining actual potential risk and appropriate protection of relevant receptor groups (human and ecological).

10 - What specific data gaps have you encountered when assessing sediment quality relative to the current BC standards? (41 responses)

- n/a
- typical vs sensitive sediment - perhaps should have just one standard for all sediment, Sched 3.4 is limited.
- Several substances do not have sediment standards (eg. TBT, NP and NP ethoxylates) that probably should, and require use of standards/screening levels/guidelines from other jurisdictions
- Absence of PFAS criteria; absence of bioaccum considerations, and limitations in the number of analytes.
- what is background and what is contributed from off-site sources
- Pathway-specific guidance, human health effects, organotins (TBT and others), bioavailability
- Gaps in emerging contaminants
- Bioaccumulation
- Standards don't incorporate modifying factors such as organic carbon content.
- Accounting for background soil concentrations in areas with manmade water bodies
- Marine standards, extra receptors not protected with current standards (wildlife, seafood consumption, human health exposure), background considerations, investigation

guidance

- applicability of sensitive use standards where typical is likely adequate, lack of background concentrations
- Lack of standards for many substances.
- Bioaccumulation pathway not included in sediment standard derivation; also would be very helpful to have a screening process for whent the bioaccumulation pathway needs to be assessed, it is not necessary for all contaminants. Sediment standards lacking for most of the contaminants in the CSR (for which there are water and soil standards).
- Empirical contaminant data for prey species and predators to corroborate model outcomes in foodweb accumulation model and in some cases updated sediment contaminant date for the suit of POPs and emerging contaminants data, as well as total organic carbon (TOC) content, and the lack pf contaminants (POPs) toxic effect concentration thresholds in top predators (e.g., marine mammals) to be used for deriving SQGs and standards other than those available for PCBs.
- limited parameter list
- ambiguity with how to deal with the area between high and low water mark; lack of parameter specific standards and so being forced into risk assessment; no human health standards
- Lack of transparency in data upon what standards for individual parameters is based (i.e., P28)
- The bioavailability component is a big one. However, literature is limited and can be difficult to interpret. More bioavailability toxicity related studies (ie determining bioavailability related chemical toxicity thresholds) are needed.
- There seems to be less biotic tissue sampling information available to the scientific community and public. The feds and province seemed to do more of this in the 1980's when I started my career. Maybe it is more common than appears but the data is not appropriately shared. I reckon that if the taxpayer is paying for it the reports should be made readily available.
- same as question 8
- Transparent derivation process to identify which specific TRVs were used to derive the CSR sediment standards (specific organism(s), level of effects/protection level, whether TOC normalized for organics, use of water quality based TRVs vs. sediment based TRVs).
- 1. Over time, Typical values have come to apply no where now in BC; a gap to fill is

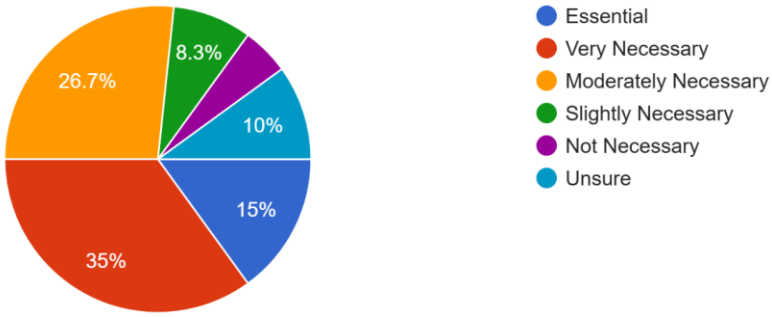
reconciling the applied protection levels w policy intent.
    - 2. Conflict with Fisheries Act arises, would be good to have a policy agreement w DFO (!)
    - 3. I don't see bioaccumulation as a data gap in the standards - there are better approaches to screen bioaccumulation than a sediment chemistry measurement.
    - 4. Defining "background" is one of the biggest gaps - we wont improve sediment health in harbours if we defeat proponents w remediation to pristine. The remediation gets stalled out and the opportunity for traction is lost. There are FAR more sediment problems out there that we are not aware of...
- People. People do not test the sediment for the proper items.
- the application of regulations across different streams such as freshwater, marine and estuarian. Its defiantly not the same for all
- Not applicable
- Similar to those already identified in your backgrounder, forcing reliance on other jurisdictions (Washington State, US EPA, EU, or ANZECC) to fill gaps, which requires assumptions about derivation methods and level of protection. The biggest omission in my opinion is total petroleum hydrocarbons, including analysis of mixture type (gasoline, diesel, lube/oil, or heavier). The PBDE, TBT, and PFAS gaps could also be filled, with possibility for BTEX and phenolics also. For some substance groups, the substance group requires evaluation of composition rather than just group total.
- Hydrocarbon standards
- Available BSAFs are not always available for freshwater or marine systems and many use a mix of studies to obtain an "aquatic" BSAF which doesn't account for varyations in uptake mechanisms for metals.
- Not sure what is meant here. When simply comparing bulk sed chem data to sedQGs, not a lot of data gaps or needs. The gaps and needs come into play when assessing other sediment LOEs.
- species relevance
- No nickel guidelines.
- Lack of standards for the broader range of substances regulated in soil or water.
- very limited list of contaminants - missing most current use pesticides, sewage related contaminants (personal care products and pharmaceuticals)
- Not sure if they're data gaps per se, but better guidance on sediment sampling density, use of grids, etc would be very helpful for many.

- Human Health Dermal Exposure (#8 and #9) and wildlife food chain exposures.
- See above
- Not all parameters that should have standards do.
- The potential for bioaccumulation, integration of Indigenous knowledge

Section 4: Proposed Approaches for Updating Standards

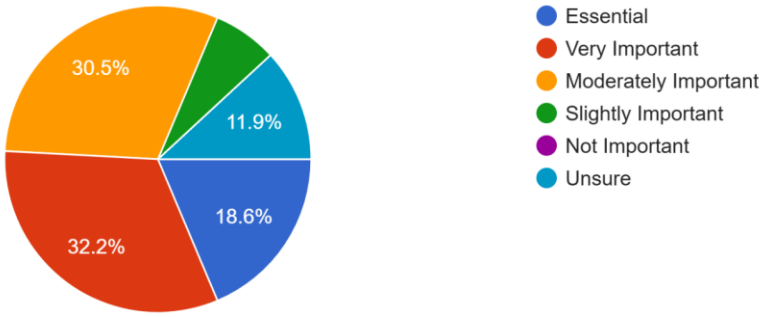
11 - The proposed update includes a 'Dual Standard' approach (separate values for benthic protection and bioaccumulation protection). How ...ach is for improving sediment management in BC?

60 responses



12 - How important is it to systematically incorporate bioavailability adjustments (e.g., using Organic Carbon, AVS/SEM) into the routine application of BC sediment standards?

59 responses

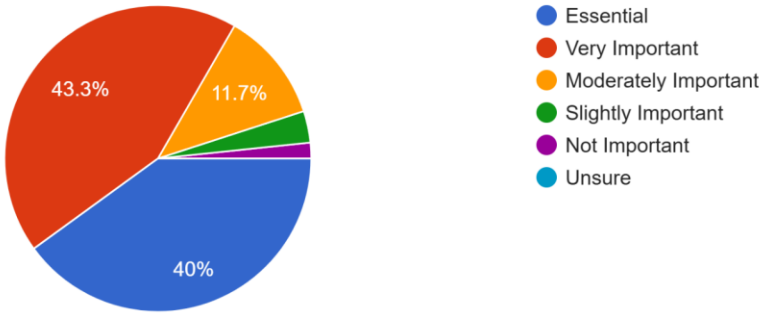


13 - Which method for deriving benthic protection standards do you think is most appropriate for BC, considering data availability and scientific robustness?

59 responses

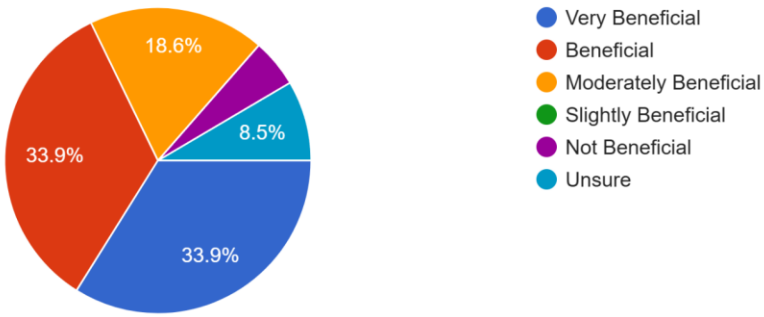
14 - How important is it to expand the list of regulated contaminants in BC sediment standards to include substances like PFAS, current-use pesticides, and organotins?

60 responses



15 - How beneficial would a formal, tiered assessment framework incorporating multiple lines of evidence be for complex sediment site assessments in BC?

59 responses



16 - What are your thoughts on the proposed 'Dual Standard' approach? What potential benefits or challenges do you foresee in its implementation? 46 responses

- n/a
- In theory, it seems protective. My concern is that some substances may have low, stringent standards that are difficult to remediate or there may be anthropogenic background influences that will make it not possible to delineate and remediate.
- I like the approach, but may be unclear when to compare to benthic protection only (and not compare to bioaccumulation protection), which could lead to inconsistent application of standards by different stakeholders throughout the province.
- Dual standard approach is a good idea and would simplify decision making for risk assessors. Challenges will be which substances to include, which bioaccumulation factors to use, which wildlife to include, and what human shellfish/fish ingestion rates to use.
- I like it. It does not necessarily need to start off with a massive list of contaminants. Rather it could focus on priority contaminants where there is evidence of significant bioaccumulation concerns based on data supported by human dietary studies, tissue studies, Southern Resident Killer Whales, etc.
- This reminds me of when soil vapour sampling first came out and required soil vapour testing if hydrocarbons were a PCOC, even when soil and groundwater were non-detect. The complexity and cost of sampling versus the benefits needs to be considered. By default, most streams, estuaries and shorelines are crown land, and are subject to contamination from a number of sites. While the polluter-pays aspect of joint and several liability under the CSR is beneficial for sites with defined boundaries, this liability framework is unfair for sediments in a location such as the Port of Vancouver.
- My initial thoughts are that this makes things a bit more complex then they currently are and in general, a simple approach is better as it reduces the chance of improper application. However, given there are soil matrix standards, practitioners are already familiar with a "multiple standard" approach so this may be a mute point.
- This will be very useful in dividing out considerations in a screening-level risk assessment though relevant data needs for some contaminants may be challenging. It's easy to "ask for everything" with this work.
- I think this will address a critical gap in the sediment guidelines although it may not be necessary for all constituents (i.e., those that don't bioaccumulate would be assumed to more toxic to benthic inverts immediately in proximity to the sediments rather than higher trophic levels).
- As indicated earlier, bioaccumulation standards are not needed for all regulated substances
- There could be a lot of confusion as we already see this with the use of the current 'typical' and 'sensitive' sediment standards
- More use of professional judgement
- Having these standards would expedite investigation/risk assessment for some sites. But, it may be difficult to come up with these standards.

- potential confusion on application depending on if it is clear or not
- Sediment sample collection often has related sampling artifacts, such as changes in redox of sediments. What was not bioavailable in-situ is bioavailable ex-situ and visa versa.
- It's only useful if there is a clear definition of what "bioaccumulation protection" means. All chemicals bioaccumulate to some degree. Does this mean "biomagnification protection" and would it apply only to chemicals with a high potential for biomagnification? If yes, then the dual standard approach is important. In my experience the difference between bioaccumulation and biomagnification is not well understood at the regulatory level in BC.
- Fishing and sea food consumption are a major part of BC so a standard that will protect human and other species who are in potential risk must be implemented.
- I think implementing a proposed Dual Standard' approach by separating values for benthic protection and bioaccumulation protection is necessary to benefit the protections of most of the species of the foodwebs and ecosystems (an ecosystem-based approach standard)
- makes sense
- This would be useful for specific bioaccumulative substances but not needed for all. Sediment risk assessments already address substances that exceed generic standards.
- not opposed to the idea, However, I think it would be difficult to not apply the bioaccumulation human health standard without hydrotech/geo assessments. Scope of where the land use applies would need to be very clear.
- Sediments are still - in my opinion - vastly understudied in academics and especially in industry/consulting. I think the dual approach sounds like the first step - and hopefully it will help push the science forward.
- Tendency for government to overuse precautionary approaches making management of material expensive and impractical given risk.
- i agree and like everything proposed, well done
- A dual standards approach would address more receptors (i.e., not just focus on benthic invertebrates). A challenge would be to identify the list of substances that have sufficient information to determine their bioavailability per the definitions in Protocol 1, and sufficient toxicological data to allow for development of standards. There is not currently a list of substances for which bioaccumulation-based standards could be derived, or which might warrant research support by ENV to develop (perhaps the Water Quality Branch has something to contribute in this regard).
- My response to this question depends on the uncertainty in using measured sediment chemistry as a predictor of food chain exposure to eco and HH receptors... I hunch that digging into this will reveal that, except for a few contaminants where biomag is the process, the numbers we would get for bioacc std would be too uncertain or too conservative for use. Would be a good conversation for this group to have and maybe do a thought experiment and trial a metal, a PAH and PCBs, to see how it would work.
- Getting people up to speed and following something like this is always difficult. A good educational plan may be helpful for all industry professionals that are interested!
- provide clear clarity and better findings

- We approve of this approach. This will create guidelines that are protective of entire ecosystems rather than one aspect. The challenges include longer, more complication guideline derivation process, need for more kinds of high-quality data. Thoughts on specific challenges are:
    - - Rather than a dual standard approach, could consider multiple pathways such as done in CCME soil guidelines, which allow certain pathways to be omitted if not operable at a site. The final guideline is the lowest of the pathways.
    - - Suggest separating human health and ecological pathways.
    - - Consideration is needed regarding to what trophic level the guideline protects—primary, secondary or tertiary consumers, or all three? Primary or secondary consumers are often the most sensitive in CCME soil guidelines, but this may not be the case for all chemicals. Might consider separating avian vs mammalian (also aquatic vs terrestrial organisms consuming aquatic species) so certain pathways can be excluded in not operable.
    - - How to consider mobile organisms that might only spend part of the time in a contaminated site (e.g., salmon, whales, etc) as assuming 100% living/feeding at contaminated site would be unrealistic and result in overly conservative and possibly unrealistic sediment concentrations.
    - - This approach will likely only consider trophic transfer from sediment organisms to higher trophic levels, and not additional accumulation of higher trophic level species via water and/or direct contact with sediment. However, given that bioaccumulative substances tend to have low water solubility, uptake from water could be a minor exposure route.
- Generally in favour, especially for substance groups like PCBs and mercury. The problem is that application in a bioaccumulation context requires consideration of scale rather than point by point screening. Not sure how that would work in a CSR or broader context.
- Benefits that both pathways are addressed at sites where they are relevant but not necessarily encumber small sites
- How would this approach take into account sensitive vs. typical criteria. Or would the use of sensitive and typical criteria be retired? This is a bit unclear at this point in the survey.
- Concern rising from clients trying to argue against remediation in water systems not directly linked to human consumption such as small streams or non-fish bearing wetlands.
- Depends on the contaminant, but generally a good idea. Would address a current missing piece where possible, but could confuse users unfamiliar with key ecotox concepts.
- Challenges include cost and timing for clients. I see potential benefits from the process but also see that the dual approach is usually used in risk asessment.
- Bioaccumulation may not be relevant based on site size / species present.
- Helpful, because for small areas of contaminated sediment, benthic protection might be all that is needed. For larger areas of sediment, it would be useful to have bioaccumulation protective standards.
- If it's organized similar to the matrix standards in Sched 3.1, it would be easier to apply.

- I am sure it would be more work and effort to develop this so this is the limitation, but ultimately it would be a more holistic and thorough approach to regulating contaminants in soil and Canada should be incorporating these approaches as to protect all organisms exposed to contaminants via any media. WHO One Health Initiative approach should be the goal while we are developing new regulations.
- I think it's getting ahead of itself at this stage. I would prefer to see a more top down approach that considers better coordination/integration of provincial/federal jurisdiction and responsibility; a more clear set of assessment endpoint goals and for what types of aquatic bodies; consideration of the practical application of standards including time/cost; and of course the latest science with respect to chemical toxicity that considers their typical fate and transport in aquatic systems with priority on the more toxic, bioavailable, bioaccumulative chemicals that are longer lasting in the environment.
- I can see the need for a Tri-Standard approach - human health dermal contact (at beaches and intertidal recreation areas), direct contact for benthic invertebrates, and indirect contact to wildlife through food consumption.
- We - False Creek Friends Society (falsecreekfriends.org) are in the earliest stages of developing capacity to conduct sediment research - but it is essential we do so.
- I believe this can be extremely beneficial, especially when combined with a tiered assessment framework.
- A duel standard approach will make it harder for a QP to evaluate the data in the data, and be sure it is being done the way the ENV wants it. The result is that the lowest of the two standards will because the default standard, and the higher number would be irrelevant. Thus essentially as single standard.
- I like it. We have been trying to incorporate a dual standard approach into the COPC screening other media types. For example, we will incorporate Ontario soil guidelines protective of mammals/birds to screen for bioaccumulation potential and associated risk in the soil COPC screen for terrestrial ERAs.

17 - What are the key considerations for formally linking sediment quality assessment to Human Health Risk Assessment (HHRA) in BC, particularly regarding fish/shellfish consumption? 43 responses

- n/a
- is it not already linked?
- bioaccumulation potential; likelihood of fishing/harvesting in a particular area
- Whether BC ENV wishes to apply human health ingestion based sediment standards and modelling to areas that are subject to DFO harvest closure based on their proximity to marinas or urban areas/sewage.
- I like what was done with the BC ENV Fish Screening tool. If tissue concentrations are about X threshold, then you need to do more work. I could see a fish or shellfish tool, that uses similar assumptions, and back-calculates a threshold in sediment based on HH TRVs and biota-sediment bioaccumulation factors.
- In industrialized areas where multiple polluters and pollutants are present, liability needs to be managed.

- Unsure if this is the kind of thing you are looking for but her is my answer.....Background conditions. Collecting background data to confirm/refute if elevated concentrations are a result of AECs or a background scenario. This may reduce the # of COCs pulled into an RA or possible eliminate the need for an RA. Additionally, wasn't there an attempt to try and get a database going that linked sediment quality to tissue concentrations? It was many years ago, so I might be off base with where that was discussed, but its an idea either way.
- Benchmarking consumption levels specifically in coastal/First Nation communities where consumption rates may be elevated.
- Traditional Knowledge, particularly robust First Nations consumption rates of fish and shellfish.
- Option 1
- linkage needs to be specific to the organism being consumed.
- Sensitive and typical standards are not a good framework for standards. We should have one standard that includes protection for seafood consumption (human and wildlife), and one standard is not (although i don't know where these would apply). Having standards protective of different receptors and uses would help help sites with minimal contamination to not need to do HHRA, or for sites where harvesting is unlikely. HHRA at all sediment sites is overly onerous, and a contaminant threshold (i,e, the standards) should be used.
- away out if the area being worked in is subject to a fish/shellfish consumption ban.
- Substance concentration>bioavailability>aquatic receptor exposure>human consumption (organism and rate of consumption)
- Toxic effect concentration or thresholds for the suit of targeted and.or selected contaminants (PFASs, CUPs, oganotins) along with the WoE of human toxic effects and daily dietary intake rates for fish and shellfish consumption, mainly in First Nation Communities heavily reliant on seafoods.
- are benthic organisms actually harvested for human consumption.
- Contaminant bioavailability, uptake into food, toxicity via food consumption
- establishing that fish/shellfish are actually being harvested in an area.
- na
- Well a baseline in fish/shellfish consumption would be useful. This is what I was doing in the 1980's at Environment Canada. Facts are people are not generally eating shellfish from polluted sediments so it is unclear what the risk is we are trying to prevent. Fish being more highly motile, again unsure what bioaccumulation is going on, although mercury in some species has been a long known problem. Fish limits are so small now, can a person even capture and eat enough of a high risk species to hit a dangerous exposure level?
- biomagnification, protection of teratogenic effects on pregnant people from seafood
- In my experience, tissue data is much more meaningful than empirical extrapolations from sediment to tissue given the inherent site-specific variability in physical properties of sediment, and in the uptake by organisms (e.g., lipophilic substances based on log Kow vs. actual concentrations in tissue which are affected by organism metabolism and excretion; metals speciation such as inorganic vs. organic forms of metals such as

arsenic and mercury). Modelled concentrations often grossly overestimate bioaccumulation compared to measured tissue data, and cooked vs. uncooked food. It may be more realistic to have a relatively short list of the most concerning bioaccumulative substances, and where certain thresholds in sediment are exceeded (e.g. > UCCs), have a requirement to obtain measured tissue concentrations (field tissue samples or site-specific bioaccumulation sediment tests with organisms such as clams to see what actual site-specific bioaccumulation occurs).

- Regarding direct contact pathways, Health Canada provides guidance on human health for direct contact with sediment, but there is high variability and uncertainty in sediment to skin adherence and contaminant absorption factors, as well as linkage to grain size.
- Liaison with federal counterparts is essential here, as well as Min of Health and with groups working towards country foods health (e.g., look at Burrard Inlet work) - this is a big ball of wax :) and lots of process before the science. Perhaps this could be a secondary objective to the main focus?
- Population, inffluents into a certain area, does one have a baseline?, how far does this reach?, how many subjects are being followed/studied?
- Not applicable
- For the strongly bioaccumulatives, the main issues are incorporating bioavailability and site-use assumptions (factors that profoundly affect dietary uptake). For metals, the main challenge will be how to incorporate dermal contact scenarios, which are highly uncertain.
- Many contaminated areas are also under harvesting closures
- Tissue residue guidelines over sediment guidelines would help with this barrier. Fish and shellfish have multiple routes of exposure and the magnitude of each (sed, pw, sw) depends on the fate and transport of the contaminant. Tissue guidelines would remove the need to rely on multiple media and have a lower level of uncertainty when modelling risks for humans as the guideline could be used to identify the need to conduct a dietary assessment.
- Isn't most of the BC coast under some sort of shellfish consumption restriction?
- Bioaccumulation should be assessed with regards to species and actual uptake amounts.
- I would not try. Current standards that do this have weak basis and are often not very applicable.…though are very few of them. Leave HHRA out of sediment standards. It is not possible to have a widely applicable approach as too many factors come into play and is too much uncertainty.
- I think this is very site specific and so clear guidelines on how this would be assessed should be considered.
- need current / accurate consumption levels
- On the surface it might be helpful to have sediment standards protective of human health via ingestion of food containing bioaccumulative substances, if the model used is too conservative then the sites will end up going to risk assessment and direct analysis of contaminants in tissues of food items.
- I suspect it will take studies aimed at understanding bioaccumulation factors and field and lab studies for several contaminants and will be challenging due to the number of

chemicals currently in commerce. It's possible as these field and lab studies get underway we can develop some model in vitro or in silico studies to test in a more high throughput fashion and site specific studies
- Raw vs cooked state of the food source. Raw tissue concentrations may not adequately describe actual consumed concentrations. Realistic seafood consumption levels relative to regulatory default assumptions. Home range of consumed species relative to sites of interest. Bioavailability of chemicals in water/sediment and bioaccumulation of chemicals into food sources.
- NOt going too conservative with regards to fish/shellfish consumption rates.
- HHRA for False Creek at some point has to produce data for risk analysis for guide to swimming activities for humans in False Creek.
- consumption rates and proportion of collection within an APEC versus other areas.
- Bioaccumulation and bio transfer risks.
- I think there is a relatively high level of uncertainty in modeling / predicting concentrations of COPCs in fish/shellfish from a sediment concentration. Perhaps a screening standard could work, but likely would need to address through multiple lines of evidence in a detailed HHRA.

18 - Regarding a Tiered Approach (e.g., Tier 1 generic numerical; Tier 2-3 site-specific numerical): What site-specific information and lines of evidence (beyond chemistry) are most critical to include? 43 responses

- n/a
- presence of fish, species that take up the contamination, the exposure pathways to humans.
- organic carbon, AVS/SEM; reference site comparisons; tox test data; species abundance data; tissue data
- Depends on the nature of the site and its usage, but sediment toxicity can be useful. BICS is often a headache. We have also started analyzing the tissues of benthic organisms themselves to see if a) they are bioaccumulating the contaminants b) levels are above CTLs.
- Probably irrelevant, but I worry that a tiered approach can be complex and result in improper application. If possible, simple is best.
- Site usage categories would be most useful to hone in on a relevant screening value.
- Toxicity and Biological Community. I think CCME has fairly good, recent guidance on lines of evidence in risk assessment that can be drawn upon to formulate this guidance.
- Relevant toxicity tests and benthic invertebrate communities (standard LOEs in ERA)
- Option 1
- land/water usage - likelihood of exposure to humans
- Scouring potential
- surveys and toxicity tests applicable to each receptor group, i.e. a set of chemistry, toxicity, species surveys for each trophic level and feeding guild. In addition, significant background information is needed for both biological surveys and chemistry. What are the requirements for the background site?

- TOC, bioavailability of metals, type of habitat/land use (urban vs remote)
- I assume you mean sediment chemistry, exposure and uptake
- bioavailability, laboratory toxicity, benthic community structure, food chain assessment, guidance on spatial area of effect and how to link that to population/community risks.
- Critical habitat, species foraging behavior, climate change and cumulative effects with other pollutants (chemicals mixture or 'cocktails') and anthropogenic stressors.
- grain size, organic carbon, AVS/SEM
- TOC, AVS/SEM, toxicity tests, benthic community analysis, bioaccumulation
- na
- The bioavailability aspects are critical, but also receptors and habitat suitability.
- Don't know
- Encourage background sampling to get background concentrations of sediment. For PAHs in select areas, there is a need to differ petrogenic vs pyrogenic PAHs in sediment.
- TOC and grain size adjustments at Tier 1 and/or Tier 2. Porewater concentration data vs. water quality guidelines at Tier 2. Measured tissue concentrations at Tier 3.
- Sediment Quality Triad elements, and room to augment site-specifically w tools like - porewater chemistry and tox, fate modeling in sediment (using mini-CSM tools to build arguments for loadings and speciation), etc.
- Needs to have a map of all influents coming in, in all areas of study. Needs to follow the subjects to ensure that one knows where they have been. A sample of each subject should be taken when tagged for reference.
- Organic content of the sediment, sediment grain size and composition, pH, intended use of the site (i.e., recreation, commercial/industrial activities, etc.), type of carbon, is a pathway operable at a site, any site-specific input values to models that are generally stable, site specific partition coefficients (Koc, Kd). For bioaccumulation consideration, the time spent feeding in contaminated site. Specifics/proportions of diet e.g., 50% small fish, 50% crustaceans. Consideration of aging? This may need to be Tier 3/site specific, requiring testing to demonstrate lack of bioavailability.
- I could write at length on this, but to be concise I will simplify to 1) bioavailability factors; 2) comparison to local reference and background; 3) standardized sediment toxicity tests; 4) functional measures of community health (richness, proportions of major taxa); 5) concentration-response information from related sites.
- toxicity testing, TIE
- Wouldn't this be better to tackle in an update of the 2008 DERA or 2010 SABS WOE documents as opposed to a sediment focused work group? There are other priorities that should be addressed during the PF phase of work with sediment before these come into play. For example - clearly identifying aquatic bioaccumulative parameters, adding unregulated contaminants from other media or newly identified, revising the use of typical vs. sensitive standards, adding a "dual standard" approach.
- Descriptive site-assessment protocols to determine numerical values
- Avs-sem; toc; grain size
- species diversity study, traditional knowledge, taking into account bioavailability (SEM/AVS). I think this should be at the risk assessment level though.

- density / grain of sediment can hinder some species presence.
- Sediment/site use. In particular, is the sediment-containing site likely to be used for recreational or subsistence collection of food items (e.g. fish, shellfish,)
- freshwater/marine status
- understanding bioaccumulation in wildlife at various sites through food chains due to contaminated sediments; toxicity data for multiple species
- Aquatic site size, location relative to other potential sources of contamination (linkage to upland sources if that's the case); lab toxicity of collected sediments; benthic community assessment (at higher tiers, but still needs better interpretation/regulatory expectation with respect to results and their inclusion/application), tissue sampling of food types if the site may be used for country foods harvesting.
- Human accessibility to contaminated intertidal sediments.
- Not competent to answer
- bioaccumulative nature of the COPC, bioavailable nature of the COPC, potential exposure pathway (what is it being exposed to and how is it being exposed)
- potential for recreational use. frequency or likelihood of dredging. Extend of commercial/industrial use (boat and ship usage of area). Sensitivity and value of habitat and local species.
- I think additional lines of evidence should be incorporated into an ERA (not the screening standards). These LOEs would depend on the site and circumstances, but the most useful ones I have used include indicators of bioavailability (AVS/SEM, TOC, particle size, pore water concentrations), toxicity (toxicity tests). I find benthic community assessments challenging to successfully implement due to the variability in habitat types and the difficulty in identifying appropriate and comparable reference locations.

19 - Do you have experience with sediment quality frameworks from other jurisdictions (e.g., US EPA, Ontario, Washington State)? Are there specific elements from elsewhere that BC should consider adopting or adapting? 37 responses

- No
- no
- n/a
- no/very limited experience
- No. Potentially Atlantic RBCA; however, their guideline values for hydrocarbons may be overly conservative.
- No, my experience is largely with BC CSR or CCME.
- We use the TBT guidance that EPA uses, you've already covered considering TOC's effects on bioavailability.
- Not at this time.
- Quite familiar; no need to re-invent the wheel; the actual values don't matter as much as the framework within which they are used
- no not familiar with other jurisdictions. Washington State may be the best example for adopting regulations/guidelines - prior to Trump administration if they have been recently revised.

- Acceptance of applying background values
- US EPA PAH Equilibrium partitioning should be considered when deriving new standards
- Organotins US EPA/Washing State
- USEPA, and Washington
- For marine sediments - Puget Sound / Washington Dept of Ecology has are more extensitve list of contaminants and includes the apparent effects thresholds (AET) which is the concentration for a particular chemical above which adverse effects were always found for at least one of the following four biological indicators:
    - 1. Amphipod: 10-day mortality sediment bioassay; AET = higher mortality than control (p<= 0.05).
    - 2. Larval: mortality/abnormality sediment bioassays using Pacific oyster, blue mussel, purple / green sea urchin, sand dollar; AET = Higher mortality than control (p<= 0.05).
    - 3. Microtox saline extract: Decreased luminescence from bacteria Vibrio fischeri after 15min exposure; AET = light output < 80% control (p<= 0.05).
    - 4. Benthic infaunal abundance: Class crustacea, Class Ploychaeta, Phylum Mollusca; AET= <50% of reference for any of the groups.
    - Also, the Puget Sound / Washington Dept of Ecology approach includes The mean Sediment Quality Guideline quotient (mSQGq) involves dividing all sediment constituent concentrations by respective guidelines and then taking the average ratio.
    - It provides an indication of the potential for mixture toxicity which might not be adequately represented in the screening of individual sediment contaminants.
    - The overall average can be calculated for individual chemicals or for chemical groups (after averaging within a chemical group).
    - I have just experience at the national or federal level for Canada's Three Oceans. For example, see: McTavish, K., Alava, J.J., Brown, T., Crossland, M., Dangerfield, N., Hickie, B., Ross, P.S., and Tillmanns, A. 2024. A Framework for the derivation of environmental quality guidelines that protect apex marine mammals from persistent organic pollutants (POPs). Canadian Technical Report of Fisheries and Aquatic Sciences (Can. Tech. Rep. Fish. Aquat. Sci.) 3582: viii-28p. https://publications.gc.ca/site/eng/9.931293/publication.html
- none except the TBT criteria from Puget Sound.
- The size fraction aspect still confuses me a bit in BC. US EPA suggests that bulk sediments be evaluated.
- No I only worked with provincial and federal standards.
- Marine Canadas uses petrotox model to PHC sediment standards (i.e F3) and they are far too low and often result in flagging exceedances exceedances that are just naturally occurring organics in F3 carbon range. The model is fugacity based rather than SSD or evidence from tox studies.
- Yes. TOC normalization and grain size adjustment. No others that immediately come to mind
- Yes, and I think this is too big a question for response here. One way of soliciting this

kind of information would be to convene a virtual workshop and include colleagues from EU, US, Oz, etc. I would love to help with that - there are three generations of sediment specialists out there... the old-timers (that includes me, as a Peter Chapman disciple), the implementers, and the next-gen - if you took this approach, would be important to span not just jurisdiction but gen.
- In situ sediment stabilization as a remedial method
- CCME contaminated sites guideline frameworks—consideration of multiple pathways in determination of a final overarching guideline. CCME aquatic guidelines and use of SSDs. ECCC proposed approach to sediment guidelines. FEQGs.... Consideration of salinity, pH/pKa, total organic carbon (TOC), Kow/Koc, temperature, and other TMF for different substances.
- I was lead author for the updated federal (FCSAP) risk assessment guidance, which covers a lot of the same territory, both in the main ERA module and in supporting frameworks such as Aquatic Sites Framework. Another worth considering is the Atlantic RBCA framework which addresses some specific gaps (TBT, BTEX, TPH). The other jurisdictions cited are helpful for filling knowledge gaps for specific substances, and some procedures (e.g., OC-normalization).
- the separation of sensitive and typical sediment in BC is confusing, should consider different categories
- Yes. The key ones appear to have been noted already. Might want to consider standards to align with varying ecological protection goals.
- I dont have experience in other jurisdictions.
- SSD is useful (Ontario) because you can pull out relevant tox information.
- Ontario. Contains background sediment concentrations for metals commonly found in mineral soils and some organics that are widespread. Combines some elements from risk assessment (biomagnification, toxicity, benthic community structure) into the framework
- not really
- Yes. Please develop a tributyltin benchmark.

20 - Please provide any other comments or suggestions regarding the scientific basis, policy implications, or practical application of potential updates to BC's sediment quality standards. 30 responses

- n/a
- no comment
- If funding was available please consider performing and including spiked sediment toxicity testing for substances lacking standards, for substances with conservative standards, and as a second line of evidence to the correlative statistical BEDs database approach to deriving standards.
- I am supporting multiple projects with First Nation food-harvesting considerations, where the Nations are keen to see foreshore areas remediated for harvesting purposes. By considering bioaccumulation the sediment standards will support the restoration of these areas.

- This has the potential to be a very complex standard, with large legal implications to the small number of affected sites under the existing CSR liability framework. The question becomes whether the juice is worth the squeeze, as this is shaping up to require costly sampling. The environmental impacts of sediment remediation are orders of magnitude worse than a simple gas station excavation, and the adequacy of any restoration attempts within aquatic environments is a lingering uncertainty.
- I've been asking EC for TBT screening criteria for a couple of years, they are considering it, perhaps there's a way to collaborate here. I also find in the field that sometimes the other organotins are present at concentrations up to 10x TBT which makes me question which of the organotins is driving toxicity (even though TBT is the most toxic).
- Is there any consideration for a temperature factor in the standards? I'm thinking of both an increase in the toxicokinetics of contaminants with warmer water (warmer water = contaminant is more toxic) and temperature induced organism stress which makes the organism more suseptable to contaminants (warmer water means organism is stressed and is more suseptable to contaminant). A way of "future proofing" the methodologies with climate change if water temperature is an input.
- Looks promising...
- It's time for the standards to be updated!
- Sediment (and therefore fish/shellfish) are often of significant interest to first nations, so consulting with them on the standards will be needed.
- Currently the standards work at the site assessment stage to trigger sites into the contaminated sites process. Consideration for Tier 1 and Tier 2 sediment standards prior to full detailed ERA would be practical.
- Additional guidance / regulatory policy needed for assessment of spatial extent of contamination and effects - at what spatial scale does an effect become meaningful.
- I understand that BC ENV may want to take a more precautionary approach than previous derivation methods and guidance - if this is the cause, the scientific or policy rationale should be clearly stated.
- I strongly agree with the proposed approaches to sediment standards development, although I only dealt with soil, soil vapour and groundwater contamination I believe that including new emerging contaminates, taking into account additional chemical factors and addressing all potential risk impacts is crucial to our field of work.
- I think a One Health approach to include environmental, marine wildlife and human.public health should considered for the potential updates to BC's sediment quality standards.
- N/A
- BC could improve risk assessments by integrating bioavailability models and measuring porewater concentrations, particularly for metals and organics.
- Much of what is being proposed is risk assessment, not standards for site characterization purposes.
- na
- The contaminated media management has become too much of a closed shop, and more practical solutions need to be found to reduce management costs. Currently a small group of professionals are rostered to do this work and there are limited options for

material disposal that is adding inordinate costs to what really should not be such an expensive undertaking.

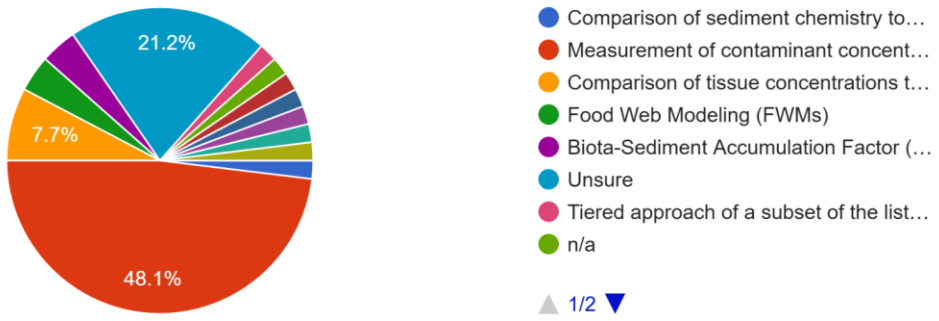
- An overall conceptual approach is needed which will take time and thought to assemble - including clarity on how the pieces will fit together. The list of possible approaches being proposed is likely too much to take on in one bite -- you may want to start with two pieces (from your list) in Phase 1... and get those right, and then tackle the next phase.
- A major decision point for you is likely to be: (1) do we build a SQV database (a database of values from elsewhere) or take someone else's and update it vs (2) building on existing databases (Long, McDonald, USEPA Region 10 yadayada).
- If this is to be done successfully "ALL" relevant information will have to be collected and maintained. Qualified people will have to undertake such work. If its only done halfway it will not be useful/defendable.
    - - We agree with the proposed use of the SSD approach and bioaccumulation approach for the development of new sediment quality standards.
    - - Consideration should be given to what data will be used in the development of the SSD and what HCx value from the SSD will meet the protection goals for the program. Can a set range of toxicity endpoints be used (similar to CCME aquatic guidelines which list an order of prefered endpoints). Is the lowest value available for a species used, or the geomean of all values for the same endpoint?
    - - Options should be considered re: if e.g., aquatic data converted to sediment concentrations using EQP (when applicable) can/should be used to increase the available data set or to meet data requirements. If EQP is used, are there/should there be limitations on species used (e.g., only benthic or epibenthic that were tested in water only, or all species as the assumption is that the range of sensitivities is the same for pelagic and benthic species) or limitations on amount of EQP data used?
    - - Should guidelines be developed for both contaminated sites and for non-contaminated sites? Depending on the protection goal used, a contaminated site sediment guideline might not be appropriate when considering regulations or policy for contaminant input to a non-contaminated basin (e.g., effluent limits, modelling of run-off, etc). i.e., a clean-down-to-level vs a pollute-up-to-level?
    - - Is there a minimum data set of species and/or number of data points required?
    - - If the new approach results in a lower guideline compared to the old method, how does this impact use of old guidelines as it will take time to revise all old guidelines.
- Too much to summarize in a survey entry, but I have been invited to participate in the workshop panel, so I can pass along more thoughts in that format. I will leave one suggestion here, which is that having multiple tiers of hazard can be very effective relative to a "bright-line" approach. The sensitive/typical distinction is partly this idea, but I think that more categories would help to characterize hazard before advanced tools are considered.
- Database used for derivation should be publicly available
- Outdated and glad to see Schedule 3.4 is being overhauled.
- Protection levels could be defined, perhaps by area like soil (ie 100 m2)

- None.
- See above, practicality has to factor into this work. The federal vs provincial jurisdictional questions should be better resolved and meshed before finalizing. Beneficial use and its broader implications should be more deeply considered and perhaps applied more broadly.
- We would love to connect with CEW.
- I think there should be consideration to the complexity of the screening standards vs practical / straight forward application; I think increasing levels of complexity should be maintained in a risk assessment.

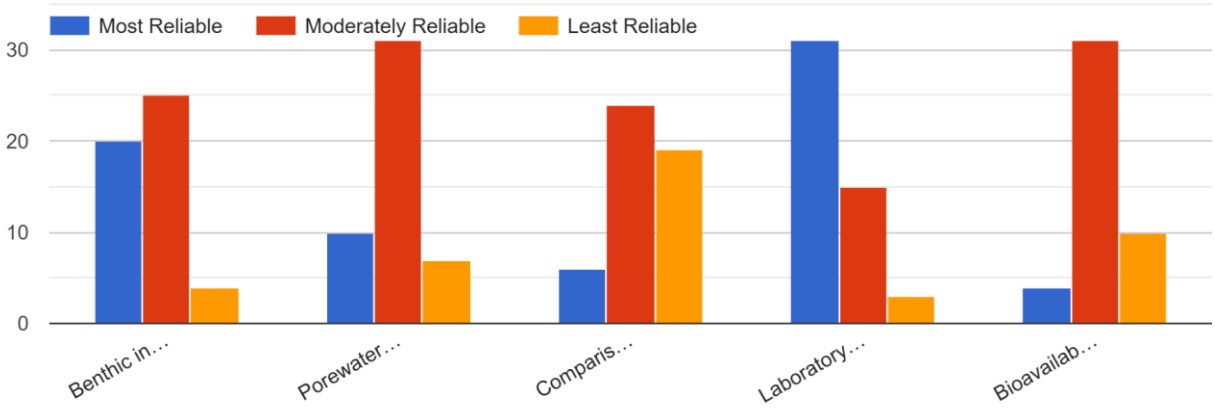
Section 5: Methodological Preferences & Data Needs

22 - When assessing bioaccumulation risk from sediments, which assessment tool(s) do you find most reliable?

52 responses



21 - When assessing direct toxicity risk to benthic organisms, which assessment tool(s) do you find most reliable?



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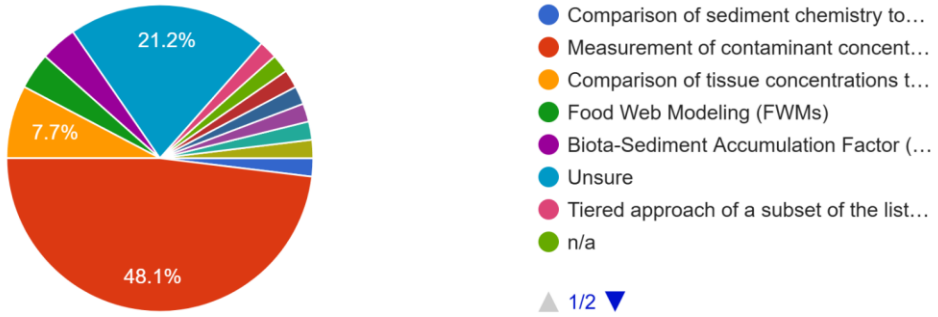
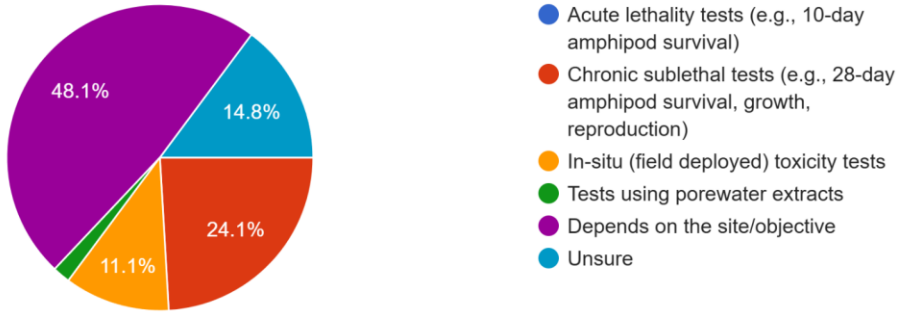


23 - What type of sediment toxicity testing provides the most valuable information for site assessment in BC?

54 responses



24 - How can sediment standards better account for the cumulative effects of multiple contaminants often found at sites? 37 responses

- regional/area studies would be needed
- Difficult to express in a single number/standard - conservative safety factors based on the literature may be an option
- BC's original sediment criteria attempted to do this, similar to a mechanism used and published by Don MacDonald in the late 90s and early 2000s. Mean sediment quotients. However, it can be a little difficult to do, and to interpret the resulting value.
- Great question --- it would be cool to see consideration given to Total HQs or other models.
- it cannot. Same with synergistic effects that are unknown. Save the science experiments for massive sites such as smelters, pulp mills or military bases. The CSR was intended to provide certainty for landowners after the Expo 86 lands, let's not lose sight of that.
- This is applicable to all media... Either adjusting the "allowable EC" to consider this, or in a risk assessment, reducing the acceptable HC/ILCR to consider this.

- Published guidance on contaminants with the same mechanism of action - ie/ sum quotients. For contaminants with different mechanisms of action, I'm not sure save for whole sediment toxicity testing. Maybe published known interactions?
- Integration of a framework that considers cumulative toxicity, including those constituents that have the same/similar toxic modes of actions (PAHs, TCDD/F, select metals) and those that have antagonistic modes of action (metals and ions).
- Need to be interpreted with other LOEs (toxicity tests, benthos) as part of ERA; definitely not sum of HQs (or SQs) across contaminants
- Ensure additivity must be included
- The standards should include a safety factor to account for this
- do we need to? if risk assessment likely anyways and its accounted for there through actual testing?
- Assessment methods that allow for exposure to the all the contaminants such as those based on toxicity testing are best for assessment cumulative effects.
- One option is the mean Sediment Quality Guideline quotient (mSQGq) from Puget Sound (see my response earlier)
- Proposing and formulating a chemical mixture toxicity approach for the suit of multiple contaminants at specific, local or regional sites.
- not sure
- Adopt a tiered assessment framework
- Difficult - better to conduct toxicity tests and benthic surveys which capture cumulative effects
- expand list of contaminates with developed standards (PFAS, etc.).
- I would love to see more toxicity identification evaluations when multiple contaminants are present.
- I don't think they can, and truth is it seems less important than the main toxicant that results to mortality.
- Laboratory whole-sediment toxicity testing using the media that contains the multiple contaminants/mixture which is the best approach for surface water testing to consider mixture toxicity and routinely done as part of effluent release criteria (i.e. USEPA Gold Book for effluent release has a whole sediment toxicity release criteria which is also likely going to be the upcoming/pending criteria for releasing oil sands process water in alberta/AEPA)
- Since contaminant mixtures can be highly variable, particularly in larger sites such as water lots and harbours, sediment standards as numerical values may not be appropriate for or able to account for this. Use of multiple lines of evidence where site complexity warrants is more likely to be able to assess the cumulative effects of contaminants since which the particular contaminant(s) that is/are eliciting the greatest adverse effects may not be able to be determined without something like a toxicity identification evaluation, and TIE studies are often not conclusive in proving direct causality associated with a specific contaminant.
- They won't - that is why one option is for sed standards to be a screening step (default value) - with room to look at whole sediments and site specific information after that.
- n/a
- Once the studies have been undertaken and the sites and locations are all known one can start to understand which combinations or contaminants are the worst on the specimens being studied.
- When we develop environmental quality guidelines, for chemicals within the same family or having the same mode of action, an additive model is often protective (TU, hazard index, TEFs, or something similar). This could fall within a guideline for a group or class of chemicals e.g., dioxins and furans, PCBs, or this could be a consideration within

supplementary guidance on how to consider cumulative effects of a variety of chemicals at individual sites. If the latter, this could be parked until the approach to developing standards is completed.
- complex, categorize contaminations by mode of action and most potent be the threshold
- By moving away from reliance on numerous individual substance guidelines, and more toward total or subgroup thresholds that also include bioavailability adjustment as applicable. This works will for broad groups such as PAHs, PCBs, etc. For more complex mixtures that include multiple types of contaminants, validation with laboratory tests will be needed, so the standards themselves could focus more on the gradient of response rather than bright line standards.
- Include summed parameters for substances with similar mechanisms of toxicity
- No standards have achieved this in any regulated media. There are alot of factors at play in the aquatic environment including multiple sources (pw, sw, gw, sed) contributing to cumulative effects. Currently we need to update how we assess single parameters with higher levels of confidence and more robust standards before we tackle cumulative effects.
- Using sediment HI approach similar to Pel-q and mean pel-a approach.
- I dont think this is feasibile - would be assessed on a site by site basis. could provide document of potential known cumulative effects for insight, but I think developing standards would be incredibly difficult.
- Better left to risk assessment. I suppose there is a theoretical risk of several contaminants all being present at concentrations less than their respective standard and their mode of action being similar resulting in unacceptable cumulative risk but I think the conservative nature of generic standards, even using a tiered approach means that this will rarely occur.
- Derive a Cumulative Effect Index that is based on the number of substances exceeding a standard and the magnitude of the exceedances. A CEI of zero means that all analyzed substances meet the sediment standards. A CEI of 10 or more could be considered as a factor in whether the sediments make it a high risk site.
- run some controlled mixture toxicity studies to understand effects or in situ so environmentally relevant exposure scenarios are better understood
- Creation of normalized impact values or toxicity factors, use of whole-sediment tox tests

25 - From a regulatory science perspective, what are the key factors for ensuring updated sediment standards are implementable, enforceable, and achieve the desired environmental protection outcomes? 45 responses

- they cannot be too complicated that it is difficult to apply (simple to use). They should not be lower than background concentrations as this will add more work to determine local background concentrations. New standards are needed for emerging or other contaminants (expand the sediment standard list). Increased lab costs will result in fewer samples analyzed which may increase uncertainty.
- Practicality, ease of use, based on current science
- Standards should not be set below or too close to background concentrations.
- I am not sure I understand the question, but I think the updated sediment standards do need to better capture things like low-level contaminant loading to sediments from sources like CSOs and WWTPs. It would be great to see these standards as a driver for the Province of BC to be a leader in mitigating contaminant impacts from municipal discharges.

- Two overused catchphrases are applicable here: K.I.S.S. , and don't let the perfect be the enemy of the good.
- simplicity
- Clear unambiguous guidance and access to guidance
- Understanding the level of protection (as well as protection for all trophic levels) desired for site type categories and ensuring that the standards derived are clear in how those desired levels of protection are met.
- Clarify sensitive/typical sites (if a distinction is needed at all); determine spatial scale at which SedQC exceedances need to be interpreted (e.g., 1/10 station or more?) to determine if CSR standards are met or not
- Need to be realistic and non-optional
- Making them easy to understand so that they are applied correctly
- standards need to account for toxicity modifying factors (e.g. pH, organic carbon, etc..)
- different tiers of standards, site use, urban environments
- Defensible, easy to implement, enforceable
- Clear scientific basis. If decision made to be more precautionary than scientifically-derived, then the rationale/clearly should be clearly descdribed (even if it is not a scientific rationale).
- For any media sampling for environmental proposes I believe the standards should be relevant to the laboratory capabilities, cost and complexity of sampling method and adjustable for the site specific factors like land use and potential risk pathways.
- Weight of Evidence, ecosystem-based approach and One Health approach in tandem with the precautionary principle following the UN sustainable development goals (SDG), including Life Below Water (SDG 14), focusing on conserving and sustainably using the oceans, seas, and marine resources for sustainable development, aiming to protect marine life, reduce pollution, and address overfishing.
- not sure
- Provide decision trees, flowcharts, and worked examples in guidance documents. Integrate chemistry, toxicity tests, and benthic community data in a weight-of-evidence (WOE) approach
- clear direction of how and where standards apply in a protocol
- Sufficient data and sound derivation method so that standards are protective at the desired level of effect (e.g., EC20)
- na
- Educating the regulators on how the standards were derived and the limitations of those standards. As well open dialogue and communication to keep improving the standards.
- Keep it simple. Keep it practical.
- Considerate of laboratory detection limits/laboratory abilities (do not set standards at levels below laboratory detection limits)
- They can't be too complicated (i.e., requiring expensive analyses) at Tier 1. An approach that applies more detailed analyses as degree of contamination (concentration, extent, bioaccumulation potential) increases seems to be most likely to achieve reasonable environmental protection outcomes without a need to frequently default to the use of enforcement actions such as investigation and remediation orders. Clear environmental

protection goals need to be clearer in policy - every site should not automatically default to "sensitive sediment use".

- -Alignment with best practice elsewhere (i.e., don't reinvent the wheel)
    - -Leverage tools/methods from elsewhere
    - -Documentation of rationale for tools/methods/derivation procedures/underlying datasets
    - -Be prepared to make the judgement/policy calls that will be necessary (this might be challenging, so plan ahead for it)
    - -Consider (not sure this is feasible) looking at lit to see where std were applied and how that aligned to predicted risks and post-remediation outcomes. Folks like Steve Bay, Allen Burton, and Tim Canfield,
- n/a
- Education and clear implementation guidelines.
- Should be based on the best available scientific methods and allow account for site-specific characteristics to be accounted for to a certain degree. Should be easy to understand and implement by the user.
- have engagement with practitioner community and industry to understand and unintended consequence
- There are so many. But one that comes to mind is the need for consistency in protection goals (especially acceptable effect sizes for lab testing and field validation tools).
- Realistic standards in terms of concentrations encountered and associated with effects with a transparent derivation, excluding substances without reliable data sets
- Honestly, the SABS vs. the CSR vs. sites requiring certification documents - all have different science perspectives and key factors at play currently
- Sediment quality management is generally a watershed (or coastline) concern except in cases with limited impacts that directly result from an activity (e.g., TBT from historic hull cleaning).
- Regular revisits to ensure aligned with best practices and consider a working group tasked to stay on top of best practices in sediment assessment.
- Input from the professional community with feedback taken into consideration. Clear expectations/guidance from ENV on implementation from the start.
- sediment assessments should be required to have a field observation / tox test if exceed a protective standard. must include a background / off-site assessment, as absence could be due to mortality tox or avoidance behaviours.. or maybe no one ever lived in the sediment!
- It's important that sites with concentrations of contaminants that are not causing impairment don't regularly get identified as contaminated and need to go through a time and money consuming risk assessment.
- They need to be easily applied, covering a similar range of substances to Schedules 3.1 and 3.2
- Sufficent toxicity data is needed that provides clear evidence that these regulations are indeed protective and how mixtures of contaminants will behave
- Simplicity of application, even if that requires that they're overly conservative. Allowing additional tiers such as risk assessment, helps address the concern associated with

being overly conservative. Perhaps there could be an intermediate step before full RA. If the specific steps used to derive a given standard are clear and a practitioner can show that any of the derivation steps are not appropriate for a given site and can modify the approach with site-specific info (tox test for a more appropriate site-specific species, etc), perhaps that could be implemented as well, but simple concservative standards allow for easier implementation, enforceability... and perhaps it provides a precautionary principle component that helps protect for cumulative effects etc.

- Ensure that the laboratories can easily reach assess the media and obtain results below the standards.
- I think they need to be risk-based and scientifically defensible. I also think they need to be relatively simple to apply and geared for screening purposes.
- Easy to interpret and implement, rely on achievable laboratory limits and analyses

Appendix E. CEW Session Schedule

This appendix provides the detailed schedule for the CEW session (October 7, 2025).

- **Platform Session (8:30 am - 12:00 pm)**

  1: Whales, water and sediments: Towards a renewed risk-based approach to environmental contamination by Peter Ross

  2: Holistic protection of aquatic ecosystems: Developing a scientific framework to modernize sediment quality standards by Jasen Nelson and Marc Cameron

  3: Bioaccumulation and sediment assessment: Evaluating Canada's regulatory readiness by Joline Widmeyer

  4: Applying cause-effect pathways to the holistic integration of sediment quality assessments for long-term management by Wayne Landis

  5: Interactive Discussion - Holistic protection: Integrating modern science into matrix sediment standards by Beth Power and Jasen Nelson

  6: Interactive Discussion - Expanding the tiered framework: Developing a procedure for deriving site-specific sediment standards by Wayne Landis and Jasen Nelson

  7: Development of new sediment quality guideline protocol and applying it to the derivation of tributyltin sediment quality guidelines by Sushil Dixit

  8: Interactive Discussion - Modernizing BC's sediment standards: Prioritizing options and approaches (Part 1) by Beth Power, Gary Lawrence, and Jasen Nelson

  9: Interactive Discussion - Modernizing BC's sediment standards: Prioritizing options and approaches (Part 2) by Beth Power, Gary Lawrence, and Jasen Nelson

  10: Weaving knowledges: Indigenous wisdom in modernizing sediment standards for planetary health by Shannon Waters

  11: Setting a new standard: Merging western and Indigenous science to apply the Burrard Inlet Water Quality Objectives to contaminated sites by Anuradha Rao

  12: Interactive Discussion - Weaving Indigenous Knowledges and science into the sediment standards framework by Anuradha Rao and Shannon Waters

- **Poster Session**: Holistic protection of aquatic ecosystems: Modernizing sediment standards

Appendix F. Abstracts for CEW Session

This appendix includes abstracts of presentations, interactive discussions and the poster delivered during the SSTAC session at CEW on October 7, 2025.

The CEW presentations were organized as follows:

- Presentation: Whales, Water and Sediments by Dr. Peter Ross
- Presentation: Sediment Standards Project Overview by Marc Cameron and Jasen Nelson
- Presentation: Bioaccumulation Assessment by Joline Widmeyer
- Presentation: Cause-Effect Pathways by Wayne Landis
- Interactive Discussion: Matrix Sediment Standards by Beth Power
- Interactive Discussion: Tiered Framework Development by Wayne Landis
- Presentation: New Sediment Quality Guidelines by Sushil Dixit
- Presentation: Modernizing BC's sediment standards: Prioritizing options and approaches by Gary Lawrence
- Interactive Discussion: Modernizing BC's sediment standards: Prioritizing options and approaches by Beth Power and Gary Lawrence
- Presentation: Indigenous Wisdom Integration by Shannon Waters
- Presentation: Merging Western and Indigenous Science by Anuradha Rao and Melany Sanchez Solano
- Panel Discussion: Weaving Indigenous Knowledges & Science with Dr. Shannon Waters, Anuradha Rao and Melany Sanchez Solano

Presentation Abstracts

Peter S. Ross

Raincoast Conservation Foundation

Whales, water and sediments: Navigating the fate of contaminants in the environment.

Divergent scientific, technical and policy tools are available for risk-based assessment of environmental contamination, permitting, and remediation. Despite Canada's history of science-to-policy successes in the area of chemical regulation and environmental contamination, challenges emerge in addressing high levels of industrial chemicals in such cases as killer whales in coastal British Columbia. These challenges underscore the need to 'connect the dots' on the various approaches to mitigating the risks associated with contaminants. Many contaminants travel through waterways, and end up in sediments. Sediments serve as either a 'sink' or a 'source', with the latter serving to deliver contaminants to the adjacent food web. A renewed focus on sediments therefore offers a timely opportunity to collaboratively develop new approaches that better protect aquatic ecosystems for all. Timely questions include: How can we best protect long lived species from persistent contaminants? How can we characterize exposure in mobile or migratory species that transit a blend of urbanized, industrialized and remote habitats? Can site remediation lessen exposure for mobile species? Should a cumulative

exposure/effects approach integrate multiple contaminated sites to protect vulnerable and mobile species? Can studies of contaminated environments be used to contribute to national regulatory actions on certain chemicals of concern? An energized, multi-sector energy is needed in British Columbia to bridge current gaps in understanding, monitoring and mitigating contamination risks. This requires innovative thinking, cross-sector leadership, and a dialogue focused on valued Canadian resources like water and whales.

Jasen Nelson[1,2], Marc Cameron[2,3]

[1]British Columbia Ministry of Environment and Parks, [2]Science Advisory Board for Contaminated Sites,[3]Core6 Environmental

Holistic protection of aquatic ecosystems: Developing a scientific framework to modernize sediment quality standards.

British Columbia's current Contaminated Sites Regulation (CSR) sediment standards require updating to incorporate contaminant bioavailability, bioaccumulation, food-chain transfer considerations, mixture effects, and an updated toxicity dataset. Developing a scientifically robust and protective framework for sediment quality standards is crucial for managing contaminated sites effectively within the province.

The Science Advisory Board for Contaminated Sites (SABCS) has partnered with the BC Ministry of Environment and Parks to collaboratively develop a scientific framework for modernizing CSR sediment standards. The proposed framework includes: 1) a dual standards approach to address risks from direct and indirect exposure (including food chain transfers); 2) a tiered approach for enhanced site-specificity with options to integrate multiple lines of evidence, including bioavailability, community metrics, habitat condition; and 3) modern approaches for risk-based derivation (e.g., Species Sensitivity Distribution).

Building on input from a survey previously sent out, this session will present the proposed framework, highlight key survey findings, and facilitate collaborative refinement through targeted interactive polling. Participants will consider key methodological choices, data needs, and implementation practicalities. The insights gathered will directly inform the SABCS Sediment Standards Project and will be documented in a white paper that details the proposed scientific framework for deriving and updating the CSR sediment standards.

This presentation outlines the proposed framework for sediment quality standards based on preliminary research findings and initiates a collaborative refinement process with session participants. Active participation will help ensure the resulting framework reflects the best available science, incorporates diverse perspectives, and effectively protects both ecological and human health.

Joline (Jo) Widmeyer

SLR Consulting

Bioaccumulation and sediment assessment: evaluating Canada's regulatory readiness.

Bioaccumulation in aquatic ecosystems is governed by complex biological and chemical processes. Existing federal and provincial sediment quality criteria do not specifically account for potential adverse effects to higher trophic levels. It is time to re-evaluate existing sediment regulations to ensure they are adequately supporting sediment assessments being conducted and relied upon by practitioners, stakeholders, and regulators. This presentation addresses the need for a more transparent and scientifically grounded approach to sediment risk assessment in Canada, with an emphasis on bioaccumulation.

We present: (1) a concise overview of the key scientific principles underlying bioaccumulation in aquatic environments; (2) a critical analysis of current provincial and federal sediment assessment guidance, identifying strengths, gaps, and limitations; and (3) a comparison of international regulatory approaches to integrating bioaccumulation, with recommendations on potential adaptations for the Canadian context.

Dr. Wayne Landis

Western Washington University

Applying cause-effect pathways to the holistic integration of sediment quality assessments for long-term management.

The challenge in managing sediments is the multitude of contaminants, management goals, and environments ranging from freshwater streams to deep marine. It is also necessary to engage diverse sets of regulators and stakeholders, their diverse management goals, and to construct a suitable framework that facilitates collaboration, decision making and adaptive management. There are also other chemicals, water quality parameters and climate change effects that can affect biotransformation, uptake, and act as additional stressors altering the overall environmental impact. This presentation demonstrates how cause-effect pathways can be constructed to link sediment concentrations to their impact on multiple endpoints and can be used for adaptive management. These case studies use the relative risk framework to describe the cause-effect interactions between contaminants and management endpoints. In these examples Bayesian networks (BNs) are applied to perform the calculations but Monte Carlo or structural equation modeling are also candidate methods. There is an extensive literature on the use of BNs in environmental assessment so there are multiple case studies and multiple software packages exist with a variety of features. Several examples will be presented. The Upper San Francisco Estuary has a variety of contaminants such as Hg and pesticides and multiple endpoints such as smelt and salmon. The second example is the MacKenize watershed in western Canada and the risks due to Hg to a variety of endpoints in the context of multiple stakeholders (https://doi.org/10.1093/inteam/vjae011). Similarly, these approaches can be applied to

contaminated harbours, mining sites, smelter deposits and other contaminated sediments.

Sushil Dixit

Environment and Climate Change Canada

Development of a new sediment quality guideline protocol and applying it to the derivation of tributyltin sediment quality guidelines.

William Martin, Almira Khan, Janet Cermak, Sushil Dixit Environment and Climate Change Canada, Gatineau, QC In 1995, the Canadian Council of Ministers of the Environment (CCME) published Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. This document outlines two methods for deriving sediment quality guidelines (SQGs): the Spiked Sediment Toxicity Test (SSTT) approach which applies a safety factor to the lowest acceptable endpoint, and the National Status and Trends Program (NSTP) approach which uses field study/co-occurrence, SSTT, and equilibrium partitioning data to calculate a threshold effect level based on the geometric mean of specific percentiles of the effect and no-effect concentration data. Though included for future use, the SSTT approach was not recommended at the time due to limited spiked sediment toxicity data and lack of standardized methods. As of 2025, there is significantly more high-quality SSTT data in the literature and better approaches to guideline derivation than the SSTT or NSTP methods. To capitalize on this, a new sediment derivation protocol is proposed that uses a species sensitivity distribution (SSD) approach adapted from the CCME protocol for water quality guidelines. It incorporates SSTT and equilibrium partitioning data to derive two types of SQGs: preventative for unimpacted sites and remedial for contaminated sites. SQGs for tributyltin using both the novel SSD approach and the current CCME methods are presented as a case study for comparison.

Dr. Shannon Waters

Office of the Provincial Health Officer

Weaving knowledges: Indigenous wisdom in modernizing sediment standards for planetary health.

Our waters, lands, and sediments are not mere resources; they are kin, fundamental to the health of all beings. The approaches to developing environmental criteria, including those for sediment quality, have been viewed primarily through a Western scientific lens. This perspective misses the deep, relational understanding inherent in Indigenous Knowledges – wisdom cultivated over millennia of direct observation and stewardship. As Deputy Provincial Health Officer for Planetary and Water Health, and as a member of the Stz'uminus First Nation, I see an urgent need and profound opportunity to embrace ""Two-Eyed Seeing.""

This presentation will explore the critical importance of integrating Indigenous Knowledges into the modernization of sediment standards. We will discuss how Indigenous perspectives on the interconnectedness of all living things, the spiritual significance of water, and the identification of culturally vital species and sites can enrich and expand our definitions of a healthy, protected environment. By braiding ancient and "younger" scientific methods, we can move beyond purely numerical benchmarks towards more holistic, place-based standards. This approach will strengthen ecosystem protection for the beings, including humans, who comprise them. Such approaches are now also required to uphold the principals of BC's Declaration on the Rights of Indigenous Peoples Act.

Anuradha Rao & Melany Sanchez Solano

Tsleil-Waututh Nation

Setting a New Standard: Merging Western and Indigenous Science to Apply the Burrard Inlet Water Quality Objectives to Contaminated Sites.

səlilwət (Burrard Inlet) is at the core of Tsleil-Waututh Nation (TWN) unceded traditional territory. Tsleil-Waututh have used, occupied, and governed səlilwət according to Coast Salish protocol since time immemorial. Adverse effects of colonial settlement, urban, industrial, and port development have eroded the ecological health, integrity, and diversity of səlilwət and are preventing Tsleil-Waututh from practicing their ways of life. Tsleil-Waututh Nation has a goal to restore the health of the Inlet so the community can once again utilize the waters and beaches of səlilwət for traditional food harvesting and other cultural practices.

TWN's Burrard Inlet Action Plan is a founding guidance document to improve the health of səlilwət. Updating the Burrard Inlet Water Quality Objectives (WQOs) is the first identified priority. The updated Burrard Inlet WQOs are co-signed by the Province of BC and TWN, representing a first of its kind Government-to-Government initiative that weaves together Indigenous and western science. WQOs are numbers or statements that represent safe levels of substances in waterbodies. They inform resource management decisions and promote the stewardship of water resources in BC.

Contamination in səlilwət has long surpassed what is allowable under Tsleil-Waututh law. TWN's basin-wide data analysis and visualization demonstrate that ~700 contaminants have been detected in səlilwət, entering from multiple sources, and potentially from the ~4600 contaminated sites in its catchment area. The work to implement and attain the WQOs requires collective effort. We have an opportunity to reframe contaminated sites management to help attain the WQOs and restore water values.

Interactive Discussions

Beth Power

Azimuth Consulting Group

Holistic Protection - Matrix Sediment Standards.

Is there a need to develop sediment standards that provide holistic protection and leverage modern scientific methods? This 15-minute interactive discussion, facilitated by the Science and Standards Technical Advisory Committee (SSTAC), aims to gather expert input on a proposed dual standards approach. The session will explore how the dual standard approach can provide holistic protection, where: 1) standards protect direct exposure to sediment; and 2) standards protect indirect exposure via the food transfer pathway. Participants will discuss key attributes of holistic protection and provide feedback via polling on the practical application of Species Sensitivity Distributions for direct exposure assessment and Biota-Sediment Accumulation Factors or Food Web Models for deriving bioaccumulation-based standards. This session will help refine both the overarching protection and the technical derivation methods for robust, modern sediment standards, contributing to refinement of the interim scientific framework.

This interactive discussion is an important part of the community engagement within the SSTAC Sediment Standards Project. This discussion provides an opportunity for attendees to contribute insights on the key topic: dual standards approach, which will directly inform the refinement of our proposed scientific framework for updating the sediment standards in BC. Furthermore, your participation will directly inform a forthcoming Science Advisory Board for Contaminated Sites white paper and help build the foundation for the next generation of sediment management in BC.

Wayne Landis

Western Washington University

Expanding the Tiered Framework, Site-Specific Sediment Standards.

Effective sediment quality management necessitates a flexible framework, moving beyond fixed standards to incorporate site-specific complexities for protective and practical assessments. Current Contaminated Sites Regulation sediment standards do not integrate site-specific data, so numerical screening overlooks unique site conditions.

This 15-minute interactive discussion, moderated by the Science and Standards Technical Advisory Committee (SSTAC), seeks expert input to develop a tiered sediment quality assessment framework for BC. The objective is to collaboratively design a practical framework integrating diverse site-specific data — such as contaminant bioavailability adjustments, benthic community health metrics, and other lines of evidence — culminating in a methodology for new sediment quality standards.

Participants will engage in moderated polling and focused discussion covering: Potential framework structures; decision trees for tier advancement; specific data requirements for site-specific considerations at each tier; and methods for integrating multiple lines of evidence.

This interactive discussion is an important part of the community engagement within the

SSTAC Sediment Standards Project. This discussion provides an opportunity for attendees to contribute insights on aspects of the key topic: tiered approach, which will directly inform the refinement of our proposed scientific framework for updating the sediment standards in BC. Furthermore, your participation will directly inform a forthcoming Science Advisory Board for Contaminated Sites white paper and help build the foundation for the next generation of sediment management in BC.

Gary Lawrence[1] & Beth Power[2]

[1]WSP [2]Azimuth Consulting Group

Modernizing BC's sediment standards: Prioritizing options and approaches (Parts 1 & 2).

British Columbia's sediment quality standards require comprehensive modernization across multiple scientific and regulatory fronts to ensure robust ecosystem protection and alignment with current scientific understanding. Addressing the myriad of complex issues, from site-specific assessments to emerging contaminants, necessitates a prioritized approach. This high-level, integrative and interactive discussion, hosted by the BC Science and Standards Technical Advisory Committee (SSTAC), aims to gather expert consensus on the relative priority and urgency of key proposed solutions for updating these standards. Key themes for discussion and ranking will include: the development of tiered, site-specific assessment frameworks (incorporating bioavailability and multiple lines of evidence); implementation of dual guideline approaches (for direct exposure to sediment contamination and indirect exposure via food transfer); strategies for addressing emerging contaminants and complex mixtures; and tackling challenges related to data availability, accessibility, and reliability. Participants will engage in a structured ranking exercise and a moderated discussion to prioritize these multifaceted approaches.

This interactive discussion is an important part of the community engagement within the SSTAC Sediment Standards Project. This discussion provides an opportunity for attendees to contribute insights into prioritizing available options and approaches for updating BC’s sediment standards, which will directly inform the refinement of our proposed scientific framework. Furthermore, your participation will directly inform a forthcoming Science Advisory Board for Contaminated Sites white paper and help build the foundation for the next generation of sediment management in BC.

Poster Presentation

Science & Standards Technical Advisory Committee: Jasen Nelson[1,2], Cara Lachmuth[1], Jennifer Trowell[3], Marc Cameron[2,4], Geoff Wickstrom[5], Peter Ross[6], Shannon Bard[2]

[1]British Columbia Ministry of Environment and Parks, [2]Science Advisory Board for Contaminated Sites, [3]Ausenco, [4]Core6 Environmental, [5]Craft Environmental, [6]Raincoast Conservation Foundation

Holistic Protection of Aquatic Ecosystems: Modernizing CSR Sediment Standards.

British Columbia’s (BC) current Contaminated Sites Regulation (CSR) sediment

standards, developed over two decades ago, are outdated. These legacy standards, based on bulk contaminant concentrations and limited toxicity data, inadequately address food transfer, bioaccumulation, and bioavailability. The Science Advisory Board for Contaminated Sites (SABCS) has partnered with the BC Ministry of Environment & Parks to collaboratively develop a scientific framework for modernizing these standards.

This Sediment Standards Project is developing a scientific framework using modern science and international practices. Key innovations include: 1) dual sediment standards for direct toxicity to benthic organisms and indirect toxicity via food web transfer, 2) a tiered assessment framework allowing for site-specific considerations, bioavailability, and multiple lines-of-evidence for ecological metrics; and 3) adopting derivation techniques like Species Sensitivity Distributions and Biota-Sediment Accumulation Factors. The project also aims to cover priority emerging contaminants.

This poster provides a high-level overview as part of the multi-faceted, collaborative engagement process for the SABCS Sediment Standards Project. The CEW session called Holistic Protection of Aquatic Ecosystems - Modern Sediment Quality Assessment expands upon this overview, including a keynote presentation, two interactive presentations and moderated workshop(s). Attendees are invited to contribute insights and collaborate throughout the moderated CEW session designed to shape a robust, inclusive, and scientifically defensible scoping plan. Participation will directly inform a forthcoming SABCS white paper and help build the foundation for the next generation of sediment management in BC.

Appendix G. CEW Session: What We Heard

1.0 Executive Summary

This report summarizes the feedback gathered from the half-day technical session (*Holistic Protection of Aquatic Ecosystems: Modernizing Sediment Quality Assessment*) held at the Canadian Ecotoxicity Workshop (CEW) on October 7, 2025. This session was designed as a targeted follow-up to the broader public survey (May-July 2025) to gather specific, technical feedback from experts, researchers, and practitioners.

Feedback was collected through real-time polling and a facilitated panel discussion. The key findings are:

1. **Strong Technical Mandate:** Experts overwhelmingly support the modernization of standards. All five key topics presented in the prioritization (Importance vs. Feasibility) polls were categorized by the group consensus as **"High Priority Near-Term"**.
2. **Clear Prioritization:** When asked to rank actions to improve matrix standards, the clear top priority was to **"Distinguish 'direct toxicity' and 'food pathway toxicity' pathways explicitly"** (1.6 avg. rank).
3. **Focus on Site-Specific Tools:** The top-ranked focus for providing the greatest value to holistic sediment management was to **"Push guidance beyond generic numerical standards"** by applying models and tools to develop Site-Specific Sediment Standards (2.0 avg. rank).
4. **Nuanced Views on Feasibility:** While there was broad agreement on the *importance* of all proposed topics, the polling revealed significant expert debate on *feasibility*. Incorporating bioavailability adjustments, in particular, showed a clear split in opinion on whether it is "feasible now" or a "longer-term" goal.

2.0 Introduction and Methodology

The session's objective was to present the proposed scientific framework and gather insights from the technical community to inform its collaborative development.

The session was structured around four key themes identified in the project's interim framework:

- **Holistic Protection:** Matrix sediment standards.
- **Tiered Framework:** Site-specific sediment standards.
- **Prioritization Framework:** Prioritizing approaches and options for modernization.
- **Weaving Indigenous Knowledges:** Weaving Indigenous wisdom and science into the framework.

Feedback was gathered using a two-part polling strategy to ensure broad and inclusive participation from the professional community:

1. **Live Polling (CEW):** During the session at CEW, polls were opened to all event attendees, capturing live feedback from a diverse group of practicing scientists, regulators, and experts. The screenshots in Sections 4.0 and 5.0 of this appendix show

these *live results* as they were captured during the event.

2. **Authenticated Polling (SSTAC/TWG):** To include professionals who could not attend CEW in person but wished to participate, a separate, authenticated poll was made available to SSTAC and TWG members. This poll opened just prior to the CEW event and remained open until November 8, 2025.

This report summarizes the quantitative findings from the live polling screenshots (Method 1). The qualitative findings from the panel discussion (Method 2) are summarized in Section 6.0.

3.0 Building on the Public Survey

This targeted technical engagement was designed to build directly upon the findings of the public survey (May-July 2025). The public survey (summarized in the *Draft Sediment Standards Review: What We Heard* report) confirmed a strong mandate for change, with **88%** of respondents supporting modernization and **73%** finding the current standards "Not Effective" or "Slightly Effective" at preventing bioaccumulation.

The survey also identified a clear roadmap, with strong support for:

- Expanding the contaminant list (95% "Essential" or "Very Important")
- Incorporating bioavailability (91% "Essential" or "Very Important")
- A formal tiered framework (86% "Beneficial" or "Very Beneficial")
- A "Dual Standard" approach to address bioaccumulation (83% "Necessary" or "Beneficial")

The CEW polls were informed by this feedback and intended to provide a necessary level of technical refinement. Where the public survey asked *if* we should modernize, the CEW session asked *how*—focusing on specific methodologies, priorities, and the scientific feasibility of the proposed framework.

4.0 Key Findings: Expert Poll Responses

Participants were polled on three key themes: Holistic Protection, the Tiered Framework, and the Prioritization Framework.

4.1 Holistic Protection (Questions 1-8)

This theme focused on defining the components of a "Matrix Sediment Standards (SedS) Framework" to provide holistic protection. Experts were polled on the importance and feasibility of developing standards for the four quadrants of this matrix.

Direct Toxicity to Ecological Receptors (SedS-contact$_{ECO}$): Seen as "Very Important" (42 votes) and highly "Achievable" (35 votes).

Figure G-1 - Holistic Protection (Q1): Importance of SedS-contact$_{ECO}$

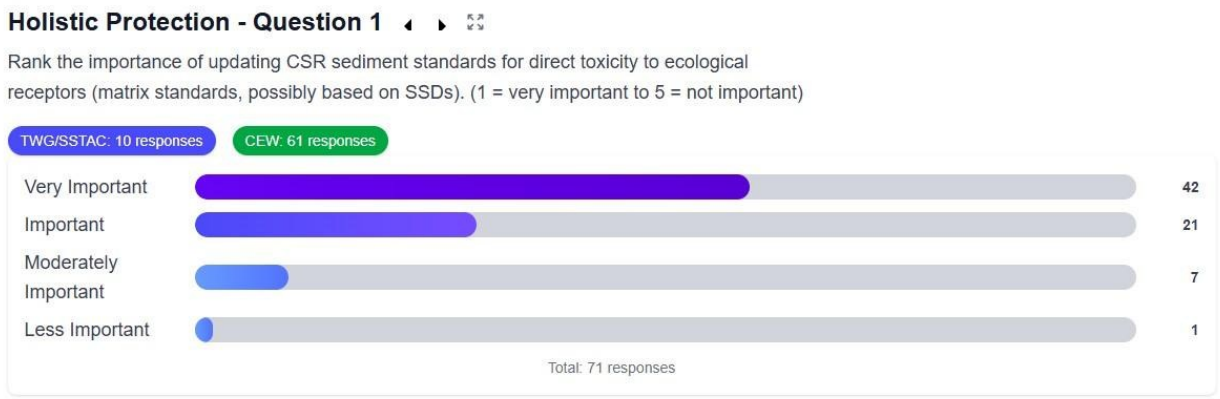
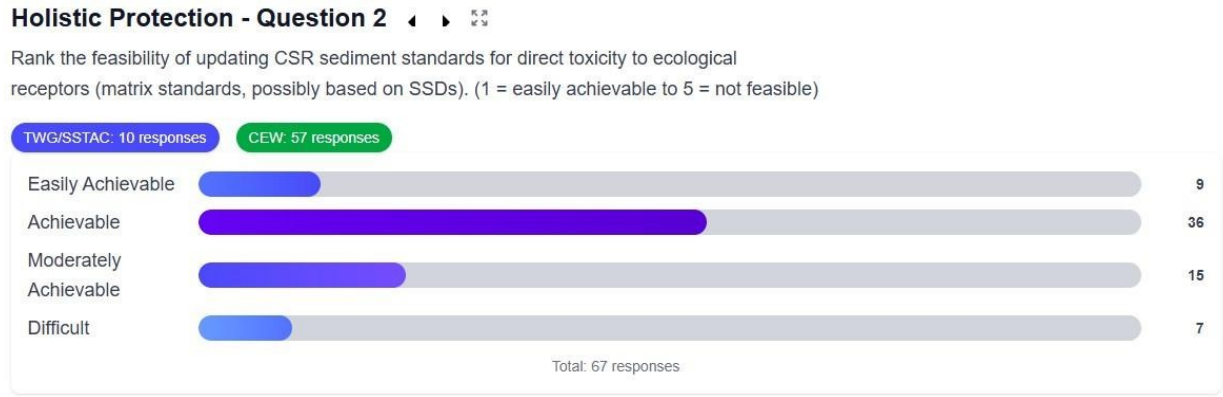


Figure G-2 - Holistic Protection (Q2): Feasibility of SedS-contact$_{ECO}$



Direct Toxicity to Human Receptors (SedS-contact$_{HH}$): Rated as "Very Important" or "Important" (42 votes total), with more varied views on feasibility, leaning toward "Achievable" (23 votes) or "Moderately Achievable" (18 votes).

Figure G-3 - Holistic Protection (Q3): Importance of SedS-contact$_{HH}$

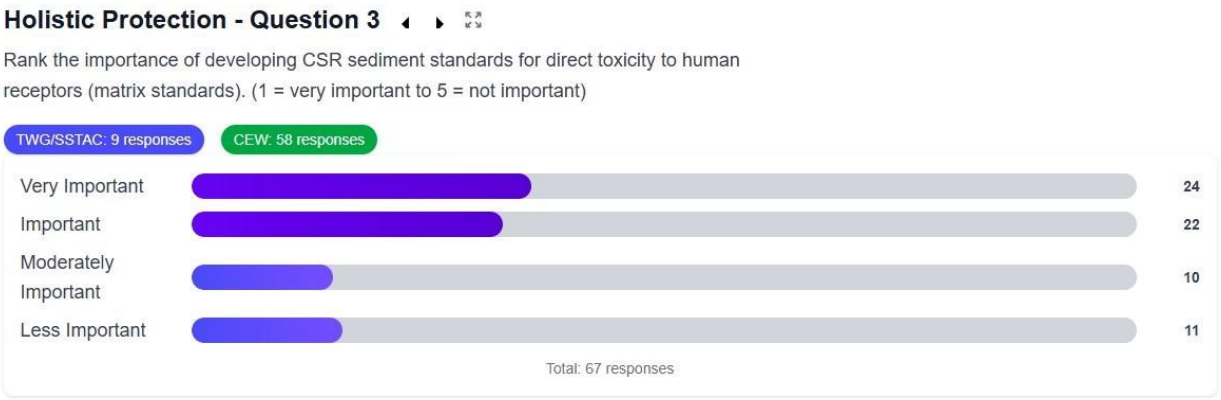
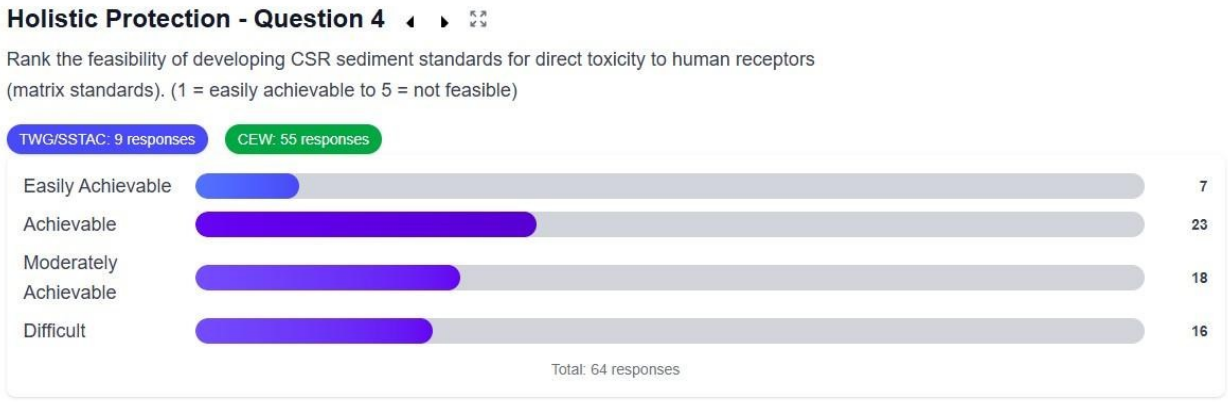


Figure G-4 - Holistic Protection (Q4): Feasibility of SedS-contact$_{HH}$



Food-Related Toxicity to Ecological Receptors (SedS-food$_{ECO}$): Received strong support as "Very Important" (39 votes) and "Achievable" (29 votes).

Figure G-5 - Holistic Protection (Q5): Importance of SedS-food$_{ECO}$

Figure G-6 - Holistic Protection (Q6): Feasibility of SedS-food$_{ECO}$

Food-Related Toxicity to Human Receptors (SedS-food$_{HH}$): Rated as "Very Important" or "Important" (50 votes total) and "Achievable" (28 votes).

Figure G-7 - Holistic Protection (Q7): Importance of SedS-food$_{HH}$

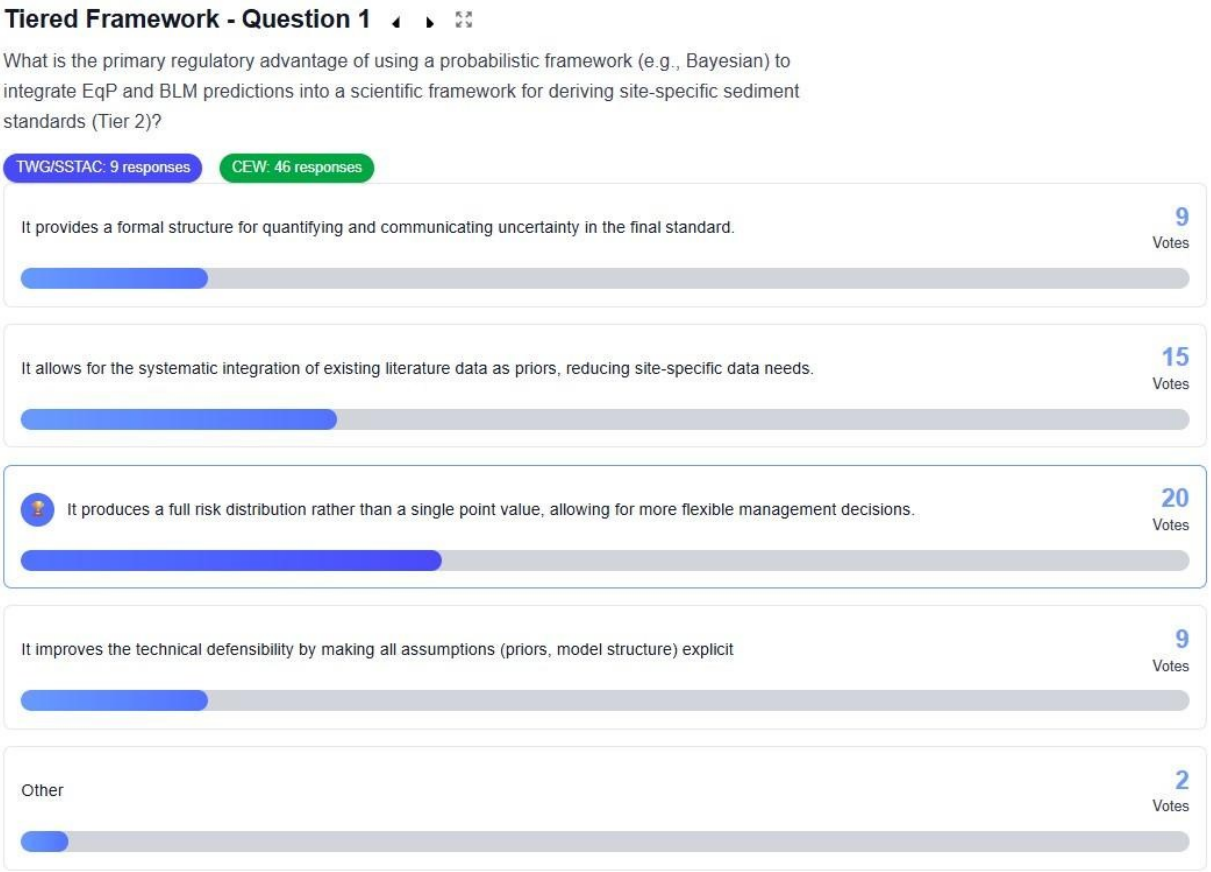
Figure G-8 - Holistic Protection (Q8): Feasibility of SedS-food$_{HH}$

4.2 Tiered Framework (Questions 1-3)

This theme explored expanding the "Three-Tier Framework" (Tier 1: Matrix [as it was referred to at CEW, now referred to as Screening], Tier 2: Site-Specific, Tier 3: Risk-Based) and the role of probabilistic (e.g., Bayesian) models.

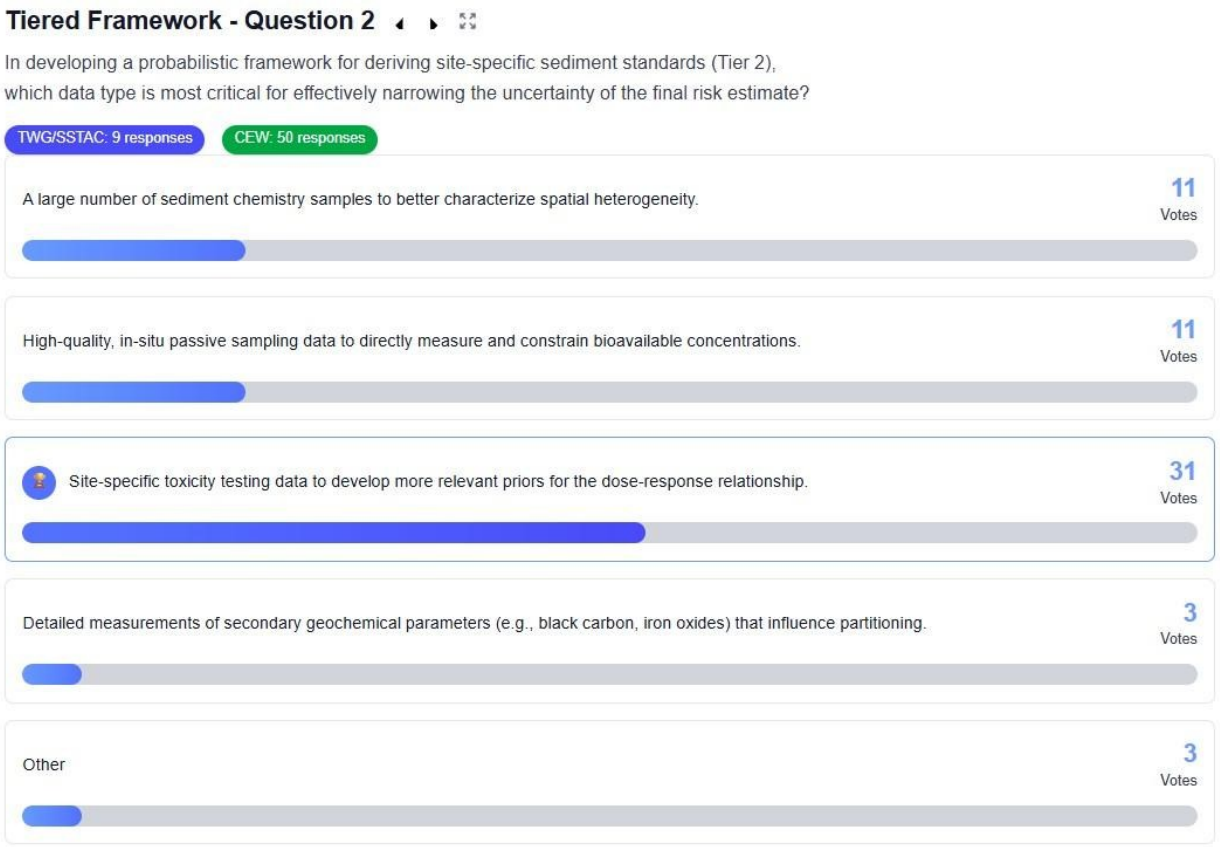
Primary Advantage of a Probabilistic Framework: The top-voted advantage (20 votes) was that **"It produces a full risk distribution rather than a single point value..."**.

Figure G-9 - Tiered Framework (Q1): Primary advantage of probabilistic framework for deriving site-specific sediment standards



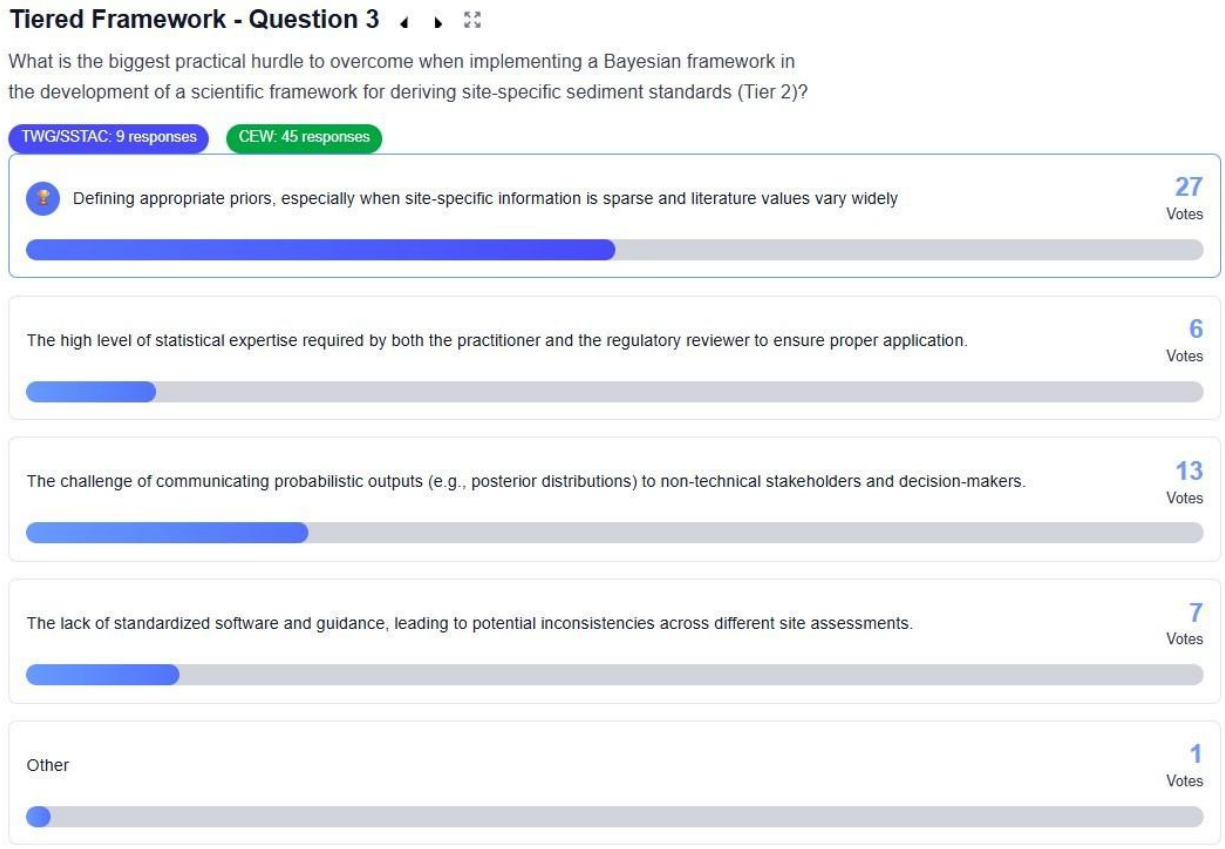
Most Critical Data Type: When asked what data is most critical for narrowing uncertainty, the clear winner (31 votes) was **"Site-specific toxicity testing data to develop more relevant priors..."**.

Figure G-10 - Tiered Framework (Q2): Critical Data for Reducing Uncertainty



Biggest Practical Hurdle: The most significant hurdle (27 votes) was identified as **"Defining appropriate priors, especially when site-specific information is sparse..."**.

Figure G-11 - Tiered Framework (Q3): Biggest practical hurdle for Bayesian framework for deriving site-specific sediment standards (Tier 2)



4.3 Prioritization Framework (Questions 1-5)

The final set of polls focused on prioritizing specific actions to guide the modernization effort.

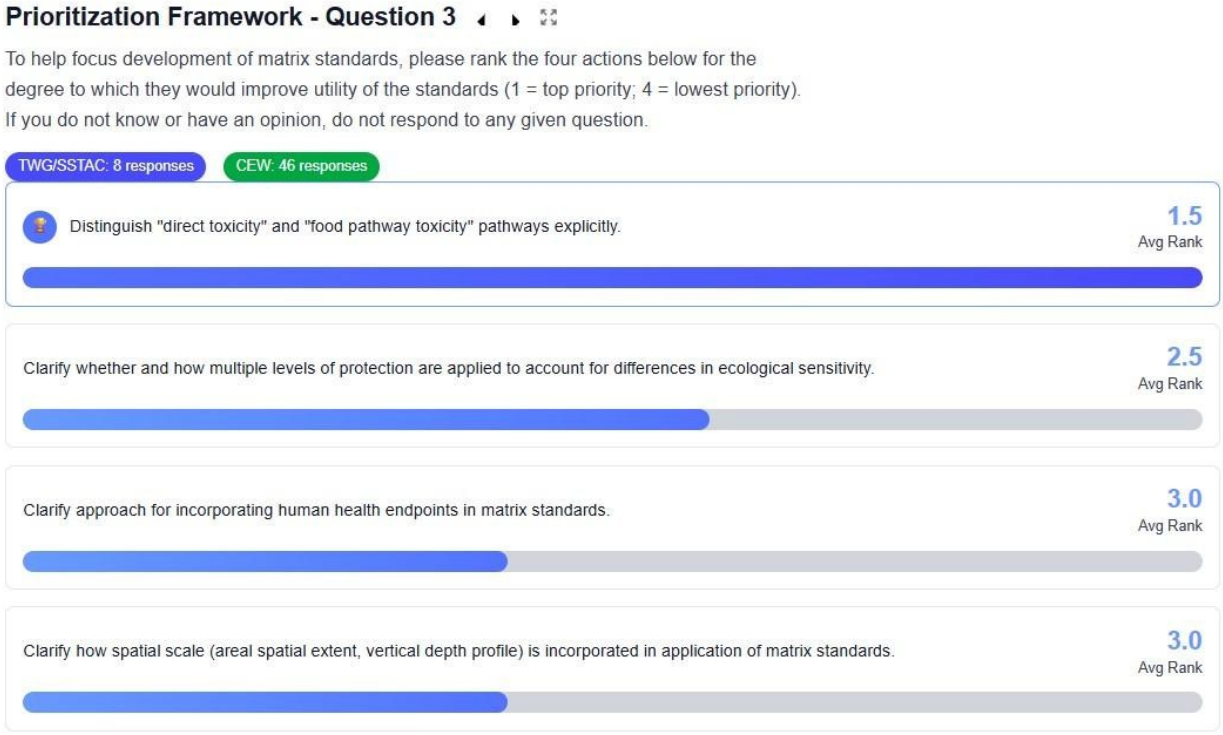
Incorporating Bioavailability: This was seen as overwhelmingly important, with 60 of 66 participants rating it "Very Important" or "Important". Feasibility was more divided, with "Moderately Achievable" (26 votes) being the most common response.

Figure G-12 - Prioritization (Q2): Importance of incorporating bioavailability adjustments

Figure G-13 - Prioritization (Q2): Feasibility of incorporating bioavailability adjustments

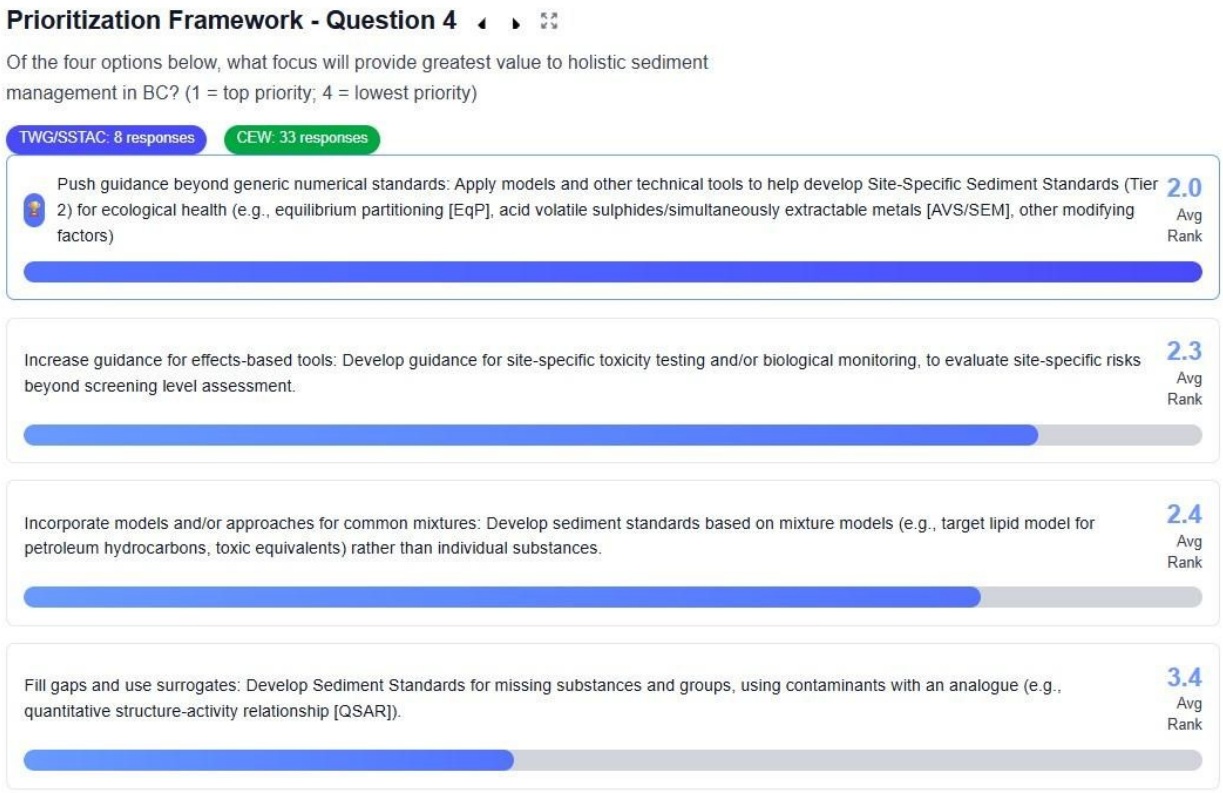
Top Priority for Improving Matrix Standards (Ranking): The clear top priority (1.5 avg. rank) was to **"Distinguish 'direct toxicity' and 'food pathway toxicity' pathways explicitly."**

Figure G-14 - Prioritization (Q3): Ranking actions for matrix standards



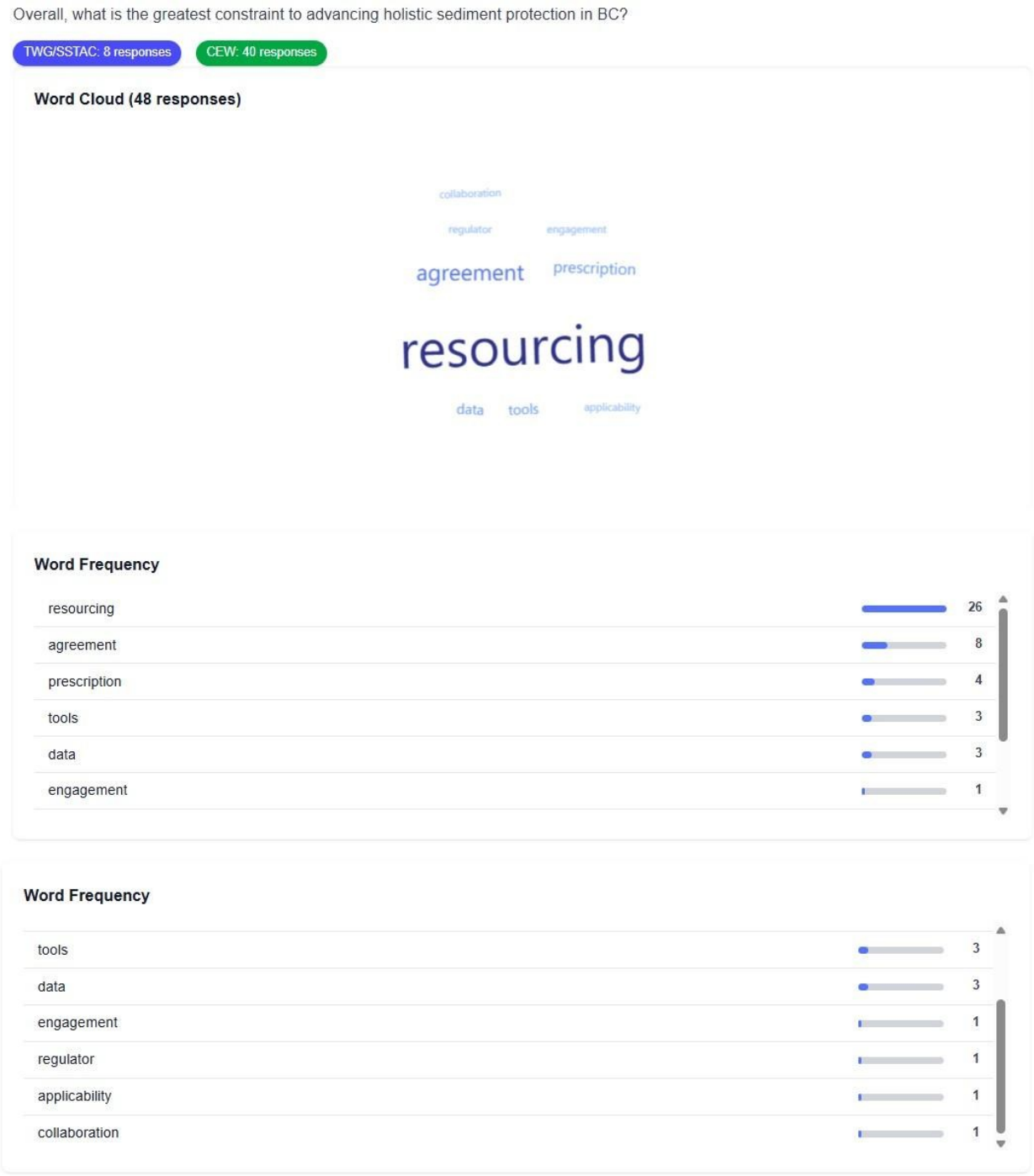
Top Focus for Holistic Management (Ranking): The top-ranked focus (2.0 avg. rank) was to **"Push guidance beyond generic numerical standards. Apply models and other technical tools to help develop Site-Specific Sediment Standards (Tier 2)..."**.

Figure G-15 - Prioritization (Q4): Ranking focus for holistic management



Greatest Barrier to Advancing Protection: A word cloud poll (45 responses) identified the greatest constraint to advancing holistic sediment protection. The most common response by a large margin was **"resourcing"** (26 responses), followed by "agreement" (8 responses) and "prescription" (4 responses).

Figure G-16 - Prioritization (Q5): Greatest constraint to advancing holistic sediment protection in BC (Word Frequency and Word Cloud)



5.0 Key Findings: Prioritization Matrix (Importance vs. Feasibility)

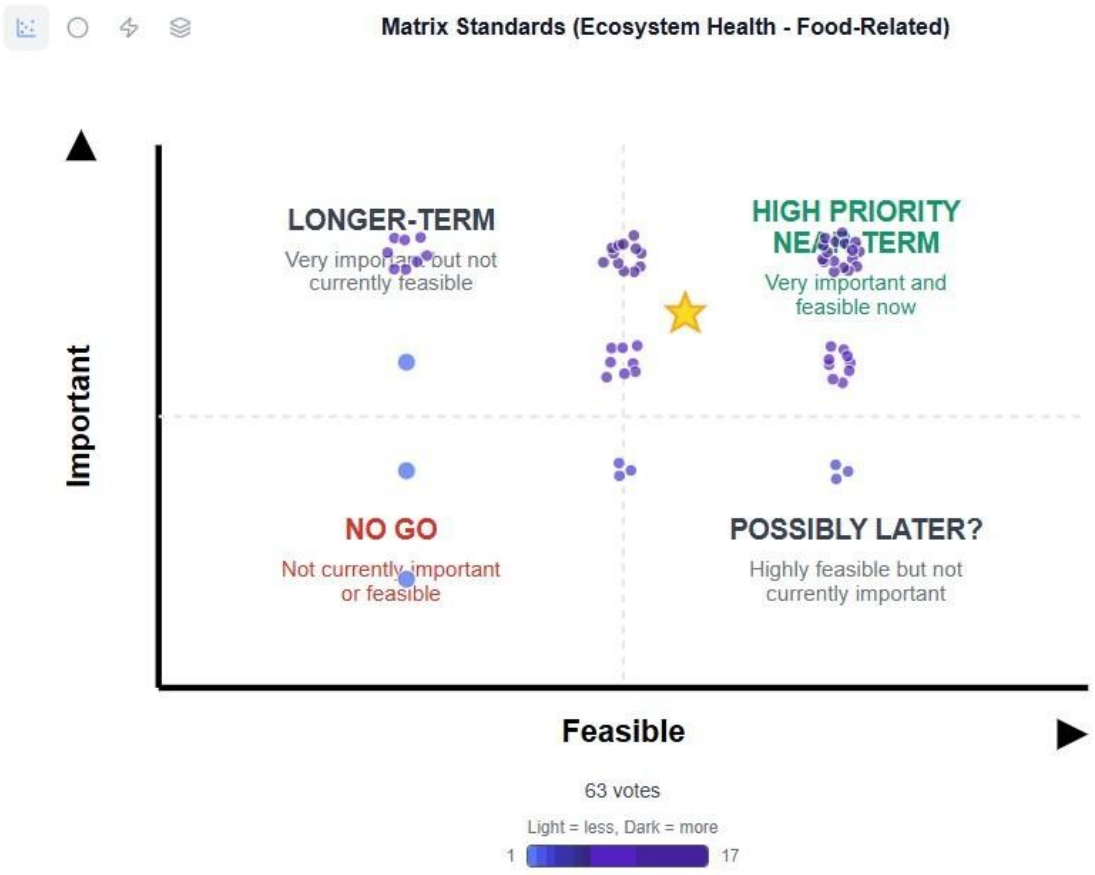
Participants' paired responses for importance and feasibility were plotted on 2x2 matrix graphs. The "consensus" star (representing the average response) for all five polled topics landed in the top-right quadrant.

Consensus Finding: All five topics were categorized by the expert consensus as **"High Priority Near-Term"** ("Very important and feasible now").

However, the *distribution* of individual responses (N=55 to 57) within the quadrants provides critical nuance about the degree of consensus.

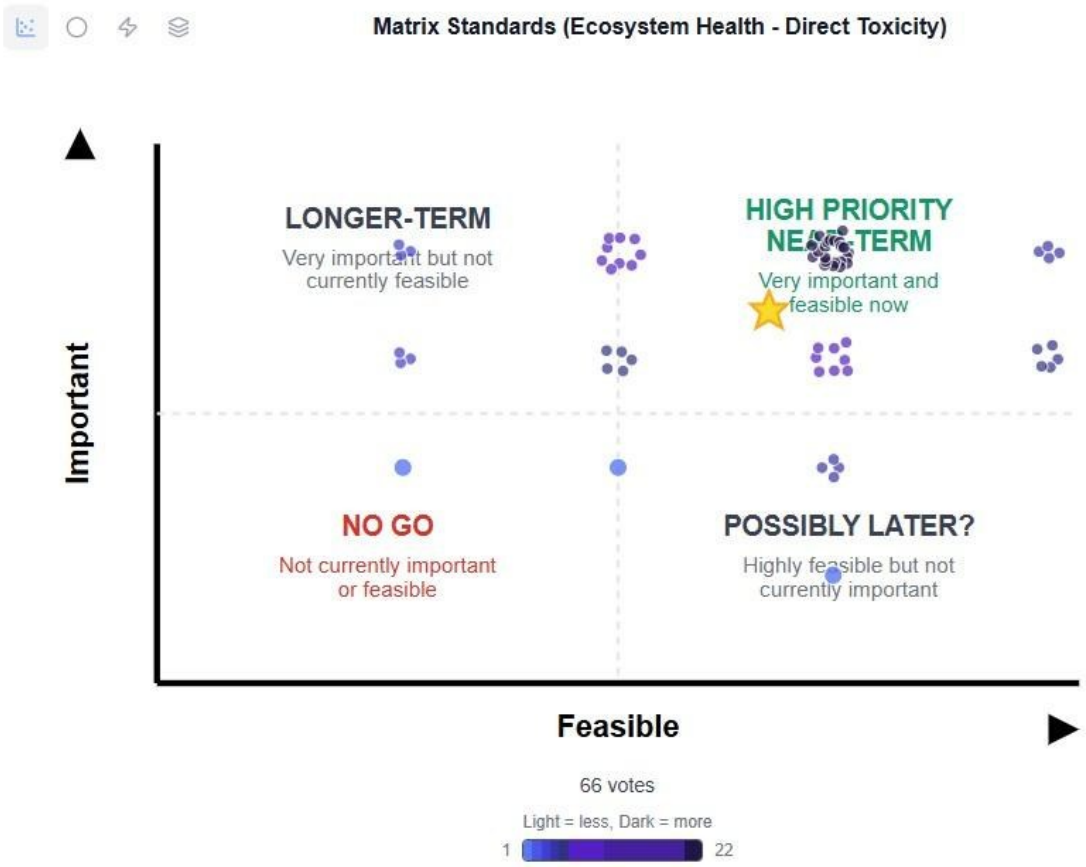
Matrix Standards (Ecosystem Health - Food-Related): Showed the tightest clustering and strong consensus, with the vast majority of experts agreeing on both high importance and high feasibility.

Figure G-17 - Prioritization Matrix: Matrix Standards (Ecosystem Health - Food-Related)



Matrix Standards (Ecosystem Health - Direct Toxicity): Showed very strong consensus with the vast majority of experts agreeing on both high importance and high feasibility.

Figure G-18 - Prioritization Matrix: Matrix Standards (Ecosystem Health - Direct Toxicity)

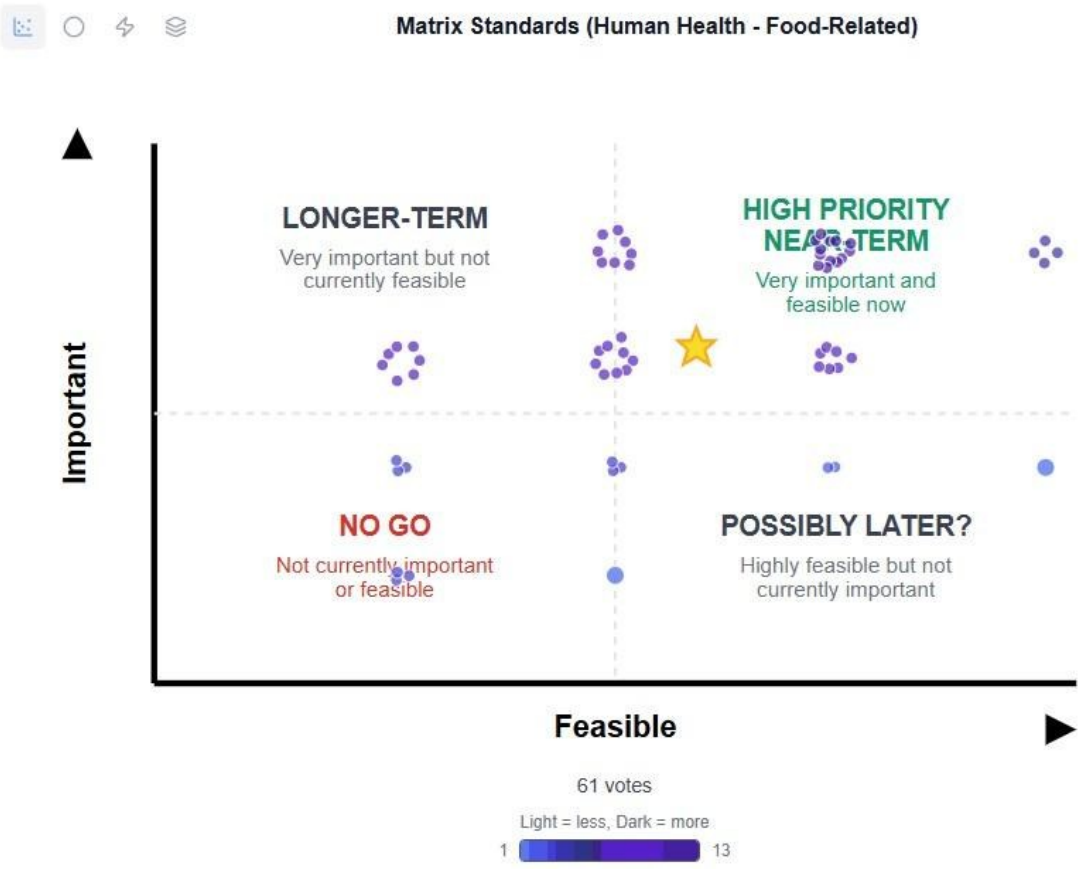


Matrix Standards (Human Health - Direct Toxicity): Showed very strong consensus with the vast majority of experts agreeing on both high importance and high feasibility.

Figure G-19 - Prioritization Matrix: Matrix Standards (Human Health - Direct Toxicity) Showed the general consensus, with experts divided on both importance and feasibility. Many agreed that the importance and feasibility of these standards were high, but the spread was greater, compared to Ecosystem Health - Direct Toxicity.

Matrix Standards (Human Health - Food-Related): Showed a wide distribution amongst experts, slightly favouring moderate importance and moderate feasibility.

Figure G-20 - Prioritization Matrix: Matrix Standards (Human Health - Food-Related) Similar to Human Health – Direct contact, experts were divided on both importance and feasibility with a greater spread, compared to Ecosystem Health – Food Related.

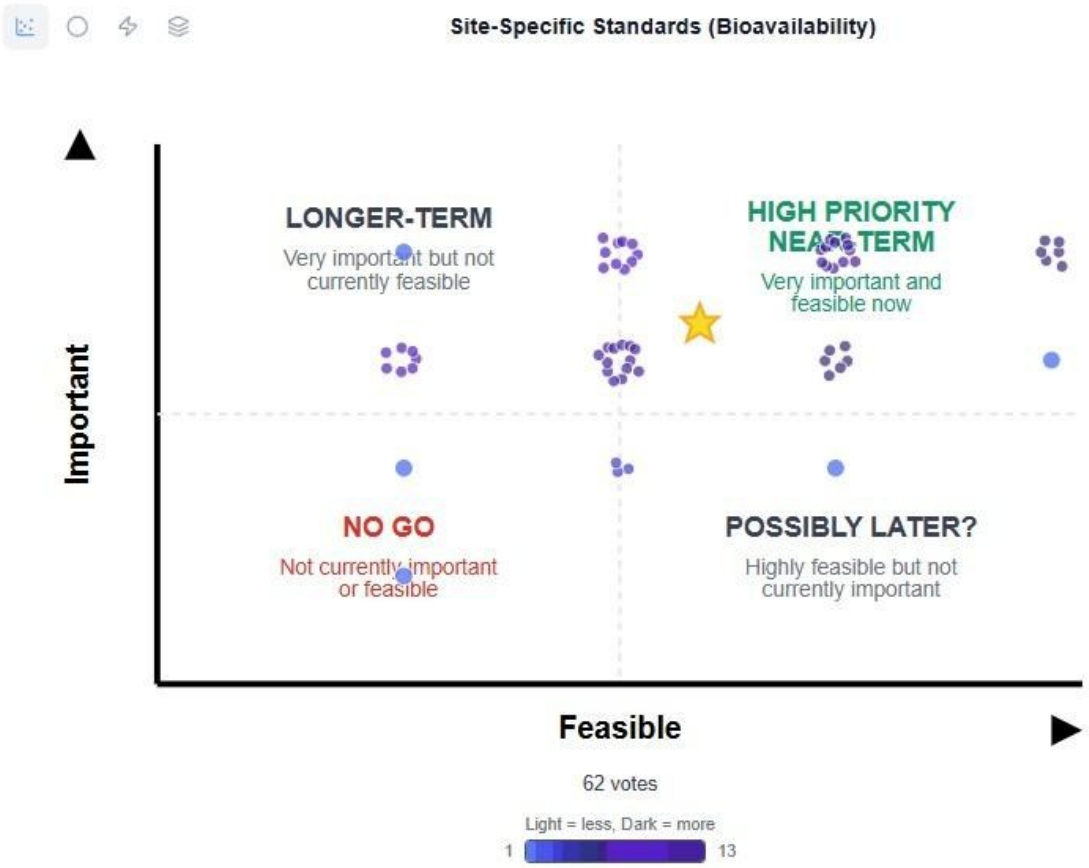


For both human-health-related topics, a strong majority landed in the "High Priority Near-Term" quadrant. However, a notable number of responses also appeared in the "High Priority Longer-Term" (Top-Left) quadrant, suggesting disagreement on *current* feasibility.

Split Opinion on Feasibility:

Site-Specific Standards (i.e., Bioavailability-adjustment): This topic showed the most division. While importance was universally high, responses were split almost evenly between the "High Priority Near-Term" (Top-Right) and "High Priority Longer-Term" (Top-Left) quadrants. This indicates significant expert debate on the *current feasibility* of implementing bioavailability adjustments.

Figure G-21 - Prioritization Matrix: Site-Specific Standards (Bioavailability)



Additional feedback at CEW was provided on the feasibility of implementation, particularly with regard to the sheer number of chemicals requiring standards. It was brought forward that some chemicals currently in use should not be on the market, reflecting outdated regulatory decisions made decades ago. The federal government, not just the province, should be directly involved since Ottawa approved these chemicals, while BC is left responsible for cleanup. There should be formal opportunities for provinces and stakeholders to provide feedback to the federal government, particularly through CEPA, during the approval process for new chemicals.

6.0 Panel Discussion: Weaving Indigenous Knowledges

This session explored the "how" and "why" of braiding Indigenous wisdom with Western science. The session was framed by two key presentations:

- A **foundational vision (the 'why')** from **Dr. Shannon Waters** (Member of the Stz'uminus First Nation; and Deputy Provincial Health Officer (PHO) in BC for Water and Planetary Health), who spoke to the importance of "Two-Eyed Seeing" and recognizing waters and lands as kin.
- A **tangible example (the 'how')** from **Anuradha Rao** and **Melany Sanchez Solano** (Staff with the Tsleil-Waututh Nation), who detailed the Nation-led, government-to-government process of developing the Burrard Inlet Water Quality Objectives to protect cultural

practices.

Following the presentations, the three speakers participated in a panel discussion. Key questions and themes from the discussion are summarized below.

- **On the Legal Status of Water Quality Objectives:**
    - **Audience Question:** *What are your concerns regarding the fact that the Burrard Inlet Water Quality Objectives are not legally binding?*
    - **Panel Response:** Dr. Shannon Waters clarified that the Water Quality Objectives **are binding in Tsleil-Waututh Nation (TWN) law**, which describes how to live and protect the environment as part of daily life. She contrasted this with colonial law, which she described as “catch guards” rather than daily instructions for living. She stressed that Indigenous law was entrenched into everyday interactions with land, soil, and water.
    - Anu Rao added that TWN is actively developing policy on how to "mesh colonial and TWN law" for work in the Inlet. She noted that streams of implementation include working within existing regulatory regimes, such as wastewater regulations, and finding opportunities that resonate with institutions.
- **On Reflecting Indigenous Values in Standards:**
    - **Moderator Question:** *What’s one key way sediment standards could better reflect Indigenous values, cultural uses, or community health needs?*
    - **Panel Response:** The panel emphasized treating the environment as a **food source for future generations**. Communities should be able to safely and abundantly eat foods and drink water. This requires a shift in thinking toward "net environmental gain" and a goal of **"No new inputs of contamination into Mother Earth"**. Dr. Waters also added that beyond the value of food, the Inlet holds a spiritual connection, describing it as “the grandmother.” The issue of historic contamination was raised, as was the challenge of remediation in an already heavily contaminated system. The panel warned of shifting baseline syndrome and stressed that restoration may take generations.
- **On Challenges of Braiding Knowledge:**
    - **Moderator Question:** *From your experience, what’s a key lesson—or challenge—you’ve faced when bringing Indigenous knowledge into Western scientific processes?*
    - **Panel Response:** Dr. Waters noted a key challenge is moving beyond component-based protection (e.g., pipes, source water) to a **"holistic watershed level"** perspective, which is inherent in Indigenous Knowledge systems.
- **Final Thoughts:** The panel's final thoughts centered on the foundational concept that in many First Nations languages, **"Landscape = Kin"**. This perspective reframes environmental protection: "How we care about the environment should be how we care about our family". Speakers reinforced this by comparing care for the land and water to caring for an ill family member. They also highlighted the role of language as a framing tool, noting that land is language - not an analogy but a lived reality. The existence of dozens of words for land, water, and invertebrates reflects this continuum, and even the sounds of words (like the sound of a river running low) can teach us how to relate to the

environment.

7.0 Conclusion and Next Steps

The CEW technical session provided clear validation from the expert community for the proposed direction of the Sediment Standards Project. There is a strong consensus on *what* needs to be done: modernize standards to be holistic, protective of both human and ecological health, and inclusive of both direct and food-pathway toxicity.

The polling and matrix analyses provided a clear prioritization, with experts urging a focus on distinguishing toxicity pathways and advancing site-specific (Tier 2) tools. The primary barrier identified by this group is not a lack of agreement, but a need for **resourcing** to accomplish these goals.

The nuanced feedback and divided opinions on *feasibility* (especially bioavailability and human health standards) are equally valuable. They highlight the key scientific and practical challenges that must be addressed in the next phase of the project. This feedback, combined with the public survey results, provides a robust foundation for developing the modernized framework.

Appendix H. Glossary of Technical Terms:

- **6-PPD:** N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine
- **AEP:** Ministry of Environment and Protected Areas
- **AER:** Alberta Energy Regulator
- **ANZG:** Australian and New Zealand Guidelines for Fresh and Marine Water Quality
- **AOP:** Adverse Outcome Pathway
- **ASTM:** American Society for Testing and Materials
- **ATL:** Advisory Tissue Level
- **AVS:** Acid Volatile Sulfide (a measure of sulfide in sediment, influences metal bioavailability)
- **BAF:** Bioaccumulation Factor (ratio of contaminant in organism to contaminant in water)
- **BBSGV:** Bioaccumulation Based Sediment Guideline Values
- **BC:** British Columbia
- **BCC:** Bioaccumulative Chemical of Concern
- **BMD:** Benchmark Dose (a dose or concentration that produces a predetermined change in response rate of an adverse effect)
- **BN:** Bayesian Network
- **BSAF:** Biota-Sediment Accumulation Factor (ratio of contaminant in organism to contaminant in sediment, OC-normalized for organics)
- **CBR:** Critical Body Residue
- **CCME:** Canadian Council of Ministers of the Environment
- **CEW:** Canadian Ecotoxicity Workshop
- **Cfree:** Freely dissolved concentration of a contaminant in porewater
- **COPC:** Contaminant of Potential Concern
- **CSAP:** Contaminated Sites Approved Professionals of BC
- **CSR:** Contaminated Sites Regulation
- **CSL:** Cleanup Screening Level (Washington State)
- **DEP:** Department of Environmental Protection
- **DFO:** Fisheries and Oceans Canada (formerly Department of Fisheries and Oceans
- **DGV:** Default Guideline Value (ANZG)
- **EC_{20}:** Effective Concentration causing a 20% effect in a tested population
- **EC_{50}:** Effective Concentration causing a 50% effect in a tested population
- **ECCC:** Environment and Climate Change Canada
- **eDNA:** Environmental Deoxyribonucleic Acid
- **EMA:** Environmental Management Act
- **ENV:** BC Ministry of Environment and Parks (formerly Ministry of Environment and Climate Change Strategy, Ministry of Environment and other variations)
- **EqP:** Equilibrium Partitioning
- **ERL/ERM:** Effects Range Low / Effects Range Median (NOAA empirical guidelines)
- **ESB:** Equilibrium Partitioning Sediment Benchmark (US EPA)
- **ESL:** Ecological Screening Level
- **EU:** European Union
- **FEQG:** Federal Environmental Quality Guideline (Canada)

- **FEL:** Frequent Effect Level (Quebec)
- **FWM:** Food Web Model
- **GLWQI:** Great Lakes Water Quality Guidance
- **GV:** Guideline Value
- **HC_5:** Hazardous Concentration affecting 5% of species (derived from SSD)
- **HHRA:** Human Health Risk Assessment
- **HOC:** Hydrophobic Organic Contaminant
- **ISQG:** Interim Sediment Quality Guideline (CCME)
- **ITRC:** Interstate Technology & Regulatory Council
- **LEL:** Lowest Effect Level (Ontario)
- **LOE:** Line of Evidence
- **MECP:** Ministry of the Environment, Conservation and Parks
- **MEE:** Ministry of Ecology and Environment
- **MELCC:** Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parc
- **MOE:** Ministry of the Environment
- **MWLAP:** Ministry of Water, Lands and Parks
- **NCP:** National Contingency Plan
- **NEL:** No Effect Level (Ontario)
- **NOAA:** National Oceanic and Atmospheric Association
- **OC:** Organic Carbon
- **OECD:** Organisation for Economic Co-operation and Development
- **OEHHA ATL:** Office of Environmental Health Hazard Assessment Advisory Tissue Level (California)
- **OEL:** Occasional Effect Level (Quebec)
- **PAH:** Polycyclic Aromatic Hydrocarbon
- **PBT:** Persistent, Bioaccumulative, and Toxic substance
- **PCB:** Polychlorinated Biphenyl
- **PE:** Polyethylene
- **PEL:** Probable Effect Level (CCME)
- **PEL-Q:** PEL-Quotient
- **PFAS:** Per- and Polyfluoroalkyl Substances
- **PHC:** Petroleum Hydrocarbon
- **PHO:** Provincial Health Officer
- **PSD:** Passive Sampling Device
- **PSQS:** Provincial Sediment Quality Guideline (Ontario)
- **QA/QC:** Quality Assurance/Quality Control
- **REL:** Rare Effect Level (Quebec)
- **RBCA: Risk-Based Corrective Action**
- **RRM:** Relative Risk Model
- **SABCS:** Science Advisory Board for Contaminated Sites
- **SecoRA:** Sediment-Ecosystem Regional Assessment
- **SedNet:** Sediment Network
- **SedQC:** Sediment Quality Criteria (BC, 2003 terminology)

- **$SedQC_{SDS}$**: SedQC for Sensitive Contaminated Site
- **$SedQC_{TDS}$**: SedQC for Typical Contaminated Site
- **SedS:** Sediment standards
- **SedS-contact:** A sediment standard derived from the matrix framework, designed to be protective against the effects of direct exposure to contaminants
- **SedS-food:** A sediment standard derived from the matrix framework, designed to be protective against the effects of contaminant transferred in the food web
- **SEL:** Severe Effect Level (Ontario)
- **SEM:** Simultaneously Extracted Metals (metals extracted with AVS, influences metal bioavailability)
- **SETAC:** Society of Environmental Toxicology and Chemistry
- **SMO:** Sediment Management Objective (BC, 2003 terminology)
- **SMS:** Sediment Management Standard
- **SPME:** Solid Phase Microextraction
- **SQAG:** Sediment Quality Assessment Guideline (Florida)
- **SQG:** Sediment Quality Guideline
- **SQO:** Sediment Quality Objective (California)
- **SQS:** Sediment Quality Standard (general term; Washington State)
- **SQT:** Sediment Quality Triad
- **SSD:** Species Sensitivity Distribution
- **SSTAC:** Science and Standards Technical Advisory Committee
- **SWRCB/OEHHA:** State Water Resources Control Board/Office of Environmental Health Hazard Assessment
- **TBT:** Tributyltin
- **TEL:** Threshold Effect Level (CCME-analogous)
- **TEQ:** Toxic Equivalents (for dioxins, furans, dioxin-like PCBs)
- **TOC:** Total Organic Carbon
- **TRG:** Tissue Residue Guideline
- **TWG:** Technical Working Group
- **TWN:** Tsleil-Waututh Nation
- **US EPA:** United States Environmental Protection Agency
- **WAC:** Washington Administrative Code
- **WFD:** Water Framework Directive (European Union)
- **WIKS:** Weaving Indigenous Knowledges
- **WoE:** Weight-of-Evidence
- **WQCIU:** Water and Sediment Quality Criteria for the Protection of Indigenous Use

Appendix I: Additional Sources Considered

This appendix includes references and links that were considered during the development of the source documents but are not directly cited in the main body of this report.

Regulatory Documents (Not directly cited in main body)

Many regulatory sources were reviewed and considered but not directly cited in the main body of this report despite their contribution to foundational knowledge (e.g., outdated and replaced government reports; selection of jurisdictions to include followed a prioritization process based on uniqueness, recency, and availability of source materials).

Academic & Grey Literature (Not directly cited in main body)

- Adams, D. A., O'Connor, J. S., & Weisberg, S. B. (1998). *Sediment quality of the NY/NJ Harbor System: An investigation under the Regional Environmental Monitoring and Assessment Program (R-EMAP)* (EPA/902-R-98-001). United States Environmental Protection Agency Region II, Division of Environmental Sciences Assessment.
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- Washington State Department of Ecology. (1991). *Sediment management standards. Washington Administrative Code. Chapter 173-204 WAC*.

Appendix J: TWG White Paper Review: What We Heard

1.0 Executive Summary

A review of the *Modernizing BC Sediment Quality Standards v2.5* draft report (the "White Paper") was completed by a 39+ member Technical Working Group (TWG) drawn from industry, consulting, government, academia, and Indigenous organizations.

Overall, the TWG's feedback was highly positive. The report was rated **"Excellent" or "Good"** for **Clarity, Completeness, and Defensibility** by a strong majority of reviewers. The proposed framework is seen as robust, comprehensive, and a long-overdue modernization of the standards.

Key synthesis of feedback and recommendations includes:

1. **Strengthen and Clarify Indigenous Integration:** While the *intent* to integrate Indigenous Knowledge (IK) is praised, TWG feedback indicates the *execution* is not yet fully supported. The report must be updated to:
    - Include the *policy rationale* for IK integration (e.g., UNDRIP, BC's DRIPA).
    - Clarify complex policy implications (e.g., vs. Health Canada's DQRA process for traditional foods).
    - Correct the structural error of listing First Nations as "Canadian Jurisdictions."
2. **Address Implementation Feasibility:** There are significant concerns about real-world implementation. The report *must* more explicitly address limited laboratory capacity for chronic toxicity testing, eDNA, and the need for method standardization for passive samplers.
3. **Improve Clarity and Readability:** The report suffers from repetition (especially in the Introduction) and a "ChatGPT feel" (per one review). A professional edit is needed to tighten the language and improve flow.
4. **Soften Declarative Language:** The report's definitive language ("will be implemented") is inappropriate and must be softened to reflect its role as a *recommendation* to ENV.
5. **Refine Scientific & Technical Details:** Reviewers provided excellent technical suggestions, including:
    - Strengthening the Introduction with more apex predator food-web citations.
    - Clarifying the distinction between an Environmental Quality Guideline (EQG) and a Risk Assessment (RA) framework.
    - Refining key terminology ("direct protection" -> "direct contact"; "anti-degradation" -> "background screening").
6. **Verification of Feedback Integration**: To ensure accountability, a dedicated volunteer editorial team manually revised the draft, followed by a rigorous, 5-cycle AI-assisted audit using Google's Antigravity IDE. This process verified that the specific feedback detailed in this appendix was authentically integrated into the final White Paper (v3.0).

This "What We Heard" report provides a detailed plan for revising the White Paper to address this valuable feedback.

2.0 Methodology

An online review form (the "TWG White Paper Review Form") was circulated to the TWG, who provided detailed feedback during:

- Phase 1 of the review (first five sections): October 8 to November 7, 2025; and
- Phase 2 of the review (last two sections and appendices): November 13 to December 1, 2025.

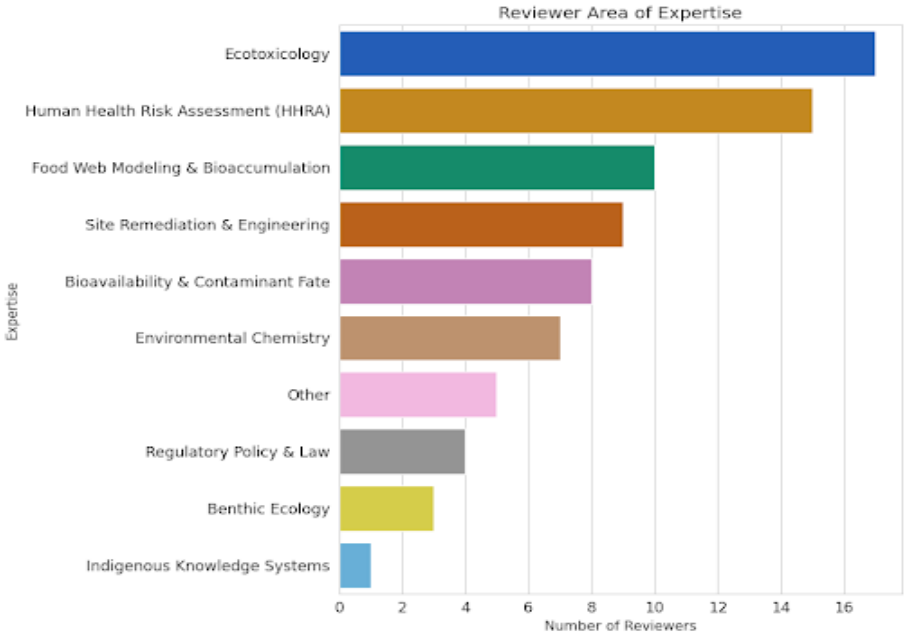
The review form included a mix of quantitative rating questions (e.g., multiple choice) and qualitative, open-ended questions for both high-level and section-specific comments. This report summarizes all 34 submissions. Quantitative data is presented in graphs, and qualitative feedback has been synthesized into key themes and actionable recommendations.

3.0 Quantitative Findings

Reviewer Profile and Overall Ratings

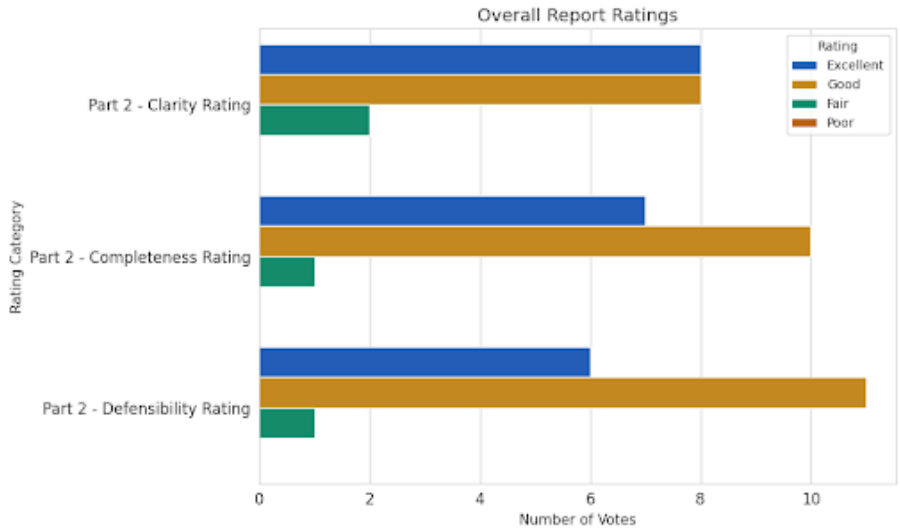
The review was conducted by a diverse group of 29 experts, with many identifying multiple areas of expertise. The primary areas were **Ecotoxicology**, **Ecological Risk Assessment (ERA)**, and **Environmental Chemistry**, ensuring a robust technical review.

Figure J-1 - Reviewer Area of Expertise



The report was rated highly for its core attributes. A combined **83%** of reviewers rated its **Clarity** as "Excellent" or "Good," **83%** for **Completeness**, and **78%** for **Defensibility**. This provides a strong mandate for the report's general approach and content.

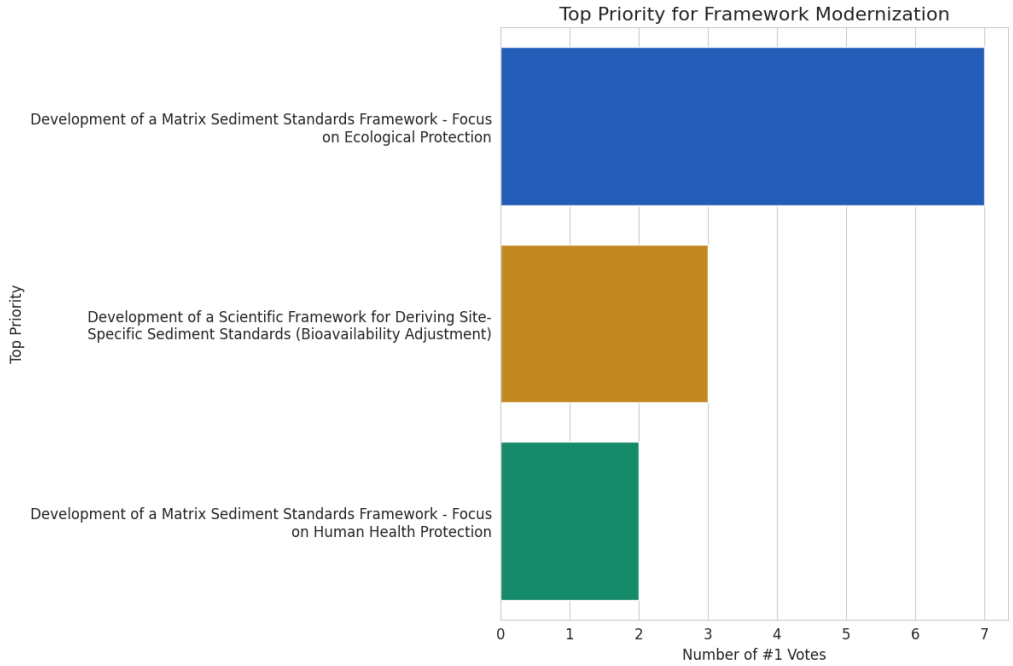
Figure J-2 - Overall Report Ratings



High-Level Strategic Priorities

TWG members were asked to rank their #1 priority for modernizing the framework. The results clearly show that the **Matrix Sediment Standards Framework (Ecological Protection)** is the top priority by a large margin, followed by a **framework for site-specific sediment standards** and **standards for Human Health Protection**.

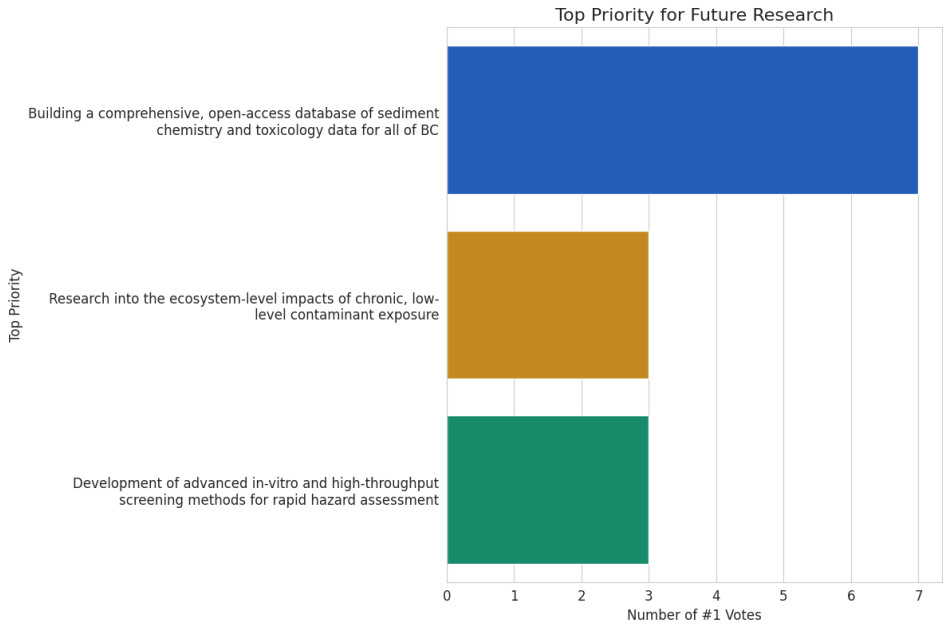
Figure J-3 - Top Priority for Framework Modernization



When asked to rank the #1 research priority, the top choice was **Building a comprehensive, open-access database** for BC, followed by research into **climate change impacts** on toxicity.

This strongly supports the "Phase 1: Desktop Data Compilation" proposed in Section VII.

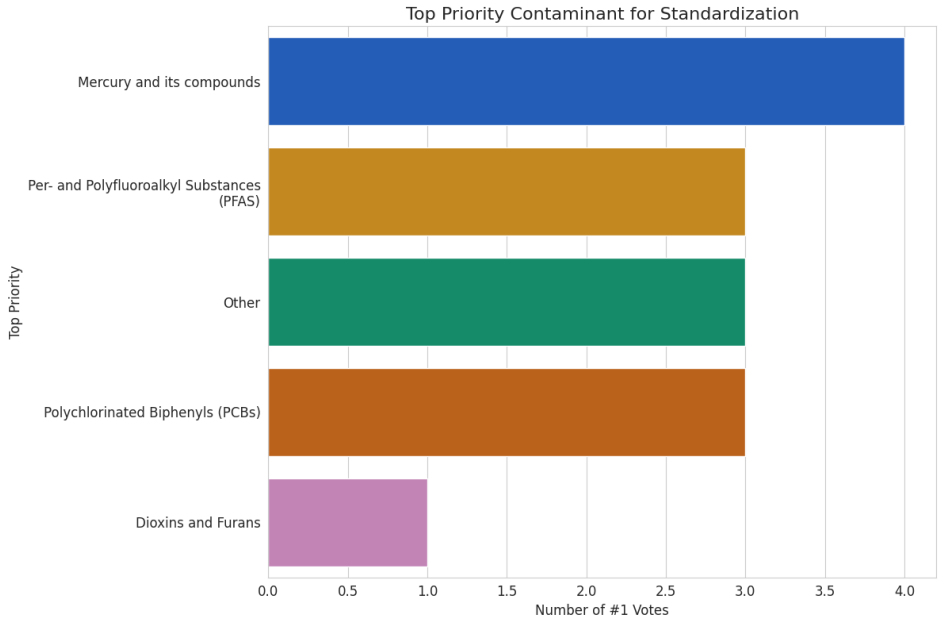
Figure J-4 - Top Priority for Future Research



Priorities for Specific Framework Components

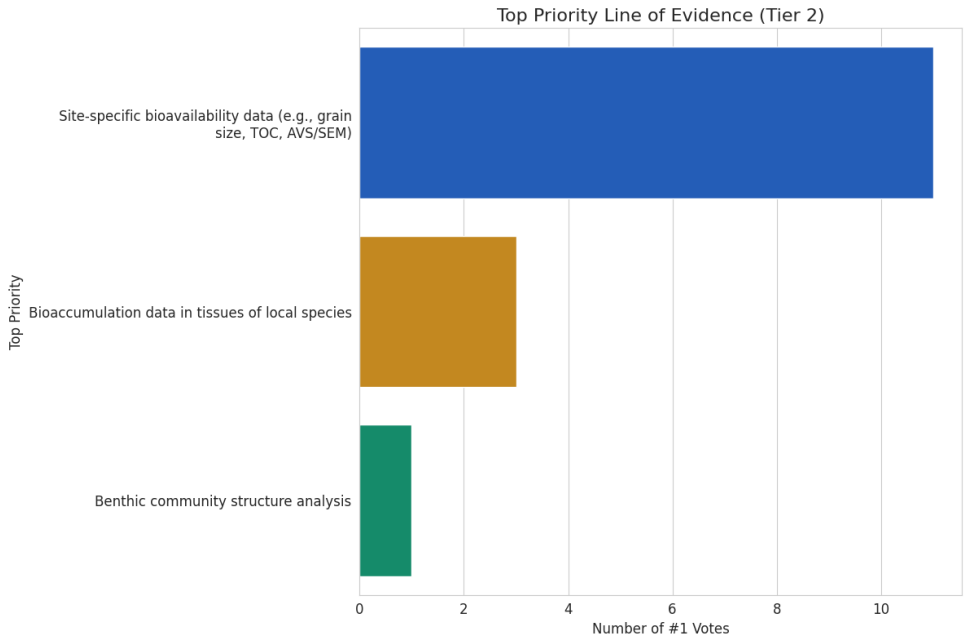
For developing matrix standards for protection of the food pathway, **Mercury and its compounds** and **PFAS** were the clear top priorities for the TWG.

Figure J-5 - Top Priority Contaminant for Standardization



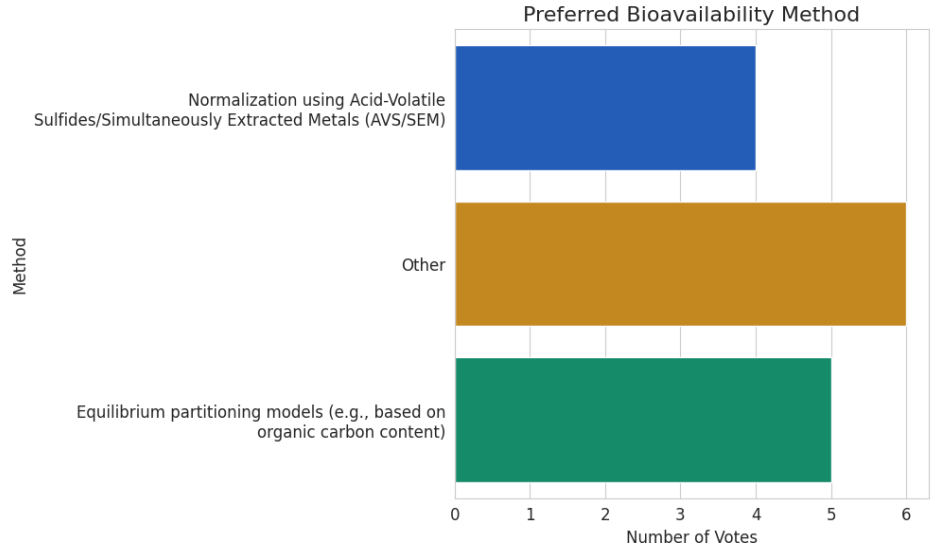
For developing Tier 2 guidance, **Bioavailability / Geochemical Adjustments (TOC, AVS/SEM)** was ranked as the top priority line of evidence to include.

Figure J-6 - Top Priority Line of Evidence (Tier 2)



Digging deeper into bioavailability, **Normalization using Total Organic Carbon (TOC)** was the most selected method by a wide margin.

Figure J-7 - Preferred Bioavailability Method

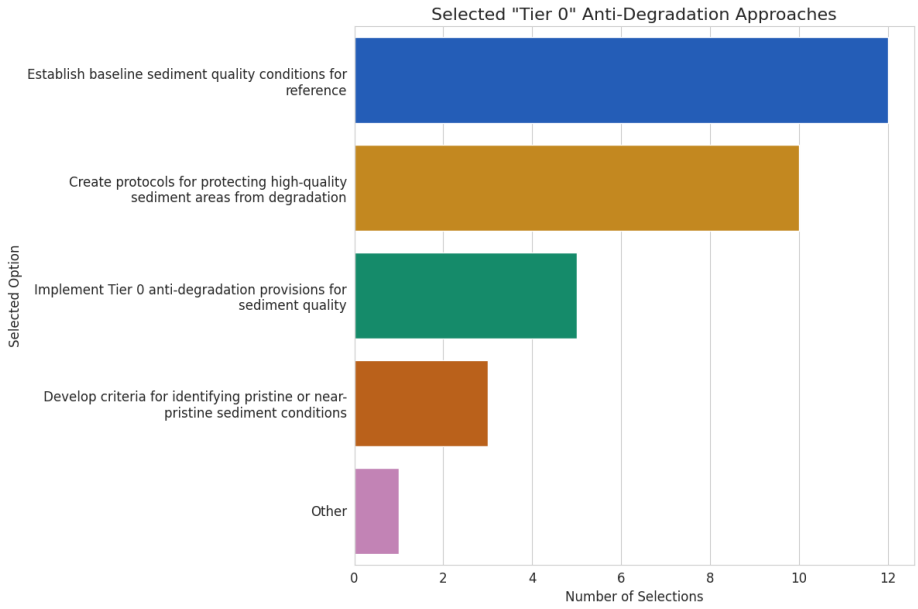


Selected Approaches for Key Initiatives

For the "Tier 0" (Background/Anti-Degradation) screening, the most selected approach was to

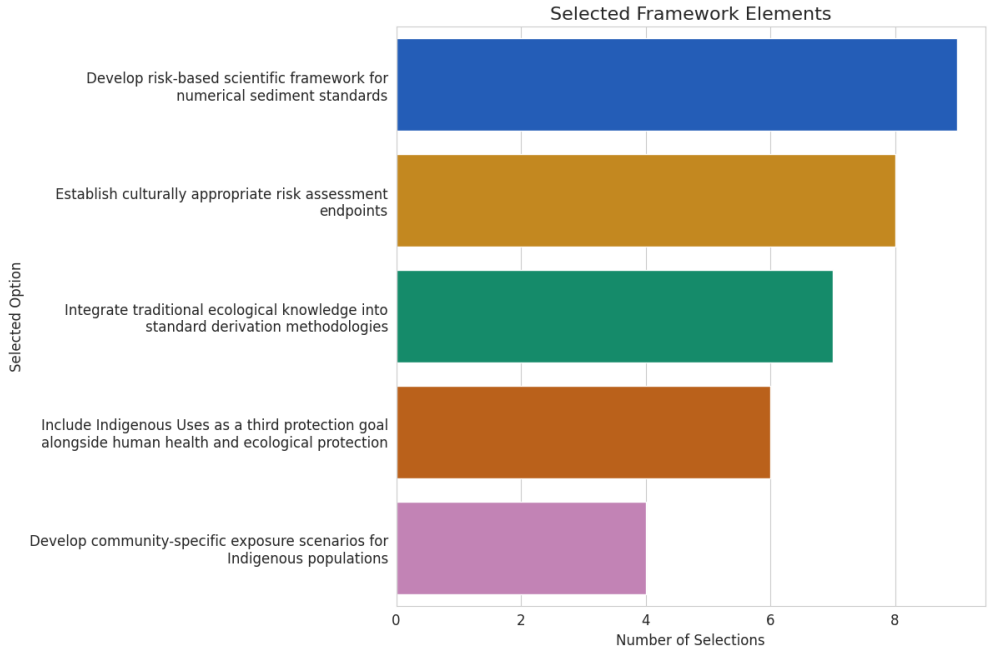
Establish baseline sediment quality conditions for reference.

Figure J-8 - Selected "Tier 0" Anti-Degradation Approaches



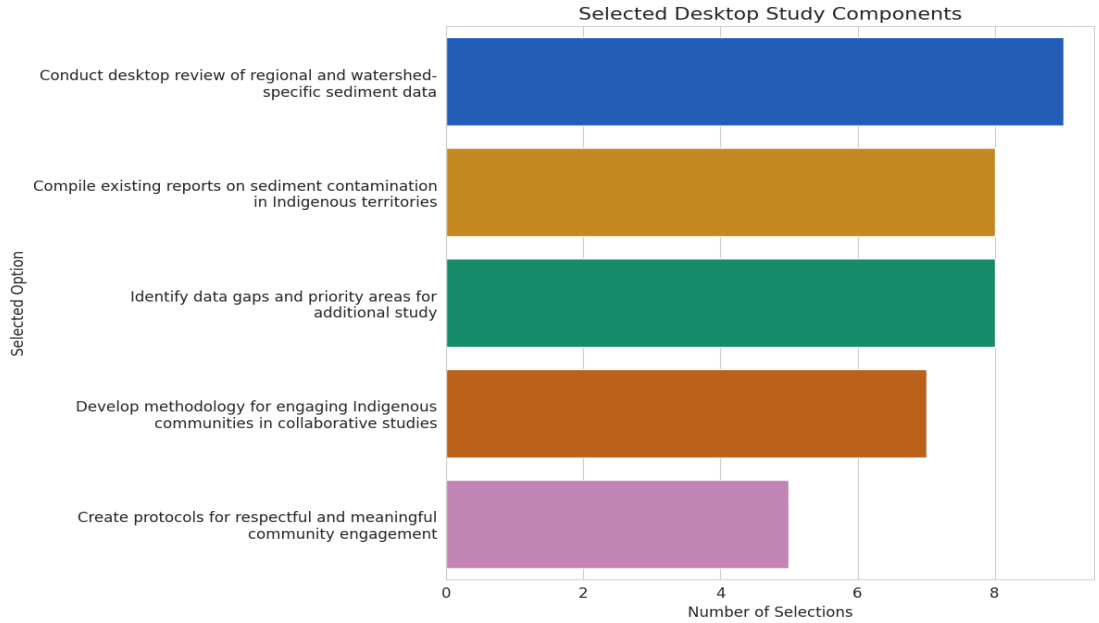
When asked what new elements should be added to the framework, **Develop risk-based scientific framework for numerical sediment standards** was the top-selected option, reinforcing the need for practical implementation tools.

Figure J-9 - Selected Framework Elements



For the proposed desktop data study, the TWG's top-selected components were to **Conduct desktop review of regional and watershed-specific sediment data**, **Compile existing reports on sediment contamination in Indigenous territories**, and **identify data gaps and priority areas for additional study**, highlighting a clear link between the data-gap and reconciliation priorities.

Figure J-10 - Selected Desktop Study Components



4.0 Detailed Qualitative Feedback & Synthesis

The qualitative feedback was extensive and highly constructive. The following is a synthesis of key themes from all open-ended comments.

4.1 Overall Report Structure and Clarity

- **The Good:** The report is "excellent and covers all the main points," "well thought out," and a "long-overdue" effort.
- **The Bad:** Several reviewers noted significant **repetition** in the Introduction (Sections I.A, I.B, I.C). The language was also described as having a "ChatGPT feel" and would benefit from a "strong edit" to be more concise.

4.2 Integration of Indigenous Knowledge (IK)

This was a major theme across multiple reviews.

- **Gap in Rationale:** Reviewers noted that the report states *what* it will do (integrate IK) but not *why*. It's missing the critical policy and legal rationale (e.g., **BC's DRIPA, UNDRIP**, and the creation of Dr. Shannon Waters' PHO position).
- **Overstated Claims:** One reviewer felt the **Executive Summary overstates the integration of IK**, noting the rest of the document doesn't yet support this strong claim.

- **Policy & Jurisdictional Questions:** A key policy question was raised about how the proposal to include Indigenous traditional food consumption in provincial standards will align or conflict with **Health Canada's guidance**, which typically requires a separate, detailed quantitative risk assessment (DQRA).
- **Structural Error:** A critical error was identified: **"First Nations are not 'Canadian Jurisdictions'"** and must be moved out of Section III.B.

4.3 Implementation, Feasibility and Laboratory Capacity

This was the most prominent technical concern, led by feedback from laboratory experts.

- **Laboratory Capacity:** The report is **too optimistic** about current lab capabilities. A reviewer explicitly stated that **"Current laboratory capacity for chronic toxicity testing is limited, especially in BC."**
- **Method Standardization:** The report must more strongly emphasize the need for standardization. The same reviewer noted that **"Passive sampling... [is] not a widely used analytical technique for regulatory purposes"** and that **"eDNA... results tended to vary widely"** between labs. This poses a "lab shopping" risk.

4.4 Scientific Framework & Risk Assessment

- **EQG vs. RA:** A key clarification is needed to define when the report is discussing **Environmental Quality Guidelines (EQGs)** (i.e., Tier 1 numbers) versus a **Risk Assessment (RA)** framework (i.e., Tiers 2/3).
- **Strengthen Rationale:** The report's rationale for food-web transfer is good but can be much stronger. One reviewer provided a list of **specific peer-reviewed papers (e.g., Alava et al., McTavish et al.)** to add to Section I.B to better support the risks to apex predators in BC.
- **Acknowledge Uncertainty:** A reviewer noted that the report should acknowledge the **limitations of SSDs**, which can lose the uncertainty data from the original NOEC/LOEC studies.

4.5 Summary of Key Revisions Based on Feedback

Following the review period, the project’s editorial team, comprised of three TWG members (**Joline Widmeyer, Lindsay Du Gas,** and **Jennifer Trowell**) and the SSTAC Co-Chair (**Jasen Nelson**), analyzed over 730 individual points of feedback, including detailed technical edits, strategic rankings, and scientific recommendations. Table J-1 below summarizes how the primary themes of feedback were integrated into the final version (v3.0) of this White Paper.

Table J-1. Summary of Key Feedback Themes and Resulting Revisions

Feedback Theme	Summary of Reviewer Input	Action Taken in Final Report
Indigenous Rights & Knowledge	Reviewers emphasized that First Nations are rights holders, not stakeholders, and should not be listed under "Canadian Jurisdictions." Several noted that while the intent to integrate Indigenous Knowledge is positive, the policy rationale (e.g., DRIPA) was missing.	• **Restructured Section III:** Created a distinct "Indigenous-led Frameworks" section separate from government jurisdictions. • **Updated Terminology:** Explicitly distinguished between stakeholders and rights holders in Section IV. • **Added Deliverable:** Added "Indigenous Engagement Support" to Phase 2 (Section VII B) to develop a respectful engagement strategy.
Laboratory Feasibility	Representatives from the laboratory sector noted that capacity for chronic toxicity testing, eDNA, and passive sampling is currently limited in BC. Concerns were raised about method standardization to prevent data inconsistency.	• **Added Section V.C:** A new section on "Laboratory Capabilities" was added, acknowledging these limitations. • **Updated Priorities:** Emphasized that standardized methods and performance objectives must be co-developed with laboratories (e.g., via BCELTAC) before advanced tools are mandated.
Framework Terminology	Multiple reviewers found the terms "Dual Standards" and "Anti-Degradation" potentially confusing or inconsistent with existing CSR language.	• **Renamed Framework:** Shifted from "Dual Standards" to **"Matrix Sediment Standards"** to align with existing soil standards concepts. • **Refined Tier 0:** Clarified "Anti-Degradation" as "Background and Current Condition Screening" to avoid regulatory ambiguity.

Feedback Theme	Summary of Reviewer Input	Action Taken in Final Report
Strategic Implementation	There was a strong consensus that a "Comprehensive Overhaul" (Option 3) was high-risk due to resource constraints. Experts recommended a phased approach that prioritizes data gathering to prevent "regulatory shock."	• **Adopted "Smart Stagger":** The roadmap in Section VII was revised to prioritize the **Data Compilation Project** and **Study Design** in 2026 (Option 1/2 Hybrid). • **Clarified Timelines:** Specific deliverables were assigned to 2026 vs. 2027+ to show a realistic path forward.
Technical Derivation	Experts noted that while the food-web rationale is sound, the "equilibrium partitioning" (EqP) method is older. Reviewers suggested emphasizing modern probabilistic models (e.g., SSDs) and tissue-residue approaches.	• **Updated Section VI:** The "Scientific Approaches" section was refined to prioritize **Species Sensitivity Distributions (SSDs)** for direct toxicity and **Tissue Residue Guidelines (TRGs)** for food web protection. • **Data Gap Acknowledgement:** Added text acknowledging that updated derivation methods require a robust new BC-specific dataset.

5.0 Feedback Integration and Verification Process

To ensure the final White Paper (v3.0) accurately reflects the consensus and technical expertise of the TWG, a rigorous two-stage revision and verification process was undertaken following the review period.

5.1 Manual Expert Revision

The project's editorial team conducted a comprehensive review of the 29 submission datasets with over 730 points of feedback. This team manually revised the draft report (v2.5) to address the scientific, strategic, and structural recommendations summarized in this appendix. This involved rewriting key sections to improve clarity, correcting policy interpretations regarding Indigenous jurisdiction, and refining technical definitions to align with current scientific literature.

5.2 AI-Assisted Compliance Audit

To verify the completeness of these revisions, a sophisticated auditing process was deployed using Google's Antigravity, an AI-powered platform that enables autonomous agentic workflows.

- **Methodology:** A specialized "Compliance Auditor" prompt was executed to systematically compare the raw feedback from the TWG (via CSV submissions) against the text of the revised White Paper (v3.0).
- **Process:** The audit was conducted over five separate iteration cycles. In each cycle, the system flagged specific reviewer comments that had not yet been fully addressed. The editorial team then surgically applied edits to resolve these flags before re-running the audit.
- **Outcome:** A **Combined Audit Report** was generated to document this verification process. This report confirmed that actionable feedback across all 12 report sections, ranging from the Executive Summary to specific technical appendices, had been successfully integrated. *(Note: The detailed Audit Report is held on file by the SSTAC and is available upon request)*

This dual-layer process, human expert revision followed by systematic AI verification, ensures that this White Paper is not merely a proposal from the SSTAC, but a validated reflection of the collective expertise of the Technical Working Group.