NATURAL SOLUTIONS INITIATIVE

WATERSHED HEALTH AND RESILIENCE INDICATORS

Strengthening Indigenous Co-Governance and Low Carbon Resilience in Canada's Watersheds

MAY 2025

SFU ACT Action on Climate Team

ACT'S NATURAL SOLUTIONS INITIATIVE

VISION:

The Natural Solutions Initiative (NSI) aims to mobilize nature-based solutions (NbS) as crucial opportunities in the transition toward just, low carbon resilient, and sustainable communities and regions.

MISSION:

The goal of the NSI is to co-create and advance a cohesive and systemic framework-for-action that optimizes the benefits of NbS for both people and nature in a rapidly changing climate.

ACT – Action on Climate Team at Simon Fraser University is a state-of-the-art research-to-practice hub for climate change and sustainability solutions. We work across sectors to mobilize relevant knowledge for practice. We do this by advancing public and private sector partnerships, coordinating and co-creating leading-edge research for practice and mobilizing policy relevant knowledge to help us all go further faster on climate and sustainability action.

RECOMMENDED CITATION

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TABLE OF CONTENTS

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BACKGROUND

Nature-based solutions (NbS) are a crucial low carbon resilience (LCR) strategy. NbS are “actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems” (UNEP, 2022).[1] NbS have the potential to address social, economic and environmental challenges effectively and adaptively, while simultaneously providing ecosystem services, human well-being, and resilience and biodiversity benefits. NbS include a suite of types and approaches that can be used to build resilience against projected climate risks and sequester carbon, all while multi-solving across other key societal challenges.

Recent climate changes have accelerated interest in and uptake of NbS as strategies to address both climate impacts and carbon sequestration, while also multi-solving across ecosystem and community health benefits. This interest is generally positive, however NbS applications tend to be developed for singular outcomes, and are often siloed across diverse disciplinary and practitioner mandates (ranging from engineering, to planning, asset management and ecology). In this way, NbS plans and projects can miss crucial opportunities to synergize goals and outcomes in support of multiple community and ecological objectives and benefits.

Moreover, Indigenous Peoples have been practicing NbS on their territories from time immemorial, yet Indigenous Knowledge systems and rights are rarely considered in NbS planning. Indeed, current NbS planning and approaches have the potential to infringe on Indigenous self-determination[2]; and "how NbS are developed, on whose territories, and with what outcomes matter deeply to the success of climate change policy as well as to the rights of Indigenous Peoples".[3]

Perspectives of Indigenous Peoples counter the separation of humans and nature often embedded in mainstream NbS frameworks, instead emphasizing the interconnectedness, relationships, and reciprocity embodied in the concept of “All My Relations.” This worldview enhances NbS by grounding them in a relational ethic that sees humans, land, and water as inseparable parts of a living whole.[2] ACT strives to weave together Western and Indigenous Knowledge systems by centering holistic NbS across approaches, scales, and areas, and by supporting co-creation of NbS.

This resource points to a strategic and timely opportunity to link place-based Indigenous Knowledge systems and practices with ecosystem-based monitoring and management at the watershed scale. Comparing nine western and seven Indigenous-led watershed assessment frameworks to better understand indicators used to evaluate watershed health, can help to advance more holistic and place-based understanding of NbS that support health and resilience in Canada’s watersheds. It illustrates how Indigenous Knowledge systems and co-governance arrangements can support timely place-based strategies for ensuring the resilience of the ecological, cultural, and societal benefits that flow from healthy and resilient watersheds to communities.[4-7] Legislation is currently being put in place in British Columbia to support co-governance and collaborative approaches to watershed stewardship, a summary of relevant legislative frameworks and strategic initiatives is provided under Appendix C.

This is part of a series of ACT's Natural Solutions Initiative (NSI) resources and tools intended to support practitioners and decision-makers as they advance NbS.[4] ACT's NSI aims to develop more cohesive and systemic approaches for NbS planning and implementation by overcoming disconnected disciplinary and practitioner approaches, ad hoc planning, and narrow applications of NbS projects. The NSI's goal is to create and test a framework-for-action that optimizes NbS benefits for both people and nature.

The following table summarizes ACT's framework-for-action, situating NbS planning and projects within a rubric of three nested, and commonly used, NbS approaches, four scales of NbS action, and with co-benefits that cross five key areas.

Table 1: The NSI Framework-for-Action[4]

Three Nested NbS Approaches *Build coherence*	**Four Scales of NbS Action** *Promote cohesion*	**Five Key NbS Areas** *Advance systemic NbS*
• Ecosystem-based management • Natural asset management • Blue-green infrastructure strategies	• Watershed • Community • Neighbourhood • Parcel	• Climate action (adaptation and mitigation) • Biodiversity • Indigenous Knowledge systems and leadership • Sustainable service delivery • Health, equity and justice

INTRODUCTION

Climate change is disrupting weather patterns, food and water sources, biodiversity and overall ecosystem health and resilience in watersheds across Canada.[8,9] Warmer temperatures pose long-term risks to water supply and water quality, threatening ecological processes and biodiversity.[8,9] Greater precipitation and earlier freshets pose challenges for managing stormwater and flood[9,10] and seasonal variability and extreme weather put stress on ecosystem dynamics, changing blooming, feeding, and migration times. All of these changes are also impacting place-based Indigenous Knowledge systems and practices, including hunting, fishing and gathering.[11]

Conventional watershed management approaches have a history of operating "as a set of separate, siloed tasks undertaken by different tiers" of government and sectors of society.[12,13] This approach to watershed management has been predominantly human-centric with a focus on ecosystem service benefits for communities.[14] Existing watershed health indicator (WHI) frameworks in Canada in theory align with integrated watershed monitoring and management approaches, holistically prioritizing environment, economy, and social considerations, but tend to focus on technical perspectives **about what can be measured**, **rather than what should be measured to best support ecosystem health and resilience**. As a result, these approaches tend to fall short when upholding Indigenous Knowledge systems and place-based interpretations of watershed health.

Indigenous Knowledge systems and/or Traditional Ecological Knowledge approaches are holistic by nature,[14] often derived with the purpose of stewarding ecosystem structure and function while providing resources to the local community.[15] Indigenous Knowledge systems do not see nature as separate from themselves and their communities,[16] but hold relationality with other species and systems, ensuring that healthy ecosystems lead to healthy people and communities and vice versa (the reciprocal connection between humans and nature). This ensures that knowledge systems are adaptive to changing conditions. Learning about stewardship from place-based worldviews is foundational for developing holistic NbS approaches that support overall health *and* resilience of watershed ecosystems and communities over time.

Understanding both the health and resilience of the watersheds upon which all communities depend is crucial, particularly under rapidly changing environmental and climate conditions. Yet conventional watershed monitoring and management face multiple challenges, and current efforts are not effectively supporting watershed health and resilience. Notable barriers to advancing watershed monitoring and management within existing structures include:

- limited institutional mandates (e.g., oversight)[4,17,18]
- jurisdictional fragmentation and regulatory silos[4,17,18];
- competing interests and goals among partners and overlapping unsustainable practices[4,17,18]
- limited interest in participating within current frameworks[15,19-21];
- the challenge of integrating multiple worldviews and principles outlined in international frameworks, such as United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)[19,20]; and

- lack of commitment, resources and co-governance structures to support Bands and Nations to effectively lead prolonged collaborative watershed management efforts and long-term monitoring horizons.[15,17,19-22]

Ecosystem-based monitoring at the watershed scale is crucial both to support the current health of the watershed and to adaptively manage ecosystem resilience under changing conditions. Identifying ecosystem-based indicators aids resource managers in understanding ecosystem health, and guides protection and restoration efforts by monitoring changes and responses to management actions.[6] WHIs are used as a tool to gain insight into the changing health or state of the local watershed, helping to "simplify an inherently complicated system" through the identification and long-term monitoring of datasets necessary for documenting and comparing watershed health over time.[5,6,7] They allow for the setting of accurate baselines, continuous trend monitoring, and targeted evaluation of conservation and response strategies across diverse ecosystems and geographical locations.[23]

Emphasizing holistic watershed health indicators has the potential to improve knowledge exchange, reduce duplication of effort and foster shared responsibility using adaptive management approaches.[15,24-26] While watershed health is discussed in current frameworks, watershed resilience indicators are also needed to identify changes and trends in watersheds over time in order to more proactively adapt to and recover from disturbances.[27] Indicator selection varies depending on the objectives and/or outcomes sought. Indigenous worldviews and place-based knowledge systems offer vital inputs to establish ecosystem and eco-cultural indicators and baselines, while also monitoring change and promoting adaptive management approaches. These efforts are particularly important as the climate changes, to develop shared understanding of key indicators needed to both monitor health and build resilience in watershed eco-cultural systems over time. It is therefore crucial to have the right partners and knowledge systems involved in the process of watershed health indicator selection.

METHODOLOGY

Indicators collected from 16 North American frameworks are reviewed, these frameworks were created by Indigenous or western authors, or through co-creative efforts. These frameworks include 12 provincial or territorial frameworks, two frameworks spanning multiple provinces, one Canada-wide framework, and one United States framework. The frameworks were identified by applying key word searches and were each developed within the past 15 years to reflect recent watershed health assessment practices. Each framework includes distinct WHIs employed to monitor, track and assess the current state of the target watershed. Nine of the frameworks considered were either Indigenous or co-created (see Appendix A for a breakdown of all 16 WHI frameworks). This report is part of a broader thesis project and the NSI. For more information, including detailed methodology and findings, please refer to Andrew Palmer's thesis: **Assessing watershed health indicators: Strengthening Indigenous co-governance and embracing climate adaptation in support of watershed resilience**.[28]

WATERSHED HEALTH AND RESILIENCE INDICATORS

NINE INDICATOR CATEGORIES TO MONITOR WATERSHED HEALTH AND RESILIENCE

Sixteen watershed health indicators (WHI) frameworks were analyzed, including seven Indigenous-led frameworks and nine western frameworks. The indicators and monitoring objectives from these frameworks were clustered into nine watershed health and resilience indicator categories. Box 1 provides descriptions of the indicator categories and examples of indicators used to reflect key monitoring goals related to water quality, land-use, climate change, biodiversity and others. Key process (e.g. storytelling) and bio-cultural (e.g., changes in wind) indicators were used to identify whether and how Indigenous Knowledge systems and leadership were part of WHI identification and the framework development process. The assumption here is that appropriately holistic WHI and resilience frameworks would support indicators across all nine categories.

BOX 1: NINE INDICATOR CATEGORIES FOR MONITORING WATERSHED HEALTH AND RESILIENCE

INDIGENOUS KNOWLEDGE SYSTEMS AND LEADERSHIP: The multifaceted knowledge systems and practices of Indigenous Peoples and place-based indicators used to steward the lands and territorial systems over thousands of years. *Example: changes in wind direction, storytelling and animal ethics*.

BIODIVERSITY: The variety of species within a watershed, including species abundance and richness, ecosystem diversity, and habitat quality and quantity, which contribute to ecological stability and resilience against environmental changes. *Example: species intactness, species population size and structure, fragmentation, disease, etc.*

CLIMATE CHANGE: Historical, current, and projected climate change impacts on watershed systems in the short- and long-term. *Example: temperature changes, precipitation changes, hydrological changes, extreme weather events, etc.*

COMMUNITY AND HEALTH: Human-centred measures of well-being within the watershed. *Example: physical and mental health, civic engagement, etc.*

ECONOMY: The impacts of economic activities and/or benefits derived from watershed resources. *Example: gross domestic product (GDP) by industry, labour force participation rate, ecotourism etc.*

LAND USE AND CONDITION: The land use patterns and their changes and impacts on watershed health and resilience. *Example: land use and land cover change, riparian connectivity, etc.*

WATER QUALITY: The chemical, physical, and biological characteristics of water within the watershed. *Example: total suspended solids, odor, dissolved oxygen, e. coli, etc.*

WATER QUANTITY AND SECURITY: The availability and reliability of water resources. *Example: long-term trends in water flows and levels, groundwater allocation, licensed allocations, etc.*

ECOLOGICAL SERVICES AND USE: The derived human-centred benefits from watershed ecosystems. *Example: Drinking water, fishing, shellfish harvesting, etc.*

DISTRIBUTION OF WATERSHED HEALTH AND RESILIENCE INDICATORS ACROSS 16 WHI FRAMEWORKS

As mentioned above, it is assumed that holistic watershed health and resilience indicator frameworks would include indicators to monitor across all nine indicator categories. Table 2 below provides a snapshot of the sixteen WHI frameworks and their locations, showing the distribution of indicators across the nine indicator categories. A frequency analysis of watershed health indicators shows similarities, differences and gaps across WHI frameworks, and the different priorities placed on watershed health and resilience indicator categories by location. Three key observations can be made from Table 2.

1. **Indicators of biodiversity (27%) and water quality (25%) are the most frequently cited indicator categories across all WHI frameworks.**
    - The Northwest Territories framework places most emphasis on biodiversity (60%) and water quality (30%) indicators. The US national framework places equal emphasis on both categories (33%), and the Yukon framework heavily prioritizes water quality (82%).
2. **The three frameworks located in Western Canada are the only frameworks to include indicators across all nine categories.**
    - Frameworks in Alberta and British Columbia contained indicators across eight and seven of the nine categories, respectively.
3. **Some WHI frameworks prioritize certain indicator categories above others.;**
    - For example, Indigenous Knowledge systems and leadership are prioritized in Nunavut frameworks (100%), water quality is prioritized in Yukon frameworks (82%), and biodiversity is prioritized in Northwest Territories frameworks (60%).

Table 2: Snapshot Distribution of Watershed Health and Resilience Indicators by Location

Location of WHI Frameworks	Number of Frameworks per Location	Watershed Health Category								
Alberta	2	0%	9%	6%	22%	6%	22%	13%	19%	3%
British Columbia	2	0%	37%	4%	7%	0%	26%	15%	7%	4%
Canada-wide	1	0%	42%	0%	0%	0%	0%	25%	33%	0%
Northwest Territories	1	0%	60%	5%	0%	0%	0%	30%	5%	0%
Ontario	4	0%	25%	15%	0%	0%	16%	39%	3%	2%
Nunavut	1	100%	0%	0%	0%	0%	0%	0%	0%	0%
Yukon	1	18%	0%	0%	0%	0%	0%	82%	0%	0%
Western Canada*	3	16%	26%	19%	12%	2%	5%	5%	9%	7%
United States of America	1	0%	33%	0%	0%	0%	17%	33%	17%	0%
Grand Total	**16**	**5%**	**27%**	**10%**	**6%**	**1%**	**13%**	**25%**	**10%**	**3%**

* Western Canada = includes a common WHI framework for five provinces and territories including British Columbia, Yukon, Northwest Territories, Saskatchewan and Alberta

It may also be observed that across all frameworks, less emphasis is placed on indicator categories related to land-use and condition (13%), water quantity and security (10%), and climate change (10%). In addition, while most frameworks have at least a few indicators for water quantity and security, only half have indicators for climate change. Monitoring these categories, which represent stressors and trends in our watersheds, are helpful for identifying both gradual and dynamic changes to watershed health over time. This is important for ensuring proactive responses that maintain and restore watershed resilience under changing conditions.

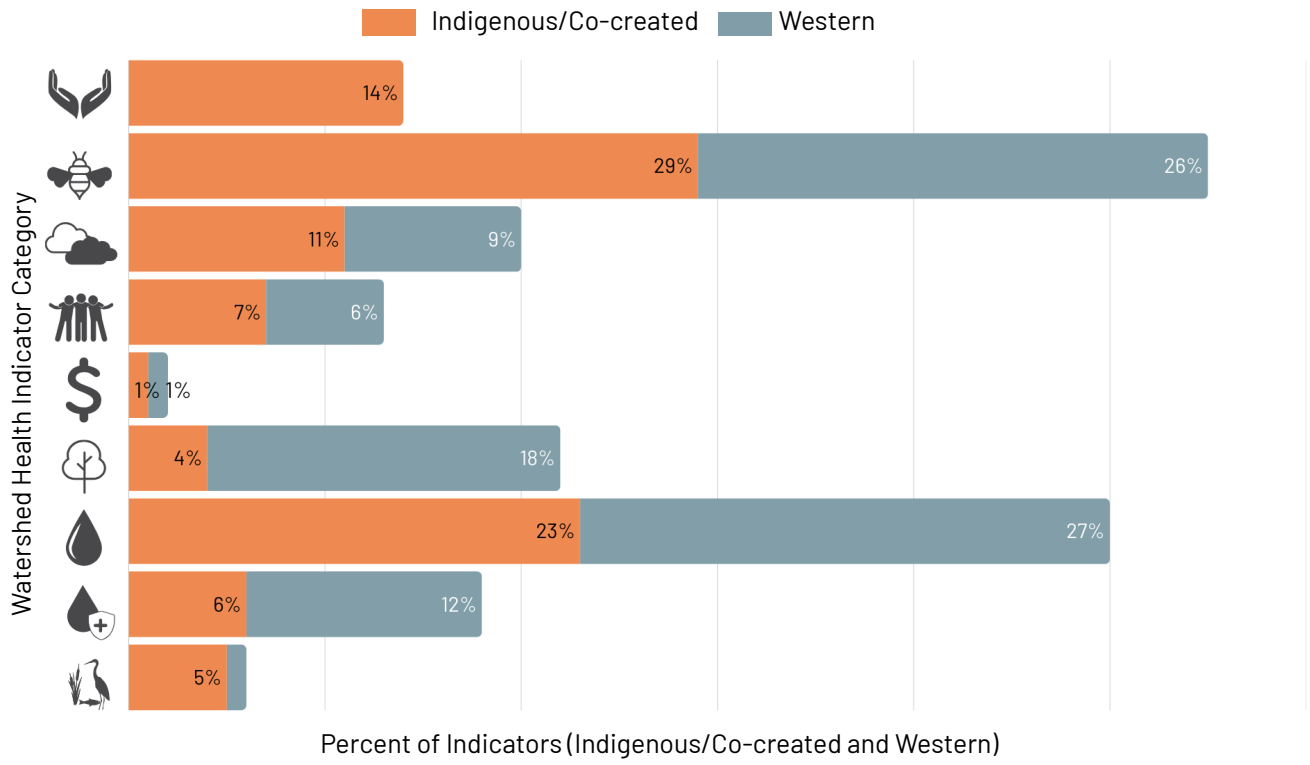
While few frameworks consider indicator categories for community and health (6%) and ecological services and use (3%), these indicator categories tend to monitor the downstream benefits and services that support the health of our communities. Not including this indicator category misses key opportunities to care for the interconnectedness between watershed health and community health and well-being.

A notable gap across all but three frameworks is the absence of indicators of Indigenous Knowledge systems and Leadership. Only WHI frameworks from the Yukon (18%), Western Canada (16%) and Nunavut (100%) include indicators in this category. The Clyde River Inuit (Nunavut) WHI framework focuses entirely on Indigenous Knowledge systems and leadership and highlights the interconnectedness between worldview, cultural knowledge, and watershed health and resilience.[28] In other words, in Nunavut Indigenous worldview, stewardship practices exist in support of, and are inseparable from, the health of the watershed ecosystem.

DISTRIBUTION OF WATERSHED HEALTH AND RESILIENCE INDICATORS BY WORLDVIEW

By comparing the distribution of western and Indigenous and/or co-created WHI frameworks across all nine indicator categories, we can see similarities and differences in indicator priorities based on worldview. Figure 1 showcases the percentage of indicators associated with all nine categories western (blue) and Indigenous/co-created WHI frameworks (orange).

Figure 1: Distribution of Indicators based on Western and Indigenous/Co-created Worldviews



There are similarities and shared priorities of note between Indigenous/co-created and western frameworks. **Biodiversity** and **water quality** have primacy in both worldviews, illustrated by the number of indicators, 29%/26% and 23%/27% respectively, in these categories and the relative balance across worldviews. Though, less frequently cited, **climate change and community and health** have multiple indicators which are also evenly distributed across both worldviews. Economy was the least cited indicator category across both worldviews, accounting for only 1% of total indicators across all frameworks.

In regard to differences of note, **land use and condition** indicators in western frameworks far outnumber those in Indigenous framework indicators such as land use types (e.g., agricultural land use) and

patterns (e.g., linear development) emphasize external stressors to the land, whereas Indigenous Knowledge systems do not distinguish communities from nature or externalize the land.[11] The emphasis on **Indigenous Knowledge systems and Leadership** in Indigenous and co-created frameworks reflects this interconnected worldview, which may contribute to the differences in focus across other indicator categories. In addition, western WHI frameworks identify approximately twice as many **water quantity and security** indicators as compared to Indigenous and co-created frameworks.

It is important to note that the characteristics of indicators used across the nine categories vary depending on worldview. Western frameworks tend to focus on measurable and quantitative indicators while indicators sourced from Indigenous led/co-created frameworks tend to reflect more qualitative, **culturally-informed** indicators. Table 3 provides a snapshot comparing indicators from western and Indigenous-led/co-created frameworks across the nine indicator categories. For more detailed examples across all nine indicator categories, see Appendix B.

Table 3: Sample Distribution of Watershed Health and Resilience Indicators

Watershed Health Indicator Category	Indigenous/ Co-created WHIs	Unit or Scale of Measurement	Western WHIs	Unit or Scale of Measurement
Indigenous Knowledge Systems and Leadership	What about the future?	• Documenting traditional and evolving systems for knowledge transfer • Developing policy and water related climate adaptation strategies		
	Storytelling	• Frequency of storytelling, e.g. we use storytelling more (in)frequently now to share our beliefs than in the past because of changes to the delta.		
Biodiversity	Texture (Fish)	• Index Biological Integrity - Fish Health	Fish Populations	Reduced length of open season, minimum size limits, fish stocking
	Smell (Fish)	• Do the fish smell funny? Do the fish smell like diesel?	Fragmentation	Extent of natural area (ha), number of patches or patch area
Climate Change	Is it safe to travel?	• Impact to seasonal travel	Temperature Changes	Seasonal mean change of daily maximum temperatures (e.g., HDD, CDD)
	Ice thickness	• Is ice thickness decreasing? Are winter temperatures warming?	Winter Ice	Ice-on and ice-off dates since 1975
Community and Health	How healthy are we?	• Access to natural food sources versus expensive and less nutritious store-bought food	Chronic Diseases or Conditions	Diabetes, Hypertension, COPD
	What about the youth?	• Youth engagement and learning, youth concerns for the future	Mental Health	Self-perceived mental health and sense
Economy	Ecotourism	• Changes over time e.g., there is more/the same/ less ecotourism now than in the past because of changes in the delta	Economic Development	GDP by industry, businesses incorporated

Watershed Health Indicator Category (cont.)	Indigenous/ Co-created WHIs (cont.)	Unit or Scale of Measurement (cont.)	Western WHIs (cont.)	Unit or Scale of Measurement (cont.)
Land Use and Condition	Hydro Development	• Impacts to water, access to healthy fish, animal harvest changes, impacts to spirituality and culture	Riparian Health	Riparian Health Assessment
	Land Use	• Stories and oral histories of land use, maps and statistics	Land Use	Agricultural land use, land development, zoning changes
Water Quality	Colour of Water and Clearness	• Has the colour or clearness of the water changed? Is the water dark, murky, dirty or yellow?	Water related advisories	Algae, fecal coliform, drinking water
	Makes good tea	• Water should make red tea. Bad water makes black tea that leaves stains in your cup.	Water Quality	River water quality index, tributary stream quality
Water Quantity and Security	Water Levels (Qualitative Observations)	• Are water levels declining in rivers, lakes and streams? Are there new sandbars/islands appearing in the rivers? Are certain traditional areas difficult to access?	Water Quantity	Water usage, water flow and availability
	Water Flow	• Changes over time e.g., There is less/the same/ more water flow now than there was in the past	Pattern of surface flows (rivers, lakes, wetlands)	Flow magnitude and variability and water level fluctuations in wetlands and lakes
Ecological Services and Use	Can I eat the fish?	• Is the fish flesh soft? Does the fish have parasites? Is the fish skinny? What is upstream? Are there changes to the land and water that could affect fish health?	Ecosystem Services	Value of Ecosystem Services
	Can I drink the water?	• Is the water colourless and clear? How does the water taste? Are there animals nearby? Are there known contaminants?	Ecological Integrity	TBD (see rationale in **Muskoka Watershed Report Card, 2023**)

A few observations suggest that western WHIs for **biodiversity** tend to focus on quantitative metrics like species richness and abundance, while Indigenous WHIs focus on species health using culturally-informed indicators such the health of harvesting areas and fish characteristics, such as fish smell and/or gill colour. Similarly, western worldviews use quantitative methods, for example western **water quality** indicators measure pollutants and pathogens and focus on meeting thresholds for regulatory compliance, whereas Indigenous and co-created WHIs use experiential assessments, like water suitability for cultural practices such as tea-making and taste (see Appendix B for more detailed examples).

Western **climate change** indicators typically focus on measurable/quantifiable variables like temperature and precipitation changes, which are often used to assess environmental shifts in land, water, and air quality. In contrast, Indigenous indicators reflect a more holistic worldview, where culture, perception, behavior and territory are seen as integrated. These indicators often emphasize shared adaptive experiences, such as the need for safe travel conditions, which are rooted in long-term observations of the landscape and seasonal patterns. This approach not only considers ecological data but also incorporates cultural and experiential knowledge, offering unique cultural indicators for assessing the health and resilience of watersheds.

This approach not only considers ecological data but also incorporates cultural and experiential knowledge. What is clear from these comparisons is that both western and Indigenous indicators bring value to overall understanding and assessment of watershed health and resilience

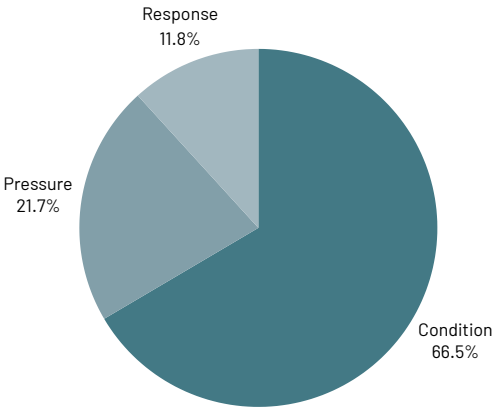
DISTRIBUTION BY INDICATOR WORLDVIEW AND TYPE

In addition to being categorized into watershed health and resilience categories and worldviews, indicators can be categorized by type (Figure 2). A combination of condition, pressure, and response-oriented indicator types are crucial for monitoring and evaluating both the current and projected states of the watershed over time. The types of indicators included in WHI frameworks, can determine to what extent changing conditions and trends and proactive responses are being monitored[17,29,30,31] Indicator type selection varies depending on the objectives and/or outcomes sought.

Condition-oriented indicators (e.g., water flow and taste) provide a snapshot of watershed health and are important for understanding changes from an agreed upon baseline, and tracking any transitions between watershed health and dis-health.[†] **Pressure** indicators (e.g., changes in snow cover) track natural processes and/or anthropogenic impacts that might adversely impact a baseline environmental state, spurring trends and projections of future environmental states.[31] **Response** indicators (e.g., changes in response to fisheries management practices) are crucial to evaluate actions aimed at restoring and/or amplifying watershed health and resilience over time.

Perhaps unsurprisingly, the highest proportion of indicators across all WHI frameworks are focused on monitoring the current state of the watershed (condition- oriented: 67%), whereas fewer indicators monitor stressors and trends (pressure-oriented: 22%) and even fewer monitor actions (response-oriented: 12%). Anticipating stressors and trends (projected changes from baseline over time), such as land conversion, environmental degradation, pollution, and climate variability are important for proactively responding to complex and dynamic watershed changes. The lower proportion of pressure and response-oriented indicators may indicate that current WHI frameworks put less emphasis on proactively building in and monitoring responses to changes and trends, thereby reducing adaptive management that monitors the health and resilience in watersheds. The focus on condition-oriented indicators may also be a reflection of limited and fragmented jurisdictional oversight of watershed health and resilience, particularly in western governance bodies.

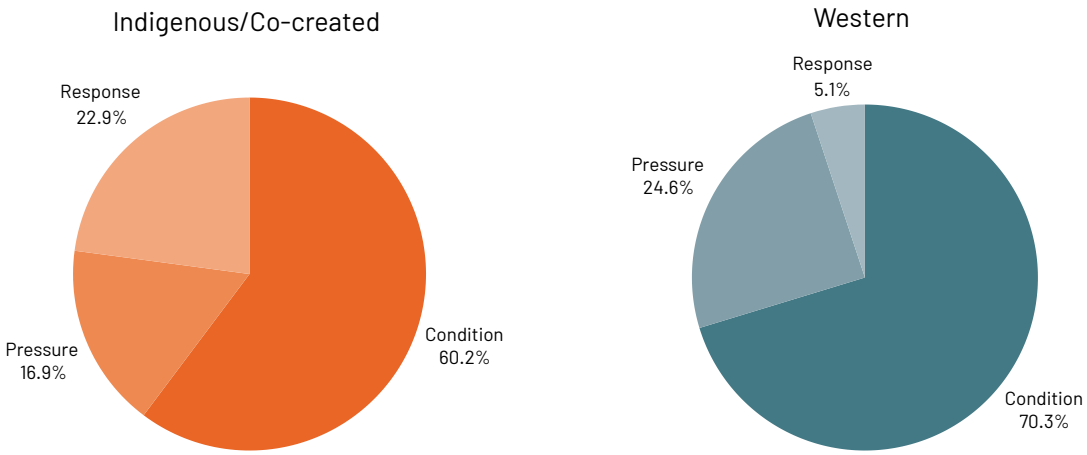
Figure 2: Watershed Health Indicator Distribution by Type



[†] There is some interesting research underway challenging the use of discretionary baselines in monitoring frameworks and calling for the establishment of socio- ecological thresholds using context-based sustainability approaches (R3.0; UNRISD)

Looking deeper into how indicator types are distributed by worldview shows a similar emphasis on condition-oriented and pressure-oriented indicators (Figure 3). Of interest, however, is the greater emphasis that Indigenous and co-created frameworks put on response-oriented indicator types. Figure 3 below shows that 22% in Indigenous and co-created frameworks are response indicators, monitoring the outcomes of adaptive interventions in the system, as compared to 5% in western frameworks. This may be due in part to the ways that place-based Indigenous Knowledge systems promote reciprocal relationship with the land, engaging with the land, water, air, and species in ways that are adaptive and responsive to changing conditions. Indicators related to the enhanced understanding of "watershed intelligence", place-based storytelling, and shared harvesting knowledge suggest that changes to the watershed are not only observed but are also sensed and attended to by Indigenous Peoples who are actively living within and on the land.

Figure 3: Distribution of Indicator Type by Worldview



OPPORTUNITIES FOR FUTURE WHI DEVELOPMENT

This research is intended to advance more holistic, inclusive and proactive indicators to help shape the social, cultural, and environmental determinants of health and resilience in our rapidly changing watersheds. The watershed scale presents a unique opportunity to enact United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), support Indigenous land-based leadership and bridge Indigenous and western co-governance approaches. This scale presents important opportunities for advancing innovative Knowledge systems and co-governance approaches with the aim of avoiding irreversible changes to the underlying ecological processes upon which all communities depend.[27,32,33]

DIVERSE WORLDVIEWS CAN SUPPORT A RICH BLEND OF INDICATORS.

As data gaps and policy misalignments challenge WHI effectiveness, indicators that are adaptable, accessible, understandable and co-developed with Indigenous leadership have the potential to provide the pre-conditions for more holistic management of watersheds.[20,34] Indigenous stewardship practices, embedded in reciprocal relationship with the natural world and the many beings residing within it, offer vital place-based perspectives that are often overlooked by conventional technical approaches.[9] These types of eco-cultural indicators transcend the conventional scope of western science by incorporating cultural, spiritual, and social dimensions that are reflective of the intricate relationships between Indigenous communities and their ancestral lands.[35,36]

MORE EMPHASIS IS NEEDED ON PRESSURE AND RESPONSE INDICATORS TO SUPPORT WATERSHED RESILIENCE OVER TIME.

This analysis helps provides some insight into the general priorities of watershed health monitoring across WHI's. Of note, many frameworks prioritized condition-oriented WHIs, with fewer frameworks including pressure-oriented indicators. Indigenous-led and co-created frameworks tended to include condition and pressure indicators, with a greater emphasis on adaptive, response-oriented indicators. To ensure ongoing ecosystem resilience in our watersheds, indicators that extend beyond condition assessment are needed. This would allow communities to project and anticipate trends and pressures and design adaptive responses that ensure the integrity, health, and resilience of our watersheds while creating shared responsibility. This shared responsibility for watershed health and resilience must include proactive sensing and responding to changing conditions. This helps to shift emphasis from monitoring frameworks that are taking snapshots of our declining watersheds, to projecting and anticipating needs to protect and restore health and resilience over time.

MORE HOLISTIC INDICATOR SELECTION IS REQUIRED.

Understanding the distribution of indicators across nine indicator categories showcases the need for more holistic WHI frameworks. Not only does a well-rounded set of watershed indicators cross most if not all indicator categories, it is also critical that they integrate diverse insights, including Indigenous Knowledge systems, and align with existing and emerging policies, to truly reflect the current realities of watershed health.[7,37] Indigenous worldviews and place-based knowledge are inherently holistic and adaptive, offering a way to monitor changes within a watershed while promoting grounded stewardship and management approaches. Western scientific indicators may aid our understanding of average conditions, cause and effect relationships, and provide quantitative measurements over time. Braiding these knowledge systems through holistic indicator selection not only ensures that Indigenous Peoples and practices are leading or co-creating place-based monitoring but also improves knowledge in more holistic indicator development and fosters shared responsibility for adaptive management approaches at a scale that typically resides outside of colonial jurisdiction.[15,24-26]

INDIGENOUS KNOWLEDGE SYSTEMS AND LEADERSHIP AT THE WATERSHED SCALE PRESENTS AN OPPORTUNITY TO CO-CREATE INDICATOR FRAMEWORKS, AND CO-GOVERNANCE ARRANGEMENTS IN SUPPORT OF THE HEALTH AND RESILIENCE OF WATERSHEDS AND TERRITORIES.

Indigenous communities have faced exclusion from land-based management planning and decision-making, with historical patterns of neglect continuing to occur (e.g., failure to obtain informed consent).[20] The co-creation of watershed indicators is an opportunity to bridge worldviews, learn about and tailor diverse eco-cultural and western indicators used to monitor ecosystem health, and uphold Indigenous Knowledge and rights, ensuring the inclusion of Indigenous perspectives and needs.[35,38-41] Indigenous Knowledge systems are intimately tied to the land. Indigenous leadership and/or co-creation in indicator development is an initial step to forming innovative place-based, co-governance arrangements in support of the health and resilience of the ecosystems upon which we all depend – our watersheds.

Photo: Christopher McLeod

CLOSING REMARKS

Climate change is impacting watersheds throughout Canada and beyond while human activities run the risk of breaching critical ecological and cultural thresholds. Rapid population growth, land-use change, dwindling water security, and the diverse risks and challenges posed by a changing climate collectively require indicators and tools to multi-solve. WHIs must not only passively monitor changing watershed conditions, but proactively identify key stressors and include climate change projections in order to enable adaptive watershed management action. Complementarities between western and Indigenous indicators and priorities, and eco-cultural indicators for adaptive management collectively provide a way forward to prioritize more holistic approaches for monitoring watershed health and resilience. Centering and elevating Indigenous Knowledge systems plays a crucially important role for moving beyond siloed and piecemeal condition assessments, toward the inclusion of pressure and response indicators that support the overall health and resilience of our watersheds under changing conditions.

The above findings indicate an urgent need to evolve towards more co-creative and co-governance approaches to develop more culturally-appropriate and resilient WHI frameworks. Watersheds provide a scale from which to support nation-to-nation relations with place-based Indigenous Peoples to advance Indigenous Knowledge and leadership, while promoting ecosystem health and resilience. Monitoring and tracking a more holistic suite of cultural, environmental, social, and economic indicators can support communities and interested parties in better understanding risks and adaptive management features in watersheds both now and into the future. Legislation is being put in place in British Columbia with the aim to support collaborative approaches for watershed stewardship. A summary of relevant legislative frameworks and strategic initiatives is provided under Appendix C.

ACT's NSI seeks to integrate Indigenous Knowledge systems and perspectives into NbS work at the watershed scale. For more information on the NSI and its related initiatives, including more resources and toolkits from our strategies and indicators series, please visit **ACT's website**.

NSI RESOURCES

The NSI mobilizes resources, tools, and case studies to increase learning about opportunities, trade-offs, and barriers in planning and implementing cohesive and systemic NbS. The following resources support integrated and systemic NbS planning-to-implementation for practitioners and decision-makers aiming to drive nature positive change:

NBS MULTI-BENEFIT INDICATORS TOOL

This tool is intended to help decision-makers, practitioners, and other relevant parties identify indicators to assess the potential multi-benefits of NbS. It helps to optimize NbS policy and planning to align across multiple priorities and provides key indicators to measure the performance and effectiveness of NbS over time.

NBS REGULATORY MECHANISMS TOOLKIT

This toolkit provides recommendations for municipalities to leverage regulatory approaches to advance NbS in their communities. For each regulatory mechanism, the toolkit provides recommendations for how the mechanism can be used to facilitate NbS implementation or otherwise advance low carbon resilience.

LOWER MAINLAND NBS BEST PRACTICES *(COMING SOON)*

This report offers best practice examples of NbS in the Lower Mainland of British Columbia. It showcases communities using the three nested approaches put forward by the NSI in order to provide decision-makers, practitioners, and other relevant parties with inspiration on how to implement more cohesive and systemic NbS.

NBS STRATEGY FRAMEWORK *(COMING SOON)*

The Strategy Framework provides practical strategies for applying the NSI Framework-for-Action in local planning and implementation contexts. It supports practitioners and decision-makers in more effectively and cohesively integrating NbS, with each strategy illustrated by a North American case example that demonstrates its real-world application.

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APPENDIX A

WATERSHED HEALTH INDICATOR FRAMEWORK DISTRIBUTION

For a complete list of indicators included in this assessment, please refer to Appendix A in Palmer (2024).[28]

Geographical Distribution of Assessed Indicator Frameworks	Indicator Count by Framework Worldview		Total Indicator Count
	Indigenous/ Co-created	Western (Settler)	
Alberta	-	32	32
Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance, 2022)	-	22	22
State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta, 2009)	-	10	10
British Columbia	6	-	27
Aspirational Targets for Watershed Health (Cowichan Watershed Board, 2019)	6	-	6
Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance, 2016)		21	21
Canada (National)	-	12	12
Watershed Reports 2020 (World Wildlife Foundation, 2020)		12	12
Northwest Territories	20	-	20
Traditional Ecological Knowledge Indicators (Kát?'odeeche First Nation, 2019)	20	-	20
Nunavut	3	-	3
Linking Inuit knowledge and meteorological station observations (Clyde River Inuit, 2009)	3	-	3

Geographical Distribution of Assessed Indicator Frameworks (cont.)	Indicator Count by Framework Worldview (cont.)		Total Indicator Count (cont.)
	Indigenous/ Co-created (cont.)	Western (Settler)	
Ontario	-	61	61
Watershed Health Assessment and Monitoring project (Ottawa River Keepers, 2023)	-	14	14
Resource Categories and Indicators (Conservation Ontario, 2023)	-	9	9
Muskoka Watershed Report Card 2023 (Muskoka Watershed Council, 2023)	-	17	17
Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority, 2023)	-	21	21
Yukon	11	-	11
Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations, 2019)	11	-	11
Western Canada	43	-	43
State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board, 2021)	10	-	10
Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership, 2017)	22	-	22
Indicators - Mackenzie Basin (Tracking Change Initiative, 2016-2019)	11	-	11
United States of America (National)	-	12	12
USEPA Watershed Health Index (USEPA, 2021)	-	12	12
Indicator Totals	**83**	**138**	**221**

* Western Canada = British Columbia, Yukon, Northwest Territories, Saskatchewan and Alberta (collectively)

To explore the Appendix A: Watershed Health Indicator Frameworks further:

- Battle River Watershed Alliance. (2023). *BRWA Watershed Health Indicator Framework*. https://www.battleriverwatershed.ca/wp-content/uploads/2022/08/BRWA-Watershed-Health-Indicator-Framework.pdf
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APPENDIX B

SAMPLES OF INDIGENOUS AND WESTERN INDICATORS BY CATEGORY

For a complete list of indicators sampled below across all sixteen frameworks, please refer to Appendix A in Palmer (2024).[28]

Watershed Health Indicator Category	Indigenous/ Co-created WHIs	Unit or Scale of Measurement	Western WHIs	Unit or Scale of Measurement
Indigenous Knowledge Systems and Leadership	What about the future?	• Monitoring and stewardship • Exploring strategies for sustainable fishing • providing opportunities for cross community, cross regional, and cross-cultural knowledge and skills transfer • Documenting traditional and evolving systems for knowledge transfer • Developing policy and water related climate adaptation strategies		
	Storytelling	• Infrequent = we use storytelling infrequently now to share our beliefs than in the past because of changes to the delta. • Frequent = we use storytelling frequently now to share our beliefs than in the past		
	Animal Ethics	• Poor = people have poorer ethics/respect towards animals now than in the past? • Same = people have the same ethics/respect towards animals now than in the past • Better = people have better ethics/respect towards animals now than in the past		
Biodiversity	Texture (Fish)	• Is the flesh of the fish firm or soft?	Species Intactness	• Species intactness (bird/ plant/mammal)

Watershed Health Indicator Category (cont.)	Indigenous/ Co-created WHIs (cont).	Unit or Scale of Measurement (cont.)	Western WHIs (cont.)	Unit or Scale of Measurement (cont.)
Biodiversity (cont.)	Fish Health	• Index Biological Integrity - Fish Health	Fish Populations	• Success of Fisheries Management Zone 15 (Plan Implementation) • Reduced length of open season • Minimum size limits (lake specific) • Fish stocking • Educational initiatives for public
	Smell (Fish)	• Do the fish smell funny? • Do the fish smell like diesel?	Fragmentation	• Extent of natural area (ha) = Watershed Area - ((Altered Landscape Area - 17 largest lakes) + 100-metre buffer applied to each feature) • As the size of quaternary watersheds vary across Muskoka, the relative proportion of each watershed covered by a given fragmentation class was calculated to allow for comparison.
	Taste (Fish)	• Do the fish taste soapy?	Wetlands and Forests	• Stories and oral histories • Local observations • Number, location, areas and species diversity of wetlands • Number, location, areas and species diversity of forests
Climate Change	Is it safe to travel?	• Impacts to seasonal travel	Temperature Changes	• Seasonal mean change of daily maximum

Watershed Health Indicator Category (cont.)	Indigenous/ Co-created WHIs (cont).	Unit or Scale of Measurement (cont.)	Western WHIs (cont.)	Unit or Scale of Measurement (cont.)
Climate Change (cont.)				• temperatures for winter (January, February, and March) • # of Days Maximum Temperature > 20C • # of Days Maximum Temperature < 0C
	Ice Thickness	• Is ice thickness decreasing? • Are winter temperatures warming?	Precipitation Changes	• Change in Annual Total Precipitation (rain + snow) • Change in Annual Total Snow • Change in Annual Total Rain • # of days with precipitation > 1mm
	Flood Extent	• Less = the floods cover less area/land now than they did in the past • Same = the floods cover the same amount of area/ land now than they did in the past • More = the floods cover more area/land now than they did in the past	Winter Ice	• Ice-on Dates since 1975 (per annum) • Ice-off days since 1975 (per annum) • Days of Ice Cover since 1975
	Length of ice period	• Short (< 5.5 months) - ice freeze up happens later (December) and thaws sooner (i.e., March) than in the past • Medium (5.5 - 6.5 months) - ice freeze up happens the same as in the past (October - April/May) • Long (> 6.5 months) - ice freeze up happens sooner and lasts longer than in the past (September/October - May)	Extreme weather events (flooding)	Muskoka flood risk factors (decision tree), 250-300mm water threshold: • Snow water equivalent above normal • Rapid Melting • Heavy Rain > 50mm • Additional Rain > 25mm
Community and Health	How healthy are we?	• Expensive and less nutritious store-bought food • Adapting to change • Decision making in support of community health	Chronic Diseases or Conditions	• Diabetes • Hypertension • COPD

Watershed Health Indicator Category (cont.)	Indigenous/ Co-created WHIs (cont).	Unit or Scale of Measurement (cont.)	Western WHIs (cont.)	Unit or Scale of Measurement (cont.)
Community and Health (cont.)		• Fishing and fostering holistic health of communities • Building healthy futures		
	What about the youth?	• Concerns for the future • Ways of engaging youth • Goals for youth learning • Youth action	Personal Physical Health	• Healthy Alta Trends Index
			Mental Health	• Self-perceived mental health • % of population with mental health conditions • Sense of belonging
Economy	Ecotourism	• Less = there is less ecotourism now than in the past because of changes in the delta • Same = there is the same amount of ecotourism now than in the past	Economic Development	• GDP by industry • Businesses incorporated
		• More = there is more ecotourism now than in the past	Economic Well-being	• Income • Labour force participation rate • Cost of Living
Land Use and Condition	Hydro Development	• Impacts to water • Access to healthy fish • Animal harvest changes • Impacts to spirituality and culture	Riparian Health	• Riparian Health Assessment
			Wetlands Inventory	• Merged wetlands inventory • % area covered by wetlands
	Land Use	• Stories and oral histories • Maps and statistics	Land Use	• Agricultural land use • Linear development • Land development

Watershed Health Indicator Category (cont.)	Indigenous/ Co-created WHIs (cont).	Unit or Scale of Measurement (cont.)	Western WHIs (cont.)	Unit or Scale of Measurement (cont.)
Water Quality	Running Water	• Water should be fast flowing and not stagnant.	Water related advisories	• Algae • Fecal coliform • Drinking water
	Makes good tea	• Water should make red tea. Bad water makes black tea that leaves stains in your cup.	Water Quality	• River water quality index • Tributary stream quality
	Colour of water and clearness	• Has the colour or clearness of the water changed? • Is the water dark, murky, dirty or yellow?		• mg/L
Water Quantity and Security	Water Levels (Qualitative Observations)	• Are water levels declining in rivers and lakes? • Are small creeks and streams drying up? • Are there new sandbars/islands appearing in the Hay River, on Buffalo River? • Is the shoreline changing on Great Slave Lake? • Are certain traditional areas difficult to access (e.g., Alexandra Falls, Buffalo River)?	Water Quantity	• Water usage • Water flow and availability
	Water Flow	• Less = there is less water flow now than there was in the past • Same = there is the same water flow now than there was in the past • More = there is more water flow now than there was in the past	Pattern of surface flows (rivers, lakes, wetlands)	• Flow magnitude and variability (including frequency, duration, timing and rate of change) • Water level fluctuations in wetlands and lakes
			Pre- vs. Post-dam or Recent vs. Historical analysis of monthly flow	• Percentage of total months, for all stations analyzed, with significantly different variance in monthly flow pre-vs. post-dam operation or for historical vs. Recent time periods in undammed systems.

Watershed Health Indicator Category (cont.)	Indigenous/ Co-created WHIs (cont).	Unit or Scale of Measurement (cont.)	Western WHIs (cont.)	Unit or Scale of Measurement (cont.)
Water Quantity and Security (cont.)				• % change in median monthly flow (pre- and post-dam) or for historical vs. recent time periods in undammed systems, • Results averaged across studied stations by mean annual flow
Ecological Services and Use	Can I eat the fish?	• Is the fish flesh soft? • Are there irregularities in the fish? • Does the fish have parasites? • Is the fish skinny? • Has the fish been tested for toxins (e.g. mercury)? • Are the eggs healthy? • Are local harvesters afraid to sell fish? • What is upstream? • Are there changes to the land and water that	Ecosystem Services	• Value of ecosystem services
	Can I eat the fish?	• Is the water colourless and clear? • How does the water taste? • Are there animals nearby? • What is upstream? • Are there known contaminants?	Ecological Integrity	• TBD (no formal approach has been devised to reliably track and quantify this indicator (see rationale in Muskoka Watershed Report Card, 2023)

APPENDIX C

ALIGNED B.C. LEGISLATIVE FRAMEWORKS AND STRATEGIC INITIATIVES

The implementation of key legislative frameworks and strategic initiatives in British Columbia will continue to play an increasingly pivotal role in shaping tailored and collaborative approaches for watershed stewardship, with an increasing emphasis on climate change monitoring and Indigenous leadership. This includes the Water Sustainability Act (WSA), the Declaration on the Rights of Indigenous Peoples Act (Declaration Act), and the anticipated Water Sustainability Strategy (WSS) and Fund (WSSF). Each of these can further support alignment with the objectives of Integrated Water Resources Management (IWRM) and trigger new opportunities to integrate climate change considerations and First Nations perspectives into water management practices across B.C.

The WSA aims to support integrated water and land use planning through the application of water sustainability plans (WSPs) which are noted to be the only statutory instrument in Canada able to link both land and water decision-making to "a long-term watershed-or ecosystem-based framework," while also facilitating co-governance agreements between the province and First Nations communities.[44] A successful example of this approach in action includes the **Xwulqw'selu Watershed Planning Agreement** between the Cowichan Tribes First Nations and the province of British Columbia.[42,43] However, the overarching effectiveness of WSPs in incorporating Indigenous law and rights remains uncertain given that their power is sourced exclusively from provincial state law.[44]

Launching soon, the WSSF aims to finance the development and implementation of region-specific WHI frameworks. This is supported by policy intention #1 of the WSSF Intentions Paper, which emphasizes the need for Indigenous collaboration and stewardship by enabling "Indigenous Peoples to be fully involved partners with recognition of their rights, needs, values and worldviews".[45] In addition, policy intention #5 aims to support water supply and demand considerations at the watershed scale by addressing the needs of the "people, the environment, and the economy" through a holistic IWRM approach.[45] Consequently, this policy intention can drive enhanced support for targeted WHI development and monitoring via "enforcement, new conservation and economic tools, and other planning processes such as Drinking Water Protection Plans, Forest Landscape Plans and Land Use Plans".[45]

Finally, Action 2.7 of the supplementary Action Plan to the Declaration Act compels the province to establish government-to-government relationships with First Nations for watershed stewardship.[46] This includes collaborating with First Nations to co-create and implement sustainable water management strategies, policy reforms, and shared decision-making at the local watershed scale, with a deadline of 2027 to formally implement under the WSS.[47]

GET INVOLVED

ACT invites collaboration and partnership from national, regional and local organizations to build a community of practice aimed at applying the NSI Framework-for-Action. The goal is to promote cohesive and systemic NbS to address the multiple challenges that ecosystems and communities are facing now and into future, and to advance knowledge that builds resilience and sustainability for people and nature.

By working collaboratively, we can catalyze learning and innovation, and advance best practices. We encourage interested parties to email us at actinfo@sfu.ca

Check out the 2023 NSI Summary for more information and sign up to ACT's newsletter to receive NSI updates!

CONTACT US

To engage with ACT about our Natural Solutions Initiative, or anything else you would like to discuss, you can reach us at:

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