Using Data from Community-based Water Monitoring in Nova Scotia

January 2021

AUTHORS

Dr. Alice Cohen, Associate Professor, Environmental Science & Environmental & Sustainability Studies, Acadia University

Aislin Livingstone, Program Coordinator, Atlantic Water Network, Saint Mary's University

CITATION

Cohen, A., and Livingstone, A. (2020). *Using Data from Community-based Water Monitoring in Nova Scotia*.

ACKNOWLEDGMENTS

Partners:

Acadia University, Coastal Action, and CLARI

Researchers:

Amber Dort, Research Assistant, Acadia University

Brooke Nodding, Executive Director, Coastal Action

Shanna Fredericks, Assistant Director, Coastal Action

Emma Wattie, Director, Atlantic Water Network, Saint Mary's University

Contributors:

The research team is grateful to the community members and policy makers who provided invaluable contributions and feedback throughout the project.

Financial Support:

Change Lab Action Research Initiative

Cover photo by Sade Stacey

CLARI COASTAL ACTION ACADIA UNIVERSITY Atlantic Water Network

CONTENTS

Executive summary **4**

Background **5**

Community-based water monitoring in Nova Scotia 6

Data-driven policy: Using CBWM data 7

Frameworks for understanding CBWM-Policy connections **9**

Scottish Environmental Protection Agency: Choosing and using citizen science 9

Chesapeake Monitoring Cooperative: Tiered data use framework 10

Research methods.. ..... **12**

Who did we interview? 12

What we heard.. ..... **14**

Are CBWM data used in government decisions? 14

How are CBWM data used in decisions? 14

How are CBWM data shared? 19

What additional data could be collected with significant investment in human and technical resources? 20

Barriers 20

Key takeaways 21

Developing a Nova Scotian Model **22**

How to use the framework 22

Policy Recommendations **24**

Future work **26**

References **27**

Appendix A: SEPA - Choosing and using citizen science framework **28**

Appendix B: Chesapeake Monitoring Cooperative - Tiered data use framework **31**

Appendix C: Interview questions **32**

EXECUTIVE SUMMARY

This report brings together academic, community, and government perspectives on the relationship between the collection of water data through community-based water monitoring programs (CBWM) and the use of that data to inform policy making. Specifically, this report addresses the question "**what happens to CBWM data once it has been collected?**".

To answer this question, we hosted a workshop in Halifax in February 2020, carried out 22 in-depth interviews in the summer of 2020, and hosted an online seminar (a 'webinar') for participants in November of 2020. We took what we heard from Nova Scotian experts and layered it onto existing practice and knowledge about CBWM and policy making around the world. The result is a place-based framework that speaks to the challenges of using CBWM data in policy making, and specific policy recommendations that address those challenges. This report is focused on Nova Scotia, but we anticipate its findings may be applicable beyond the province.

The conversation about CBWM data and policy making matters, as CBWM is an increasingly popular model of water governance in Nova Scotia and elsewhere, and is broadly understood to be a tool that can address the locally-specific dimensions of climate change, empower and educate citizens, build intergenerational connections, and identify problems where and when they start - all for a fraction of the cost of government monitoring.

The framework presented in this report encourages CBWM groups and decision makers to focus on their desired end product in order to match the action to the outcome. Specifically, the framework provides an approach to thinking about when and how CBWM data can support and enhance decision making in Nova Scotia and identifies some considerations necessary for achieving desired outcomes. Matching CBWM with specific end uses requires different funding and equipment, and we heard time and again CBWM data are used in cases where it 'fits' with a governmental application. We caution here that CBWM groups should not be seen as less expensive consultants; instead, they are partners in water stewardship, with eyes and ears on the land and water in a way that governments are not able to do. Speaking to this framework, the report proposes three policy recommendations for Nova Scotia Environment:

- Require all publicly funded consultant work to make their water quality data publicly accessible;
- Match the funding arrangement to the program outcomes; and
- Clearly communicate data quality requirements for different end uses.

The report concludes with suggestions for future research on the legal potential and limitations of CBWM data, and a more thoughtful relationship between Western and Indigenous knowledge with respect to water.

BACKGROUND

The main purpose of this project is to bring academic and community perspectives to bear on an important question: **what happens to water data after it has been collected by community groups?** This is an important question as community-based water monitoring, or CBWM, is an increasingly popular model of data collection in Nova Scotia and elsewhere. In this model, community members are out on the water collecting samples used to better understand water quality. The CBWM model has many advantages: community members are often experts on local water bodies, the sampling process is an opportunity for public education and outreach, communities can identify the sampling parameters most useful to them, and high quality data collection can be less expensive than government-derived data (these advantages are summarized in Figure 1).

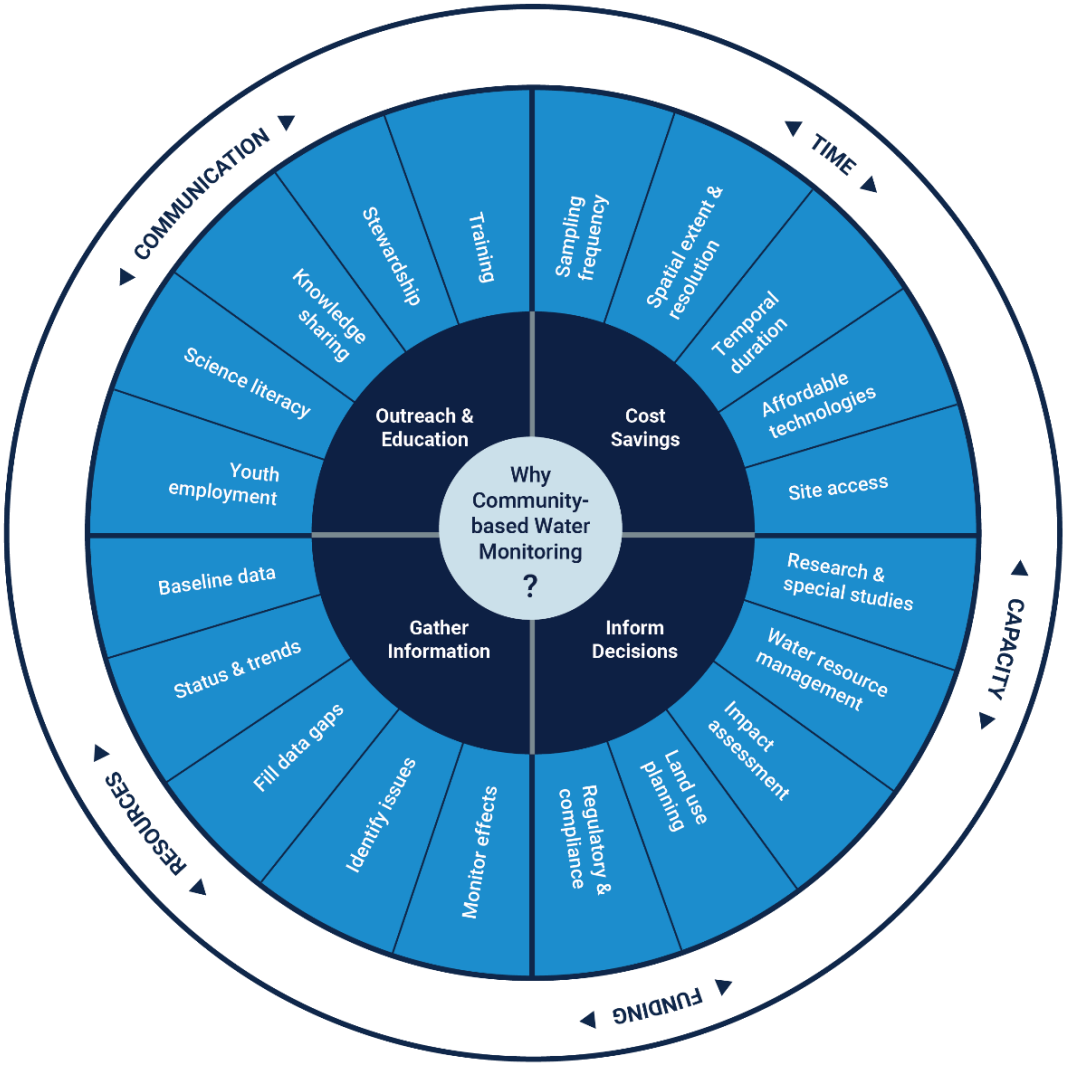


Figure 1: Advantages to community-based water monitoring, potential data uses, and key inputs

Note that the figure above does not reflect the richness and diversity of Indigenous-led CBWM in Canada. Initiatives such as Guardians programs are situated within land and water governance systems rooted in Indigenous ways of knowing, laws and cultures (read about the Indigenous Guardians Toolkit on pg. 7).

Given the promise and rising prominence of CBWM, CBWM organizations are often approached by local and provincial governments for data to use in their decision making about, for example, whether or not a body of water is safe for swimming, changes to zoning bylaws, and so on. It is also widely known that many CBWM programs submit their data to governments without knowing what happens with it. So, the relationship between the data that is collected and how it is used by various levels of government is unclear. This lack of clarity shaped the central goal of this project: to more clearly articulate the relationship between CBWM and decision making by provincial and local governments.

To address this aim, we carried out three research activities. The first activity was to seek out answers to our research questions from other jurisdictions. The second was to undertake 'detective work' interviews with community members and policy makers in Nova Scotia. These interviews were conducted in the summer and early fall of 2020 and built on a workshop hosted in Halifax in February 2020. The workshop was for Nova Scotian policy makers and asked them how they used community data in their work; the interviews drilled down into the broad workshop findings and asked detailed and specific questions about particular pieces of data. The third activity was two identical online workshops, or 'webinars' that the research team hosted for interviewees and workshop attendees. At the webinar, we presented the findings from the interviews in the context of the global research in CBWM and policy use, and asked participants to weigh in on our interpretation of the data.

The result of these activities is presented here and paints a picture of the relationship between CBWM data collection and data use in Nova Scotia.

Community-based water monitoring in Nova Scotia

Research on CBWM in Canada demonstrates its growing importance to the Canadian water governance landscape. Carlson et al's survey of hundreds of CBWM organizations in Canada showed that "CBWM programs are filling information gaps on watershed health, informing decision making at various levels of government, and fostering environmental stewardship in communities across Canada" (2017, 4).

As of 2017, there were over one hundred CBWM organizations in Canada (see Figure 2); today, we know of at least 62 in Nova Scotia. Below is a timeline from a 2017 report (Carlson et al., 2017) that illustrates the steady and rapid rise of CBWM programs across the country. The study reported on over a hundred organizations that responded to a survey; we know that far more than that exist - 62 in Nova Scotia alone.

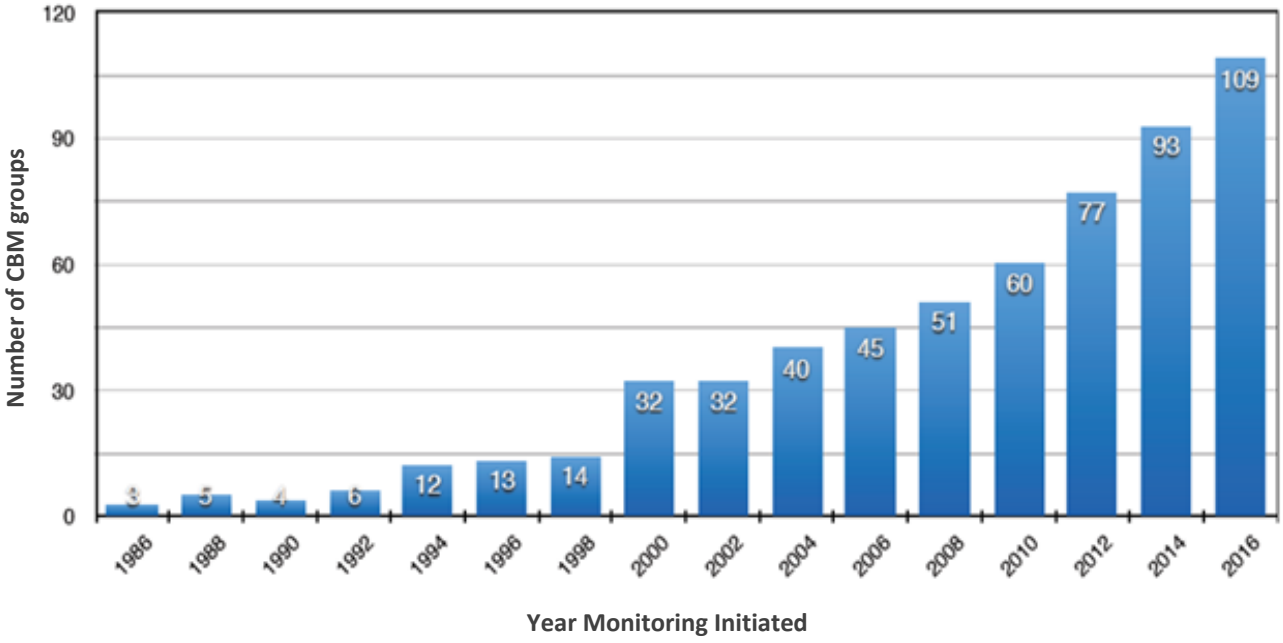


Figure 2: Canada-wide growth in CBWM projects per year. Source: (Carlson et al., 2017)

Data-driven policy: Using CBWM data

The Carlson et al. (2017) report asked the question of CBWM groups: "Does your data inform government policy?". In response, 46% said yes, 31% said no, and 23% said they didn't know. The "I don't know" response was surprising at first but makes sense: CBWM groups send data away and there is not always a mechanism for knowing how - or if - it is used. From the policy maker side, there is often no way to know what data are out there. To address this gap, a number of data sharing platforms have been developed recently.

These include:

- **DataStream**[1] is led at the national level by The Gordon Foundation, which describes it as a "powerful, online platform for sharing information about freshwater health". DataStream enables CBWM groups and others to upload, visualize, and share data in standardized formats. Data can be accessed for three hub regions.
- **CABIN**[2] - the Canadian Aquatic Biomonitoring Network Database is hosted by Environment and Climate Change Canada and is an online platform for sharing and accessing data on biological indicators of freshwater health.

[1] For more information about DataStream, see https://datastream.org

[2] For more information about CABIN, see https://www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network/database.html

- **The Indigenous Leadership Initiative**[3] is "dedicated to facilitating the strengthening of Indigenous Nationhood for the fulfillment of the Indigenous cultural responsibility to our lands, the emergence of new generations of Indigenous leaders, and helping communities develop the skills and capacity that they will need as they continue to become fully respected and equally treated partners in Canada's system of governance and economic and social growth" (see mission). A key part of this work is the development and support of the **Indigenous Guardians**[4] - a network of Indigenous-led environmental monitoring programs across the country. Data can be accessed by contacting each program individually.
- **The Canadian Integrated Ocean Observing System (CIOOS)**[5] is an open-access online platform for ocean data. CIOOS is governed by a cross-sector partnership between governments, research institutions, and non-governmental organizations in the Pacific, St. Lawrence and Atlantic regions of Canada. CIOOS seeks to facilitate data-sharing and use in order to support evidence-based decision making in marine and coastal environments.

These platforms are a necessary step in bridging the gap between data collection and decision making (see simplified data life cycle in Figure 3). At the same time, simply having the data available does not mean it is getting used. To that end, the central aim of this report is to explain what we learned about CBWM data use in Nova Scotia by developing a framework for understanding the relationship between data collection and data use. Although our research was focused on Nova Scotia, we anticipate that our findings will be applicable more broadly.

Figure 3: Simplified data life cycle. CBWM incorporates various stages of the data life cycle depending on individual program objectives, resources, and capacities. Adapted from the National Science Foundation DataONE project. Source: (Cantor et al., 2018)

[3] For more information about the Indigenous Leadership Initiative, see https://www.ilinationhood.ca/
[4] For more information about the Indigenous Guardians Toolkit, see https://www.indigenousguardianstoolkit.ca/. A map of Indigenous Guardians programs is accessible at www.indigenousguardianstoolkit.ca/map
[5] For more information about CIOOS, see https://cioos.ca/

FRAMEWORKS FOR UNDERSTANDING CBWM-POLICY CONNECTIONS

Despite its many benefits, CBWM isn't a one-size-fits all solution to filling data gaps and engaging communities in water policy, planning, and management. The potential impact of any individual program's water data on decision making depends on community priorities, monitoring design, policy objectives, jurisdiction, and a host of other factors. Given this complexity, frameworks can be a useful tool for CBWM groups, researchers and governments seeking to use community-collected data to support water decisions at various scales.

To help guide our research, we examined two existing frameworks that specifically facilitate use of community-collected data in decision making. We drew insights from these examples, our interviews, and two webinars to determine the utility and design of a framework for the Nova Scotia context.

Scottish Environmental Protection Agency: Choosing and using citizen science

The Scottish Environmental Protection Agency (SEPA) actively incorporates and supports citizen science in its routine departmental programming. SEPA is guided by a framework describing if, when, and how departmental staff should adopt citizen science. The framework starts by asking whether citizen science is appropriate for the environmental question being considered, given the resources available (Figure 4). To do this, SEPA encourages consideration of six core criteria: clarity of the question; importance of engagement; resources available; scale of sampling, complexity of the protocol, and; motivations of participants (Pocock et al., 2014).

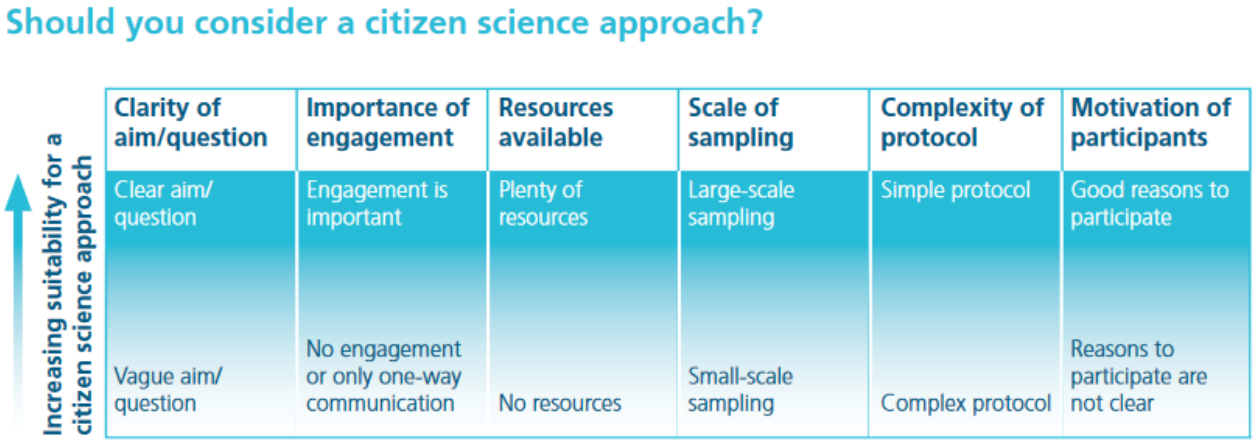


Figure 4: Key considerations to determine suitability of citizen science for governmental monitoring. Source: (Pocock et al., 2014)

The framework then guides decision makers through a step-by-step process to align these criteria with different types of citizen science that might suitably fit the agency's needs (see the complete framework in Appendix A). While the model is not specific to water, it provides a useful set of questions to guide how governments and other potential end-users can engage with – and benefit from – participatory monitoring.

Chesapeake Monitoring Cooperative: Tiered data use framework

The Chesapeake Monitoring Cooperative (CMC)[6] works to integrate and support volunteer monitoring and citizen science programs throughout the Chesapeake Bay in order to build a comprehensive understanding of watershed health. The Cooperative provides technical support and training to assist watershed groups with program design, monitoring protocols, data management, and outreach. Its goal is to enable use of volunteer and other 'non-traditional' water data of known quality by the Chesapeake Bay Program (CBP)[7]. Volunteers and citizen science groups are considered a cost-effective way to fill data gaps and supplement state-led monitoring in support of shared decision making, such as adaptive environmental management and watershed restoration.

CMC developed the Tiered Framework for Data Collection and Integration for Non-traditional Monitoring to align different categories of data based on their quality with potential end uses (Figure 5) (Chesapeake Monitoring Cooperative, 2018). The framework defines data requirements for specific uses at the Bay, state, and national level.

Data requirements for specific parameters vary per tier but may include clearly documented study designs, quality assurance project plans (QAPP), approved field protocols, and standard lab operating procedures (see full requirements in Appendix B). Depending on the group's motivations for monitoring, this guidance can have a profound effect on their program design and operations. For example, a watershed group might choose to follow EPA Volunteer Monitoring QAPP Development guidelines to facilitate broader applications of their data. Similar tiered approaches to data use have been adopted in other jurisdictions and can be a useful and transparent way of aligning CBWM data with government decision making, where desired and appropriate (Green et al., 2012).

[6] The Chesapeake Monitoring Cooperative is a partnership between Alliance for the Chesapeake Bay (Alliance), Izaak Walton League of America (League), Dickinson College's Alliance for Aquatic Resource Monitoring (ALLARM), and the University of Maryland Center for Environmental Science Integration and Application Network (UMCES IAN).

[7] The Chesapeake Bay Program is a regional, multi-stakeholder partnership between the District of Columbia; Maryland; Pennsylvania; New York; Virginia; West Virginia; the Chesapeake Bay Commission (a tri-state legislative body); non-governmental organizations, and; the United States Environmental Protection Agency.

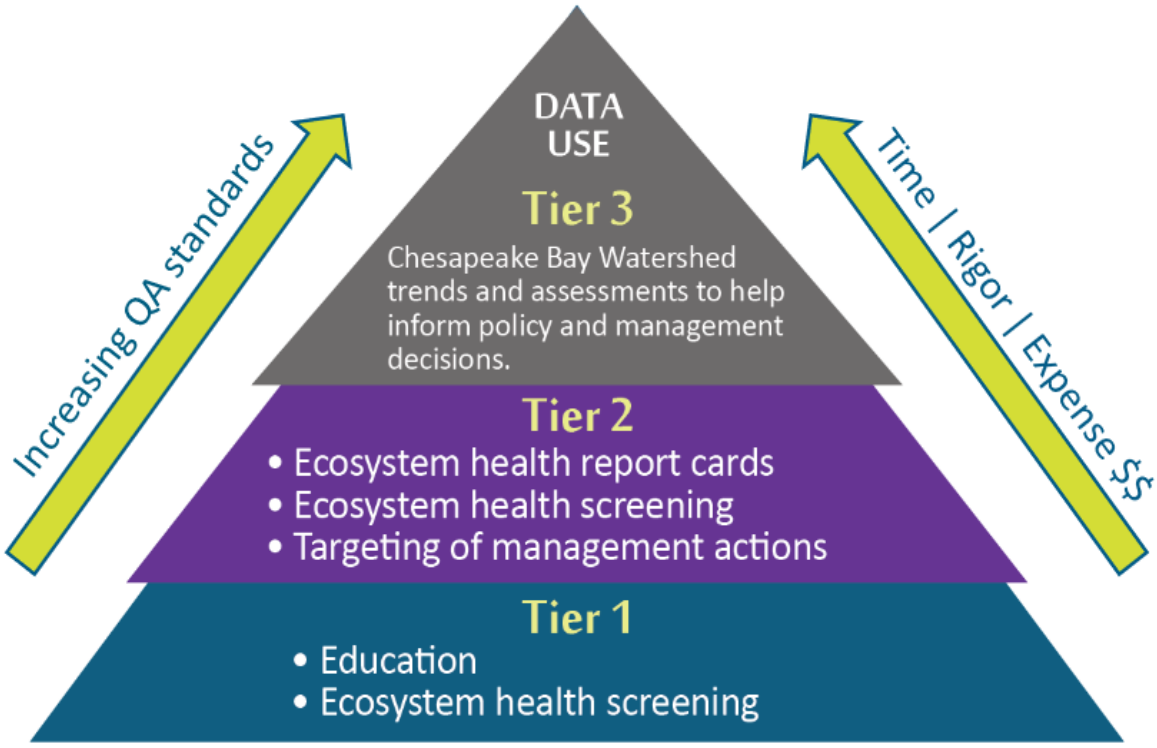


Figure 5: Tiered Framework for Data Collection and Integration for Non-traditional Monitoring. Source: (Chesapeake Monitoring Cooperative, 2018)

RESEARCH METHODS

Over the summer and fall 2020 we interviewed community members and policy makers to better understand how CBWM data are used in water decision making processes throughout Nova Scotia. Interviews were carried out virtually over Zoom video conferencing and typically lasted between 30 minutes and one hour. Our list of interview questions is included in Appendix C.

Who did we interview?

We interviewed 22 representatives of governments and organizations involved with water monitoring in Nova Scotia. Of these, 13 were decision makers from municipal, provincial, and federal government departments and nine were from non-governmental organizations that undertake CBWM activities (Table 1). Interviewees were identified from a workshop on the same topic held in February 2020 and were also canvassed from our professional networks.

While this is a small sample size, respondents represented a diverse cross-section of government decision makers and monitoring organizations throughout Nova Scotia. The respondents' focus areas are further elaborated in Table 2.

Table 1: Interview respondents

DECISION MAKERS	NUMBER OF RESPONDENTS
Municipal	7
Provincial	4
Federal	2
COMMUNITY-BASED MONITORING REPRESENTATIVES	
Watershed group	6
Consultant	2
Indigenous-led CBWM initiative	1

Table 2: Focus areas of interviewees

DECISION MAKERS
Municipal: Parks and recreation; public works and wastewater management; operations; city council; municipal planning
Provincial: Land use planning and development; water resources management; environmental impact assessment; source water protection; flood mapping; climate change research
Federal: Water quality monitoring and surveillance; water policy
CBWM INITIATIVES
Monitoring objectives: Baseline data collection; trend analysis; habitat assessment; issue identification; outreach and education; informing policy and decision making
Primary types of data collected: - Common field parameters: Temperature; dissolved oxygen; pH, conductivity; turbidity - Common lab parameters: Total dissolved solids; suspended solids; nutrients (total phosphorus, nitrate); fecal coliform / *E. coli*; cyanobacteria; metals; chlorophyll *a*; bacteria; dissolved organic carbon
Additional information collected: Water depth; eDNA; Indigenous knowledge

WHAT WE HEARD

Are CBWM data used in government decisions?

To understand how CBWM data are used we first clarified whether the respondents rely on data in their day-to-day to inform water decisions. Most of the decision makers interviewed reported using data directly or indirectly in their work. A small number don't use data at all in their decision making (Figure 6).

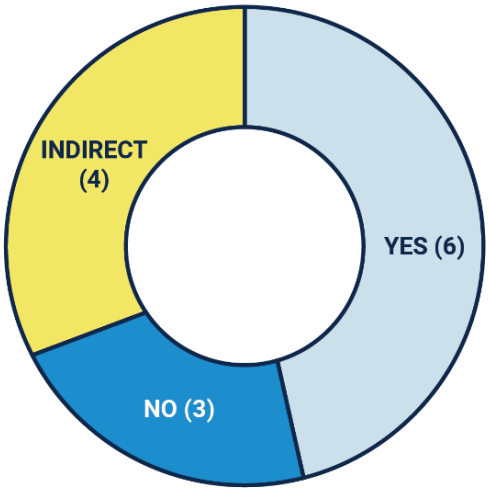


Figure 6: [Decision makers] Are you actively using any data - CBWM or otherwise - in your decision making?

Approximately half of the CBWM groups interviewed said they're approached by governments for their data (Figure 7). When asked whether and how they know the data are being used, we heard: 1) data are used or at least considered because groups present their findings to council 2) data and reports on findings are required by steering and technical advisory committees 3) the data informed a policy, and 4) the government reports back on data use. The other half of CBWM representatives are rarely or never approached for their data.

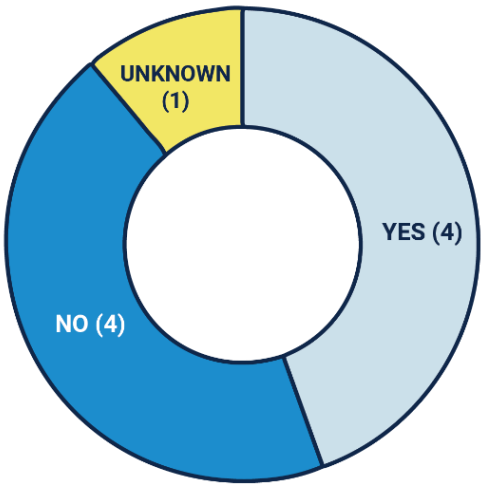


Figure 7: [CBWM respondents] Are you approached by any level of government about data use?

CBWM representatives highlighted the importance of data for informing internal organizational priorities for monitoring (what, where, how, and when), reporting project results to funders, raising public awareness of water quality issues through outreach and education, and maintaining a baseline dataset for water bodies of local concern.

How are CBWM data used in decisions?

CBWM data have been used in diverse ways to support water decisions and engage communities in environmental protection throughout Nova Scotia. Some of the decision-making processes described below directly and formally facilitate use of

CBWM and other non-traditional data sources. Policy makers also use CBWM data through informal channels and for secondary applications, for example, to fill historical data gaps, supplement government-led monitoring programs, and verify consultant-collected data.

CBWM has played an important role in identifying issues and areas that need to be investigated through official pathways. In a few cases, typically at the municipal level, CBWM provides the only source of water data and is embedded within a formal process for integrating data into decision making or, a 'decision support system'.

We have placed the range of CBWM data uses we heard about in our interviews along a continuum of decision-making processes ranging from **non-regulatory** to **regulatory** (shown in Figure 8).

Figure 9 shows how reported uses of CBWM data in the case studies we looked at align with regulatory and non-regulatory water decisions.

Figure 8: Data uses along this spectrum will require different methods and levels of rigor at each stage of the data life cycle

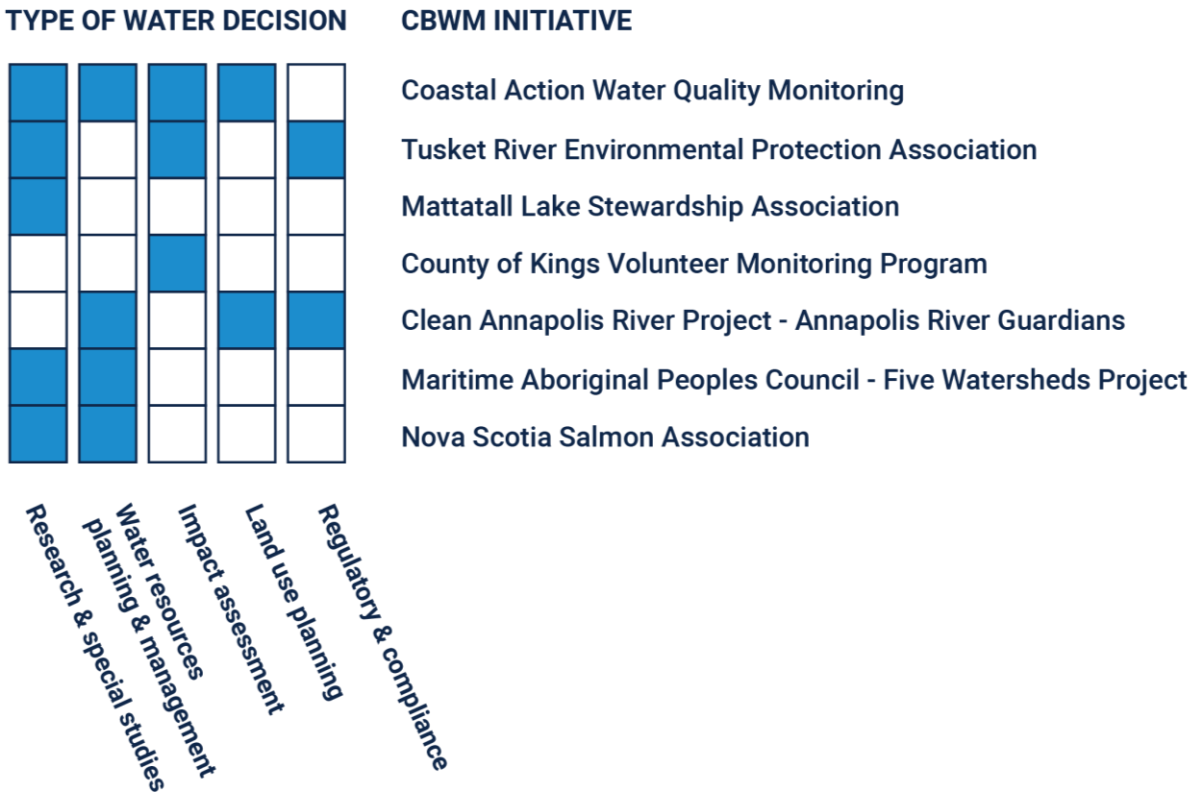


Figure 9: Alignment of CBWM data with diverse types of decision making in Nova Scotia.
Note - this list is not exhaustive

Research and special studies

Several CBWM efforts discussed in our interviews either arose from – or contribute to – special water quality studies in lakes. These are often collaborative undertakings between communities, researchers, and government staff. One example is the **Mattatall Lake Stewardship Association (MLSA)**. This group formed in response to observed algal blooms in Mattatall Lake in 2015. Soon after, MLSA partnered with the Agricultural College and Department of Civil & Resource Engineering at Dalhousie University to study phosphorus dynamics in the lake. Community-collected data directly supported this research from 2016-2019. Even after the project ended, Nova Scotia Environment continues to fund sampling to determine baseline water quality.

Another group whose data are being used for collaborative research is the **Maritime Aboriginal Peoples Council (MAPC)**, through their Five Watersheds Project. Under this multi-year coastal restoration project supported by Fisheries and Oceans Canada, MAPC has been funded to identify areas of habitat concern and develop a restoration plan to reduce barriers to fish passage. Water quality and fish survey data collected will support a multi-government effort to better manage and restore impaired waterways. Ultimately, the goal is to contribute to the recovery of endangered Inner Bay of Fundy Atlantic Salmon.

Impact assessment

CBWM data are occasionally used by environmental consultants who have been contracted by municipal, provincial, and federal governments for public projects. In these cases, the data are primarily used to complement or verify "professionally" collected information. And, while consultants often prefer to conduct their own monitoring, we heard of instances where CBWM data were needed to fill historical and spatial gaps. For example, consultants have drawn on CBWM observations to determine the presence or absence of water data needed for municipal development applications within Halifax Regional Municipality. However, unique reporting requirements between environmental consultants and their clients makes it difficult to understand the extent to which CBWM data are impacting water decisions through this mechanism.

Land use planning

Municipal land use planning was the primary use for CBWM data reported during interviews. CBWM representatives spoke about unique arrangements between their organizations and municipal staff and council. For example, the Municipality of the District of Lunenburg (MODL) and the Municipality of Chester have formalized relationships with **Coastal Action** through collaborative decision-making bodies like the Sherbrooke Lake Stewardship Committee and Fox Point Lake Water Quality Monitoring Committee. The municipalities also retain Coastal Action's water quality monitoring services for priority sites in rivers, lakes and estuaries within their jurisdictions (E.g., LaHave River watershed, Sherbrooke Lake, Foxpoint Lake, Lunenburg Harbour). Coastal Action conducts long-term monitoring and sampling for special projects to identify water quality issues, establish a baseline, understand trends, and generate watershed assessments for decision makers. In these examples Coastal Action plays several roles: engineering consultant, hub for communications about community priorities and water quality concerns, and capacity extension for volunteer monitors.

The **County of Kings Volunteer Monitoring Program** is another example of a CBWM model designed to facilitate data use. The municipality funds and administers volunteer monitoring of 13 lakes on a monthly basis from May to October. The program is governed by a multi-stakeholder technical advisory committee and monitoring results are presented to council yearly for direct consideration in municipal planning activities with the objective of maintaining good lake health. Specifically, CBWM data inform zoning standards for the County of Kings' land use by-laws, including requirements for site plan approval and control for shoreline development.

Water management and planning

Water resource management decisions fall within provincial jurisdiction in Nova Scotia. In several cases, CBWM data have been used to support collaborative decision-making processes in priority watersheds, such as through the multi-stakeholder steering committees described above. Key provincial departments represented on watershed steering committees may include

but are not limited to Nova Scotia Environment, the Department of Lands and Forestry, the Department of Fisheries and Aquaculture, and Nova Scotia Power. The **Nova Scotia Salmon Association (NSSA)** reported use of water quality data collected through the network for multi-stakeholder decisions related to watershed planning, with a focus on the effects of land-based activities on soil and aquatic health. Specific activities here may include watershed characterization, aquatic habitat assessment and restoration, and fish species recovery. Government partners have also worked with the broader NSSA network to carry out and evaluate long-term field experiments. For example, NSSA participated in a catchment liming study in West River, Sheet Harbour. The project goal was to understand the potential for this treatment to mitigate freshwater acidification, and ultimately, help protect and restore Atlantic salmon populations.

Presence or absence of CBWM has also fed into management decisions about priorities and locations for new and ongoing provincial monitoring (E.g., Nova Scotia Lake Survey Program) and budget decisions for community engagement (E.g., where to subsidize volunteer monitoring).

Regulatory and compliance mechanisms

CBWM data have occasionally been used to direct enforcement actions in Nova Scotia. Monitoring of the LaHave River over years revealed levels of fecal bacteria well in excess of federal standards for safe recreation. These elevated levels were due in large part to illegal legacy straight pipe sewage systems. Data collected by Coastal Action and citizen scientists prompted enforcement of the Nova Scotia *Environment Act* through a $17 million cost-sharing straight pipe replacement program starting in 2018.

In a similar example, the **Clean Annapolis River Project's River Guardians** program reported finding high bacterial counts compared to normal conditions within the Annapolis River and its tributaries. After these data were reported, an investigation of a local wastewater treatment facility found it to be underperforming. The municipality then allocated significant funds to upgrade the plant and address contamination concerns.

In rare cases CBWM data have been used to inform regulatory actions in Nova Scotia. For example, in 2008 the **Tusket River Environmental Protection Association (TREPA)** reported algal blooms suspected to be in connection with mink farming in the southwest region of Nova Scotia. As a result of initial community observations, ongoing monitoring, and an effective advocacy campaign, the province passed the *Fur Industry Regulations and Fur Industry Act* in 2013. The regulations tightened environmental standards, particularly those related to waste disposal and farmland runoff.

Some of the decision-making processes described above directly and formally facilitate use of CBWM and other non-traditional data sources. Examples of formal pathways include terms of reference created for collaborative watershed steering committees and, in several cases, the

operating budgets of municipalities that contract CBWM groups to monitor local rivers, lakes, and streams.

Otherwise, CBWM data have been incorporated in decisions through informal working relationships between watershed groups, policy makers, and funders. Here, the data were used primarily for secondary applications, such as complementing government-led monitoring programs or identifying issues and contamination hotspots that need to be investigated through official pathways.

Where are CBWM data not being used in decisions?

We did not see instances of CBWM data being actively solicited or accepted for use in decision making involving permitting or approvals. For example, in Nova Scotia, source water protection planning is overseen by Nova Scotia Environment in direct collaboration with water utilities and municipalities. Community members are engaged as stakeholders on steering committees but not in monitoring and other operations.

Also absent from our interviews were examples of CBWM data being used for water decisions involving the courts or litigation.

How are CBWM data shared?

The decision makers we interviewed can generally access the water data and information they need (Figure 10). In some cases where water monitoring is tied directly to government objectives (E.g., source water protection planning), decision support systems are in place to facilitate compliance and enforcement.

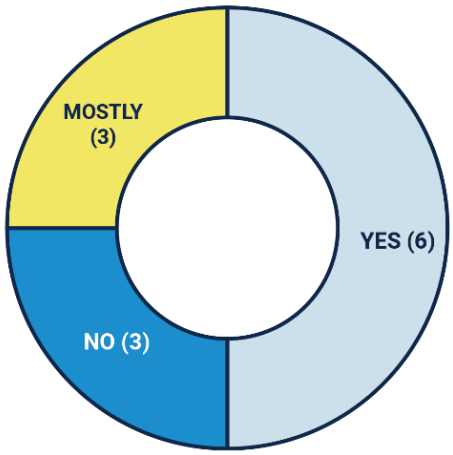


Figure 10: [Decision makers] Are you able to get the information you need?

When required for end uses like watershed assessment and modelling, decision makers – particularly those at provincial and federal levels – obtain raw CBWM datasets from project websites and open access databases (Figure 11).

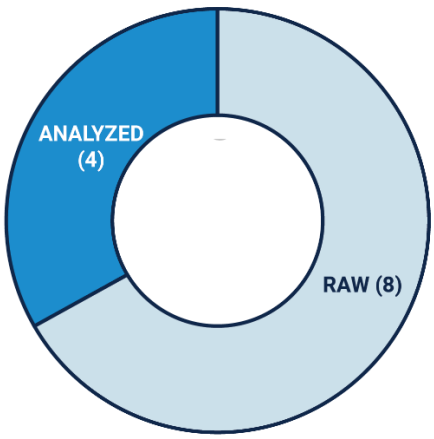


Figure 11: Format of CBWM data required for decision making

Most respondents were familiar with or actively use Atlantic DataStream and CABIN to store and share data. Detailed and comprehensive metadata can provide crucial information about data quality and was reported as an important requirement for use of any non-governmental data.

Some decision makers expressed a greater interest in obtaining synthesized data and information in the form of summary reports and watershed report cards rather than raw data, this was particularly true at the municipal level involving council-based decisions. Reasons provided for this preference included time constraints and the composition of councils, often lacking in members with scientific backgrounds.

Finally, decision makers indicated that consultant data (which occasionally includes CBWM data in aggregated formats) are under-shared and under-utilized. Respondents were keen to find methods to share consulting data to maximize its utility, enable potential use of nested CBWM data, and minimize duplication of monitoring efforts.

What additional data could be collected with significant investment in human and technical resources?

A secondary question explored in this research was whether there is a desire for more or different types of water data that could be collected by community-led monitoring efforts. Unsurprisingly, answers varied widely given the diversity of interviewees.

A few notable areas of overlap might point to directions for future collaborative work:

- Broader extents (spatial & temporal)
- Data for smaller lakes
- Flow and water levels
- Cyanobacteria
- More comprehensive information (E.g., include data about things like land use and climate)
- Groundwater (quantity & quality)

Barriers

Barriers to CBWM data use in water decisions centered around technical and practical limitations to operations as well as issues encountered during program setup.

Funding

While CBWM and citizen science can provide a more affordable means of collecting high-quality water data compared to the cost of government or consultant-led monitoring, it is not free. Some CBWM programs in Nova Scotia are volunteer run, but many employ full-time staff and require use of costly equipment and labs for sample analysis. A lack of long-term funding and support reflective of the true cost of CBWM is a barrier to maintaining long-term datasets, expanding programs to meet emerging needs, and retaining trained staff.

Scope and jurisdiction

Decision makers and CBWM groups commented on instances where the spatial or temporal extents of data collected might impede broader use. This could apply to project boundaries and monitoring locations, along with duration and frequency of sampling, among other considerations. A

tangible example mentioned in multiple interviews is a lack of data for small, rural lakes in Nova Scotia. This was explained as a result of a 'cottage effect' on how monitoring programs are designed; that is, the bulk of CBWM data are available close to where volunteer monitors and citizen scientists live, and in water bodies that matter to them (Millar, Hazell & Melles, 2019). The challenge of navigating funding partnerships across jurisdictions was another common concern for decision makers and CBWM representatives.

Data management, sharing, and quality

Both policy makers and community members commented that cleaning, formatting, and uploading data can be time-consuming and cumbersome. Capacity gaps both within government departments and among CBWM initiatives limit data sharing and use beyond its original intended application. For example, we heard of multiple instances where CBWM data collected for a specific funding program were not required to be shared publicly upon project completion – this presents a missed opportunity to glean new insights and generate secondary uses from the data.

While emerging technologies and online platforms have made it easier to share information from non-governmental sources, interviewees commented that accessing environmental data can feel like making a patchwork quilt. Decision makers expressed a desire for a comprehensive way to connect all CBWM data (E.g., water quality and quantity, fish species and diversity, weather, habitat).

Finally, even though many CBWM programs employ rigorous methods and are carried out by highly trained staff and volunteers – often in partnership with government scientists and academics – we found that some policy makers still question the credibility and quality of community-generated data.

KEY TAKEAWAYS

- **There is no single roadmap for how CBWM data are shared and used for decision making in Nova Scotia:**
  - Lack of clear guidance on which data are suitable for different types of decisions
  - Unclear policy 'entry points' for CBWM groups to share data for consideration and use beyond primary applications
  - Partnerships and program co-design with decision makers facilitates CBWM data-sharing within decision support systems for specific end uses
- **Potentially useful and quality controlled CBWM datasets are out of reach:**
  - CBWM data aggregated in environmental consulting reports
  - Contracts between CBWM groups and government clients with no public data-sharing requirements after project completion
- **Concerns about CBWM data quality persist, impeding broader use in water policy and planning**

DEVELOPING A NOVA SCOTIAN MODEL

The framework presented below is a visual representation of what we heard in the workshop, interviews, and webinar. The framework is not intended as a 'how-to'; rather, it is a tool that can be used for thinking through the relationship between CBWM and decision making. To make the framework, we drew on scholarship from around the world. In particular, we drew on:

- The Scottish Environmental Protection Agency (SEPA)'s concept of a decision-tree linking CBWM to decision making;
- The Chesapeake Bay Monitoring Cooperative (CMC)'s model of tiers of information, and;
- The United States Environmental Protection Agency (USEPA)'s spectrum of citizen science data uses.

Onto this existing work, we layered experiences and expertise of environmental decision makers in Nova Scotia in both government and in community-based water monitoring groups. The result is a visual that speaks to the Nova Scotian experience but that, we hope, is useful elsewhere.

How to use the framework

This framework is for use by CBWM groups, decision makers, funders, and anyone else interested in supporting, engaging, or carrying out community-based water monitoring.

- **Start at the top:** Why are you interested in CBWM data?
- **Go left:** If your objective is to inform water policy and decisions, what kind? See spectrum pg. 15.
- **Go right:** On the other hand, if your objective is to engage communities in water decisions but you don't have specific data needs, then CBWM still has an important role to play. Exploring opportunities for communication, collaboration and coordination with CBWM efforts can reveal surprising insights about watershed health and strengthen relationships between communities and decision makers.
- **Yes / no:** Then work your way through a series of questions to identify linkages between CBWM data and your program or departmental objectives. Roadblocks related to CBWM data availability, accessibility and suitability for policymaking can be further explored in the section about barriers (pg. 20) or problem-solved by considering our policy recommendations (pg. 24).

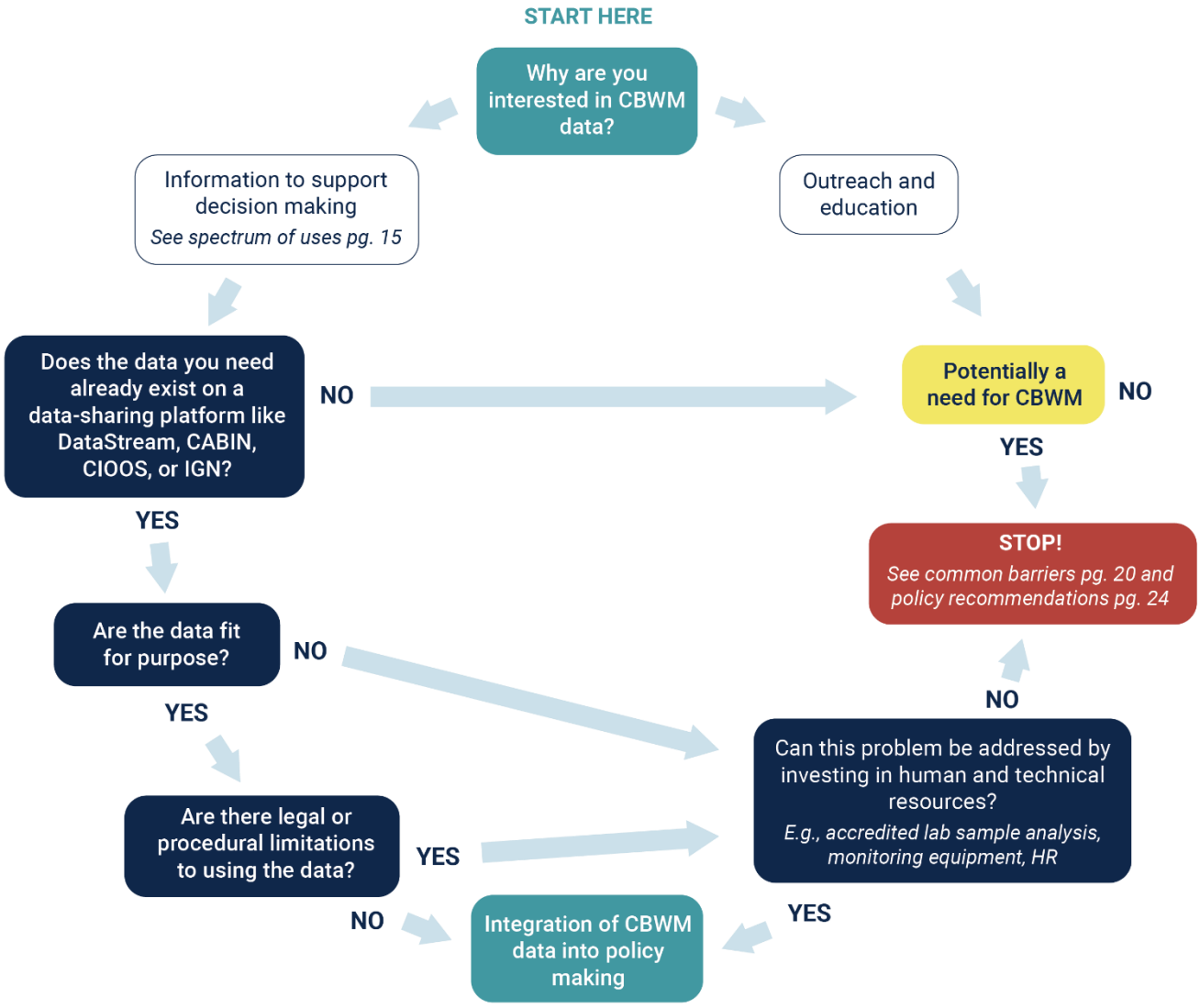


Figure 12: A suggested framework for thinking about how to connect CBWM data with water decisions in Nova Scotia

POLICY RECOMMENDATIONS

In addition to the framework above, we are making three policy recommendations on the basis of our research.

The first is to **require all publicly funded consultant work to make their water quality data available**. We heard from both governments and community groups that much of the data had been collected - sometimes multiple times - by consulting companies carrying out EIAs or other work, but that data was inaccessible because the data is protected by employee-employer privilege. Although governments cannot mandate that private entities share their data, there is precedent for mandating data-sharing arising from publicly funded activities. Academic research funded by one of Canada's three research agencies (the Canadian Institutes of Health Research, the National Sciences and Engineering Research Council, and the Social Sciences and Humanities Research Council), for example, must be publicly accessible. This recommendation could happen by including public access in all RFPs for publicly funded consultant work. Doing so would a) save community groups time and money by avoiding unnecessary duplication, and b) build a culture of data sharing among governments, community groups, and independent researchers.

The second policy recommendation is to **match the funding arrangement to the program outcomes**. Time and again we heard that the funding was a poor match to CBWM outcomes.

For example:

- A CBWM group seeking longitudinal data was only able to secure short-term funding;
- A CBWM group wished to monitor something – for example, phosphorus – that required specific and/or expensive equipment or analysis for which funding was not available;
- A government was seeking data that a CBWM group did not have the capacity to measure (for example, daily *E. coli* counts);
- A CBWM program focused on outreach and education could only get grants for specific equipment or testing activities, or vice versa.

By creating funding programs that address the lack of long-term funding, or that provide the financial or technical resources to meet a CBWM group's aims and/or governmental hopes for a given CBWM program would increase the likelihood of the data being used. The most significant obstacle here, of course, is funding, especially since one motivator for CBWM is the perceived cost savings.

Implementing this recommendation would require a circular relationship between CBWM groups and governments - something that is facilitated when the relationship is deepened with regular and data-rich contact.

The third recommendation is to **clearly communicate data quality requirements for different end uses**. Many CBWM groups are already taking important steps to maximize the utility of their data for different uses by adopting sophisticated monitoring protocols and following stringent metadata standards. However, clear guidance on data quality requirements would help increase the utility of CBWM for broader applications in Nova Scotia, particularly if there is any ambiguity around standards. For example, the US EPA and several states provide guidance and templates outlining quality assurance requirements for citizen science groups wanting to support government water decisions.

We caution here that CBWM groups should not be seen as less expensive consultant groups; instead, they are partners in water stewardship, with eyes and ears on the land and water in a way that governments are not able to do.

Although these recommendations respond to what we heard from CBWM groups and decision makers in Nova Scotia, these recommendations may be applicable to other jurisdictions. The second and third recommendations also align closely with policy directions developed for the federal government during a 2018 national roundtable on CBWM (The Gordon Foundation, Living Lakes Canada, and WWF-Canada, 2019).

FUTURE WORK

The work presented here suggests three different areas for future research. The first is on the legal potential and limitations of CBWM data. The work here touches on questions around data limitations and the purpose of data collection, but if CBWM is to be taken seriously as a source of robust data, then we must also consider the legal questions around its use. This research could address questions like: Can CBWM data be used as baseline data in Environmental Impact Assessments? Who is responsible if CBWM data is used to determine the safety of things like swimming, or fish consumption? Can CBWM data be used to show a violation of Treaty rights?

Second, we suggest that CBWM scholarship can - and indeed should - be used to cultivate more thoughtful relationships between Western and Indigenous knowledge with respect to water. There is already some great work being done here through, for example, the Indigenous Guardians Network and Decolonizing Water, and, of course more remains to be done, particularly around questions not only of what data are collected and where, but also around questions of how different kinds of knowledge are differently valued and recognized through CBWM programs.

Finally, we suggest that more work is needed on the question of tiers of water data. As suggested elsewhere in this document, other government-led environmental agencies have worked to develop models that match data use to data collection. Whether or not any future Canadian models use tiers, we suggest it would be useful to think about ways to align data needs with CBWM design and support.

REFERENCES

Cantor, A., et al. (2018). *Data for Water Decision Making: Informing the Implementation of California's Open and Transparent Water Data Act through Research and Engagement*. https://www.law.berkeley.edu/wp-content/uploads/2018/01/DataForWaterDecisionMaking.pdf

Carlson, T., Cohen, A., and Hartwig, K. (2017). *A Snapshot of Community Based Water Monitoring in Canada*. https://www.ourlivingwaters.ca/cbm_snapshot

Chesapeake Monitoring Cooperative. (2018). *Water Quality Monitoring Rubric for Tier Determination and Inclusion of Data in the CMC Database*. https://www.chesapeakemonitoringcoop.org/wp-content/uploads/2018/11/CMC-Water-Quality-Data-Rubric_6.18.2020.pdf

Green, L., Stepenuck, K., Herron, E., Deutsch, B., and Sigler, A. (2013). *Assessing the Needs of Volunteer Water Monitoring Programs*. https://blog.uvm.edu/kstepenu/files/2013/03/Inquiry_2012_Needs_Assessment_Summ.pdf

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J. & Bonn, A. (2018). *Citizen Science: Innovation in Open Science, Society and Policy*. London: UCL Press. https://doi.org/10.14324/111.9781787352339

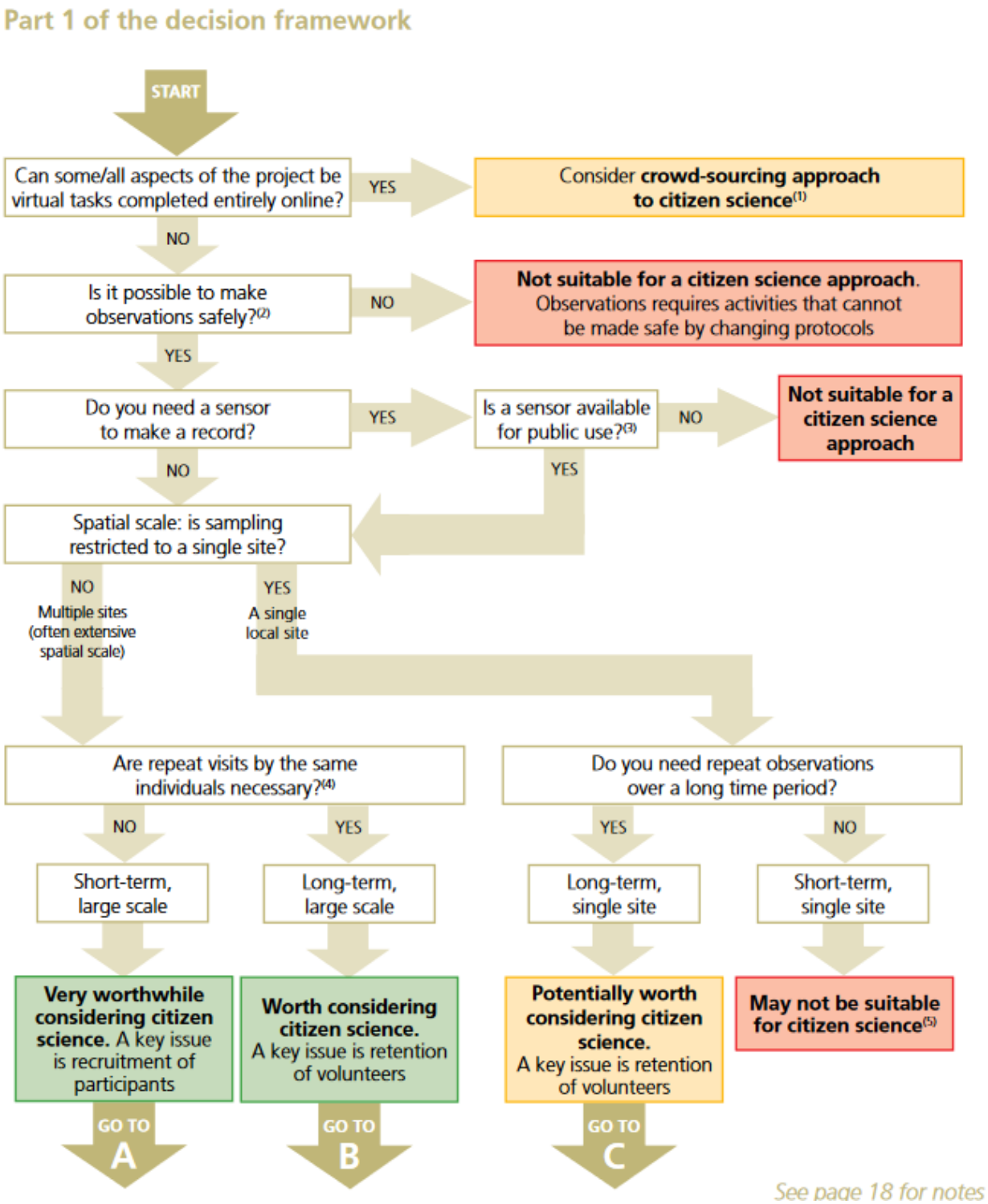
Millar, E., Hazell, E.C., and Melles, S.J. (2019). The 'cottage effect' in citizen science? Spatial bias in aquatic monitoring programs, *International Journal of Geographical Information Science*, 33:8, 1612-1632. https://doi.org/10.1080/13658816.2018.1423686

National Advisory Council for Environmental Policy and Technology (NACEPT). (2016). *Environmental Protection Belongs to the Public: A Vision for Citizen Science at EPA*. https://www.epa.gov/sites/production/files/2016-12/documents/nacept_cs_report_final_508_0.pdf

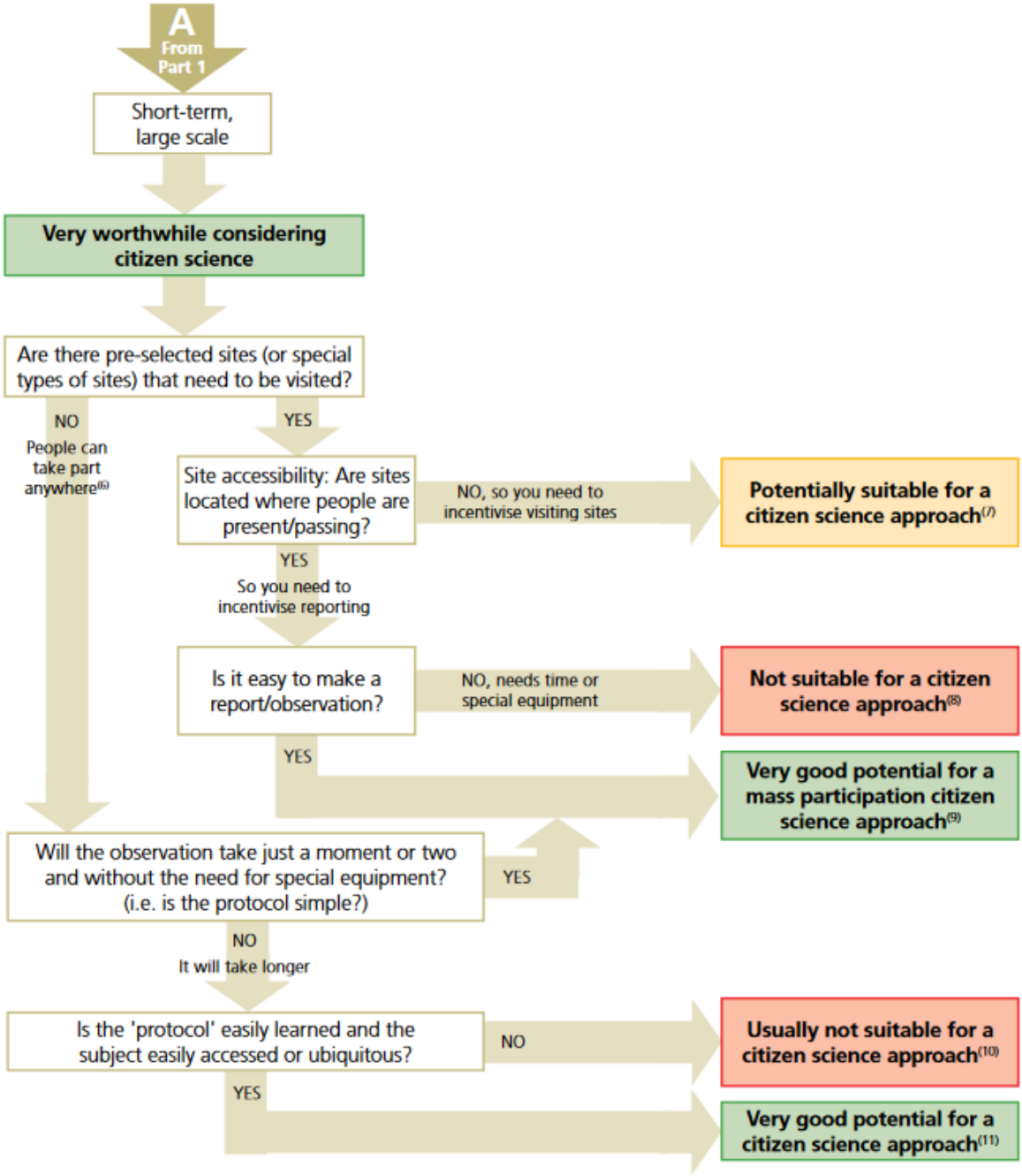
Pocock, M.J.O., Chapman, D.S.,Sheppard, L.J., and Roy, H.E. (2014). *Choosing and Using Citizen Science: a guide to when and how to use citizen science to monitor biodiversity and the environment*. Centre for Ecology & Hydrology. https://www.ceh.ac.uk/citizen-science-best-practice-guide

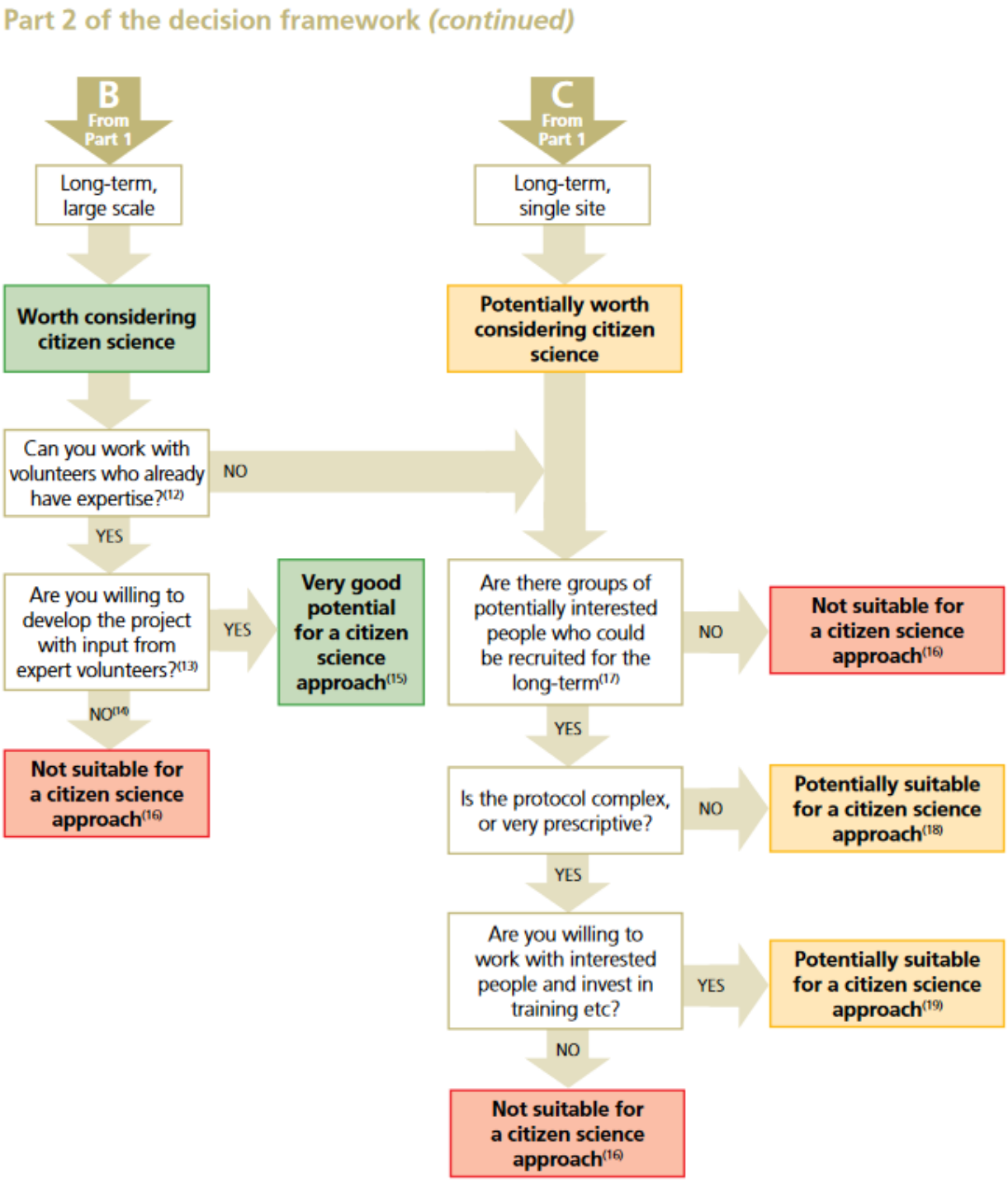
The Gordon Foundation, Living Lakes Canada, and WWF-Canada. (2019). *Final Recommendations: Elevating Community-Based Water Monitoring in Canada*. https://gordonfoundation.ca/resource/elevating-community-based-water-monitoring-in-canada/

APPENDIX A: SEPA - CHOOSING AND USING CITIZEN SCIENCE FRAMEWORK



Part 2 of the decision framework *(continued)*





To read the full report, visit:
https://www.ceh.ac.uk/sites/default/files/sepa_choosingandusingcitizenscience_interactive_4web_final_amended-blue1.pdf

APPENDIX B: CHESAPEAKE MONITORING COOPERATIVE - TIERED DATA USE FRAMEWORK

In the Chesapeake Data Explorer, datasets are classified into 3 tiers to help data users easily and quickly filter data and its potential uses. If data do not fit within the three tiers, they can be classified as *provisional*, *provisional tier 1*, and *provisional tier 2* to indicate the methods are comparable, but not exact. Data users need to examine the study design (if available), QAPP (if available), standard operating procedures, and equipment specifications of *provisional*-associated data to determine whether the data collected are suitable for the desired end use.

The tiers are determined based off of monitoring protocols, frequency, equipment, sample processing, and quality assurance, and apply to individual parameters not entire programs.

Minimum requirements in order for data to be assigned a tier level:

- Written study design (preferred, not required)
- Written Methods Manual
- Standard Field Data Sheet
- Documented site locations with latitude and longitude coordinates
- Collect samples at a specified sampling rate with an 80% completion rate

Tiers	Justification	Potential Data Use
Provisional	Program does not meet the minimum requirements.	Track groups collecting water quality monitoring data and to upgrade their methods and quality assurance processes into the Tiered Framework
Provisional Tier 1	Historic dataset that meets most of the QA procedures for tier 1 but may be missing an aspect because monitoring occurred prior to the CMC QAPP approval.	Tier 1 uses
Tier 1	Program meets minimum requirements and uses equipment that meet Tier 1 quality assurance standards.	Education, Environmental Health Screening, Targeting of Management Actions, Baseline Stream Health Assessment

Provisional Tier 2	Historic dataset that meets most of the QA procedures for tier 2 but may be missing an aspect because monitoring occurred prior to the CMC QAPP approval.	Tier 2 uses
Tier 2	Program meets minimum requirements and uses equipment that meet Tier 2 quality assurance standards.	Tier 1 uses and CMC Report Cards
Tier 3	Program completes an audit process and is approved by the Chesapeake Bay Program's Data Integrity Workgroup.	Tier 1 and 2 uses and Chesapeake Bay Watershed trends and assessments to help inform policy and management decisions.

For more information about the CMC's tiered framework, visit: https://www.chesapeakemonitoringcoop.org/wp-content/uploads/2018/11/CMC-Water-Quality-Data-Rubric_6.18.2020.pdf

APPENDIX C: INTERVIEW QUESTIONS

Decision makers

- Are you actively using any data – CBWM or otherwise – in your decision making?
- Where are you getting your (CBWM) data?
- What kinds of information are you looking for in making decisions?
- Are you able to get the information you need? Where do you find it?
- What data do you wish you had but cannot find?

CBWM groups

- (How often) Are you approached by any level of government about data use? (How)Do you know when your data is getting used?
- Typically, do you have the information that they are looking for?
    - If yes, do you share it?
    - If no, what are the obstacles to getting it?
- What information do you wish decision makers would use?
- What is the relationship between what you collect and what is getting used?