FOLLOW-UP AND MONITORING IN IMPACT ASSESSMENT

SYNTHESIS OF KNOWLEDGE AND PRACTICE

Suggested citation:

Noble BF. 2020. Follow-up and monitoring in impact assessment: Synthesis of knowledge and practice. Technical research report prepared for the Impact Assessment Agency of Canada. Ottawa, ON. 76p

EXECUTIVE SUMMARY

This report addresses four key questions posed by the Impact Assessment Agency, focused on lessons learned associated with follow-up and monitoring in impact assessment (IA), to support the Agency as it develops new and improves existing follow-up and monitoring methods and tools:

What have been the challenges, good practices and lessons learned with monitoring committees in IA?

Monitoring committees are increasingly common in IA. Monitoring committees can, among other things, enable coordination across siloed interests; ease implementation of management actions; increase knowledge about project impacts and local values; and provide an information base to improve future IAs. Monitoring committees are established for a variety of reasons and play one or more roles including project oversight, science and/or traditional knowledge-based data collection, and communications. Independence, transparency, and a balance of stakeholder interests and power are essential to the credibility and long-term success of monitoring committees, regardless of whether the mandate is science-based or a watchdog agency. Monitoring committees are most successful when there is a degree of independence but monitoring committees must not function in isolation of proponent or regulatory decision information needs – their long-term financial support can be difficult to justify.

There are examples of monitoring committees with clearly established linkages to regulatory and decision processes, but they tend to be designed from the outset with such goals and objectives in mind. Committees established for monitoring in absence of a clear mandate, objectives, or targeted monitoring questions can be short-lived initiatives. Monitoring committees require agreement on the questions to be pursued, the indicators of most importance, and how findings are to be used and by whom. Successful monitoring committees are characterized by balanced representation among stakeholders, communication, adequate and reliable resourcing, clear lines of accountability and transparency, mechanisms for dispute resolution, clearly articulated mandates and monitoring questions, responsiveness to new information needs, and active Indigenous engagement.

What types of indicators, methods and data standards have been used to monitor socio-economic effects?

There is no suite of socio-economic indicators and methods that is universally applicable; local context, values and objectives shape what to monitor and how. Indicators must be mapped to local priorities and values and developed through dialogue. Good practice suggests that indicators must be mutually reinforcing and allow for comparison of well-being over time and space. This requires a tiered approach to indicator selection to include indicators that are comparable across contexts, comparable within a community, and ones that are specific to the issues of local concern. Well-crafted monitoring questions are pre-requisites. But the tendency is to collect data now and think later, resulting in a laundry-list of indicators without *a priori* consideration as to why an indicator is being monitored and the utility in understanding trends or changes in that indicator.

Knowing the immediate and longer-term user information needs is critical to targeted and manageable monitoring programs; however, the information needs of end-users, and the specific questions they want answered through monitoring, are not always well-articulated – especially when setting IA follow-up conditions. The success of any monitoring program hinges on an established system of data governance that directs data policies and ownership. This is a pre-requisite to the operational needs of data standardization, ensuring that indicators (and data) are consistent, compatible, observable, detectable, adaptable, accessible, and usable.

What are typical criteria or principles that can be used to help determine the effectiveness of mitigation?

Determining the effectiveness of mitigation involves knowing: i) whether the proposed mitigation was implemented and is in compliance with established regulations or guidelines; ii) whether actual effects (predicted and unanticipated) were reduced to an acceptable level or avoided because of mitigation; and iii) whether desired outcomes were achieved within an acceptable timeframe and level of resource commitment. There is no clear, authoritative guidance on the best principles or criteria to determine the effectiveness of mitigation in follow-up. Determining the effectiveness of mitigation is context specific and depends on the valued-component of concern, the impact pathway, nature of the impact, and the goals or targets of the mitigation program.

Research and lessons from practice suggest that one of the main challenges to determining the effectiveness of mitigation is the lack of clarity in how mitigations are prescribed or formulated. Enduring challenges to following-up to verify the effectiveness of mitigation are mitigation actions or prescriptions that: are not clearly linked to an anticipated impact, are ambiguous in terms of how the mitigation will be implemented, lack specific timelines for implementation or system response, fail to identify a responsible party for implementation, lack specific benchmarks against which mitigation or system performance will be assessed, and lack appropriate financial resource commitments. These are fundamental and enduring challenges to IA practice across Canada that limit the ability to follow-up and verify mitigation effectiveness.

What type of institutional organization would allow the results of long-running follow-up programs to be used to inform future IAs and mitigation measures?

Institutional arrangements, more so than data per se, present the most significant opportunities and challenges to follow-up and translating results to future IAs. There is not a single type of institutional organization that is ‘best’ for all monitoring and IA support contexts. In practice, institutional organizations for monitoring and follow-up tend to adopt a distributed model, a one-window model, or an independent/exploratory approach focused on commissioned monitoring studies. A hybrid model may be most effective – a monitoring network with regional or component-specific expertise but coordinated by a centralized agency to ensure direct relevance of monitoring programs and data to decision needs. Independence and transparency are ensured by the network of participating organizations, which may include existing monitoring programs and university-based centers of excellence, and the oversight of a multi-stakeholder governance committee to determine and continuously evaluate the monitoring questions and indicators of concern.

Research and practice suggest that successful institutional organizations to support long-running follow-up programs are characterized by: a clear mandate and long-term organizational commitment; multi-stakeholder partnerships; carefully crafted questions and objectives that are scientifically tractable and developed through collaborations among scientists, managers, decision makers and other information users; openness and transparency in data; generation of information products that is useful to proponents, communities, and government decision-makers; and long-term vision, while being responsive to the emergence of new problems and information needs.

Recommendations

Four categories of recommendations are offered to support the Agency in its development of new and improvement of existing follow-up and monitoring initiatives and practices. These are explored in detail in the report and include:

Leadership on good IA practice

1. The Agency should lead the development of operational guidance (principles, templates, good-practice examples) and offer regular practitioner training on basic IA principles.
2. Whether internal to the Agency or through a third-party, the Agency should strengthen oversight and review of IA quality.

Standards for monitoring indicators and data

3. The Agency should identify a limited set of key indicators (biophysical, socio-economic) to be monitored in project IAs and by monitoring committees or other permitting authorities as applicable, such that a common baseline can be established for tracking regional change and informing future IAs.
4. The Agency should improve coordination of project IA terms of reference.

Enabling access to meaningful data

5. The Agency should establish a strategy for data governance.
6. The Agency should establish a centralized data repository or network of repositories for monitoring data.

Institutional arrangements to support monitoring

7. The Agency should, on a case by case basis, require by way of IA approval and permitting conditions the establishment of a local monitoring committee that engages both industry and communities in collaborative monitoring activities including project impact management oversight, data collection, and project and environmental performance reporting.
8. The Agency should establish a centralized monitoring agency to manage the types of monitoring activities (i.e. data collection, repositories) noted above.
9. The centralized monitoring agency or network should do more than serve as a repository and system for data management and coordination, it should also provide science leadership.

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1 INTRODUCTION

Follow-up under the *Impact Assessment Act* (*IAA*) means a program for "verifying the accuracy of the impact assessment of a designated project and determining the effectiveness of any mitigation measures." The *IAA* is explicit in the role of follow-up in encouraging improvements to impact assessment (IA) (sec 6(1)(n)). Under the *IAA* (sec 2(e)), the Impact Assessment Agency of Canada (the Agency) has the authority to establish monitoring committees for matters related to the implementation of follow-up programs and adaptive management plans. There is no further direction provided as to the nature of such monitoring committees, their governance, or principles to inform future IAs and understanding of effects to environmental systems.

The importance of follow-up to good IA is well documented in both legislation and scholarly literature. There are volumes of research on follow-up themes from monitoring design to community engagement and performance auditing, to name a few (e.g. Arts et al. 2001; Ramos et al. 2004; Noble & Storey 2005; Marshall et al. 2012; Biber 2013; Cronmiller and Noble 2018a). When done correctly, follow-up can transform IA from a static exercise in impact prediction and project approval to a dynamic system of impact management and learning (Arts et al. 2001; Morrison-Saunders et al. 2014). Some practitioners interpret follow-up to mean strictly ensuring that mitigation measures committed to are implemented and effective (Wlodarczyk 2000). The majority of IA scholarship, however, interprets follow-up as a more encompassing process, including monitoring, evaluation, management, communication, and, more recently, good governance (Pinto et al. 2019).

This report addresses four key questions posed by the Agency, focused on lessons learned associated with follow-up and monitoring in IAs, to support the Agency as it develops new and improves existing follow-up and monitoring methods and tools.

1. What have been the challenges, good practices and lessons learned with monitoring committees in IA, including for providing opportunities to local communities and Indigenous peoples enhanced roles in monitoring?
2. What type of indicators, collection methods and data standards have been used to monitor socioeconomic effects and why were they selected?
3. What are typical criteria or principles that can be used to help determine the effectiveness of mitigation in follow-up?
4. What type of institutional organization would allow the results of long-running follow-up programs to be used to inform future IAs and mitigation measures?

1.1 APPROACH

This report is organized around the four questions posed by the Agency. For each question, the following approach is adopted: **i)** a brief synopsis of key messages emerging from the scholarly literature relevant to the question; **ii)** snapshots of practice and guidance (where applicable), illustrative of different contexts and experiences; and **iii)** a knowledge synthesis that highlights key lessons.

The scope of knowledge and practice under each question is potentially broad. Attention is thus focused on the key (relevant) messages emerging from research, rather than summarizing the vast literature on follow-up and monitoring. The literature informing this report is also selective and informed by leading scholarly journals in the field, internationally recognized principles, and the author's experience. The focus is limited to project IA and on follow-up and monitoring principles and experiences that are of direct relevance to issues within the scope of project IA. Topics such as community-based monitoring where the monitoring program does not directly inform or stem from IA follow-up and monitoring, Indigenous knowledge systems, or follow-up for strategic assessment, for example, are outside the scope of this report.

There are many case studies of follow-up and monitoring to choose from – each of which depicts valuable lessons. This report does not inventory follow-up and monitoring programs in Canada; neither does it set out to systematically assess follow-up and monitoring programs to draw conclusions about the state of practice.

The case studies introduced in this report are purposefully selected to illustrate of a range of practice, experiences, and outcomes. Case studies are based primarily on the literature and other secondary sources, drawing on personal communications in some instances and also the author's previous engagement with some of the cases. In-depth interviews with monitoring committees or individuals involved in the various cases was beyond the scope of this work.

1.2 REPORT STRUCTURE

This report is presented in 7 sections, following the Introduction. Section 2 is a brief overview of follow-up and monitoring in IA. Sections 3 to 6 respond to each of the four questions posed by the Agency. Section 7 concludes with an overall synthesis and key recommendations to the Agency.

2 FOLLOW-UP AND MONITORING: A BRIEF OVERVIEW

Follow-up in IA is not new. Sadler (1987) reports on work commissioned by the Canadian Environmental Assessment Research Council in the mid-1980s, bringing practitioners together to discuss follow-up techniques and contributions. Follow-up and monitoring plays a critical role in maximizing the environmental, social and economic outcomes of a project, communicating a project's performance, maintaining a community's acceptance of a project, and promoting long-term learning and IA improvement (Noble and Birk 2011).

Follow-up in IA most often refers to the monitoring and evaluation of the impacts of a project or plan for the management of, and communication about, the environmental performance of that project (Arts et al. 2001). Most early definitions of follow-up in IA approached follow-up as a technical exercise, and rested on three pillars: monitoring, evaluation, and management (Munro et al. 1986; IAIA and IEA 1999; Morrison-Saunders and Arts 2004). In more recent years, however, communication and environmental governance have been added to this list as a cross-cutting characteristics of good follow-up (Pinto et al. 2019).

Successful IA follow-up and monitoring helps maintain a community's acceptance of a project during the construction and operations phase and provides proponents with an opportunity to deliver on promises made (Arts et al. 2001). Follow-up also alleviates knowledge-based limitations and uncertainties (Strangway et al. 2016) and promotes ongoing learning and IA process improvement. Learning through IA follow-up most often occurs at the micro-scale, focused on mitigation effectiveness and whether a project has had or is continuing to have adverse environmental effects (Kilgour et al. 2007). Learning at the micro-scale is important to project performance, determining whether project objectives were achieved, and detecting and responding to unexpected project impacts (Morrison-Saunders and Bailey 1999; Noble and Storey 2005). But learning can also occur at the macro-scale, tracking indicator change over time to help regulators, proponents, and practitioners improve future IAs and future project designs. Learning at the macro scale is important to understanding complex system behaviours and strengthening the overall science and models needed to support better IA predictions and management (Beanlands and Duinker 1983; Greig and Duinker 2011).

Generally, three parties are involved in IA follow-up (Morrison-Saunders and Arts 2004): the proponent, government agency or regulator, and the community or other independent persons or non-government agencies. Marshall (2004) reports that the pressures for IA follow-up are greatest where uncertainty in IA requires supplementation or where stakeholders require a controlling framework for the implementation of mitigation or impact management. However, Marshall notes that proponents sometimes enter into follow-up programs and agreements voluntarily, especially when there is a perceived benefit for risk management and earning a social license.

Increasingly, especially in Canada, bi-lateral or tri-lateral arrangements are emerging to support follow-up activities, with variable emphases on monitoring for learning in both communities and organisations, including capacity or competence building, development of joint actions to determine agreed outcomes, and application of lessons learnt (Mahanty et al. 2007). That said, no two follow-up programs are identical – even if undertaken in the same jurisdiction or for similar types of projects (Morrison-Saunders and Arts 2004). Follow-up programs, and how mitigation actions are verified, are often context specific and influenced by several factors including regulations and institutional arrangements, approaches and techniques, the environmental system(s) affected, resources and capacity, type of activity, level of community engagement or interest, past relations, and the commitments of the proponent – to name a few.

Notwithstanding the recognized importance of good-follow-up, research identifies a number of challenges to the efficacy of ex-post plans, including: inadequate budgets, human capacity, and implementation procedures (Jha-Thakur et al. 2009; Kosamu 2011; Gallardo et al. 2016); weak enforcement of provisions owing to limited connections between follow-up plans and the outcomes of regulatory decisions (Jones and Fischer 2016); unfocused monitoring programs or poorly articulated monitoring questions (Lindenmayer and Likens 2010; Wong et al. 2019); and limited incentives for ambient monitoring compared to compliance-based approaches (Biber 2011; Kilgour et al. 2007).

3 MONITORING COMMITTEES IN IA: PRACTICES AND LESSONS LEARNED

3.1 SCHOLARSHIP

Monitoring committees are increasingly common in Canadian IA and can play an important role in follow-up. The specific nature and composition of monitoring committees vary by project and jurisdiction (Card et al. 2014). The Columbia Power Corporation, for example, a British Columbia Crown corporation that owns and operates hydro power projects in the Columbia Basin, has established several monitoring committees comprised of a variety of stakeholders including members of local and regional governments, First Nations, special interest groups, businesses, and community members (Columbia Power 2013). In Nunavut, regional monitoring committees have been established to oversee multiple projects by multiple proponents, with the aim to provide a degree of continuity and consistency to socioeconomic data collection and availability.

Monitoring committees are usually established because of a regulatory licence condition, pressure from the public, or at the desire of a project proponent. Several scholars identify independence in monitoring and oversight as important to credible and effective follow-up (Morrison-Saunders and Arts 2004; Wessels 2013) – often emphasizing the importance of autonomous authorities for ensuring accountability to monitoring results and public confidence in the process (Diduck et al. 2012). At the same time, research speaks to the importance of multi-party participation in monitoring, including industry and regulators, to ensure informed and focused follow-up that is relevant to project operations and to decision making needs (Marshall 2005; Wong et al. 2019).

A recent analysis by Andronak (2017) reports that monitoring committees are often well-positioned to offer technical expertise to support a proponent's follow-up and monitoring initiatives, including the design and implementation of a monitoring program and reviewing aspects of project performance that may require improvement. Monitoring committees can also play less of a technical role and focus instead on facilitating dialogue between a proponent and stakeholders, including Indigenous groups, or serve as a resource to identify public concerns and promote education about a project and monitoring results. The Port of Vancouver, for example, has established four community liaison committees that "bring together diverse community stakeholders to facilitate discussions about port-related impacts" (Port of Vancouver 2015). In some cases, monitoring committees provide oversight of proponent's or government's monitoring program or commitments or both – such as the Ekati diamond mine's Independent Environmental Monitoring Agency.[1]

A scan of the literature indicates that there is no best arrangement, or purpose, for long-term follow-up and monitoring committees. Monitoring committees (programs and initiatives) vary based on the objectives they are

[1] See https://monitoringagency.net/

indented to achieve, the parties involved, and the processes they are deigned to establish. Based on Morrison-Saunders et al. (2003) and Wessels (2013), there is a spectrum of models for follow-up and monitoring:

- Proponent or industry led, focused on self-verification or project performance and self-reporting, which may engage communities or other stakeholders to varying degrees, at the discretion of the proponent.
- Government agency led, focused on compliance with IA approval conditions and, in some cases, general state-of-the-environment monitoring to provide feedback to proponents and inform future assessments.
- Community or other independent body, focused on evaluating the performance of both proponents or industry and government agencies and, in some cases, data collection and analysis.

These models are not mutually exclusive, and neither do they capture the diversity of monitoring committees. Monitoring committees can play an important technical role in the design and implementation of monitoring programs and do so in collaboration with project proponents; in other cases, they operate independently of both the proponent and the regulator. Independent or 3rd party monitoring committees sometimes serve only a watchdog role, representing a community's interests without being directly engaged by the proponent or the regulator (Andronak 2017). In other cases, independent monitoring committees coordinate monitoring activities that engage industry, government, and communities; act as a liaison with communities; and even engage directly in data collection and analysis.

The potential benefits of collaborative approaches to monitoring, such as environmental monitoring committees, are well documented in the literature (e.g. Ross 2004; Diduck et al. 2012; Andronak 2017). Such benefits include opportunities for engaging (and empowering) Indigenous communities, providing feedback to inform decisions and improve project performance, transmitting information about monitoring results to communities and stakeholders, and adding legitimacy to the project and monitoring process (Irvin & Stansbury 2004; Hunsberger et al. 2005; Andronak 2017; Cronmiller and Noble 2018a; Morrison-Saunders 2018). Morrison-Saunders and Arts (2004) suggest that for proponents, monitoring committees can help protect them from liability, maintain community acceptance, ensure better project management, and establish a green profile. For government agencies or regulators, monitoring committees and programs can validate compliance, ensure mitigation actions are implemented and performing, and build relationships with proponents and communities. For communities and other stakeholders, engagement in monitoring committees can provide knowledge about actual impacts, reduce uncertainties, ensure accountability over proponent and government actions, and establish a sense of ownership or control of project outcomes.

In principle, literature indicates that monitoring committees can, among other things, enable coordination across siloed interests; ease implementation of management actions; increase knowledge about project impacts and local values; and provide an information base to improve future IA practice. However, Larson et al. (2010) suggest that evaluating the effectiveness of monitoring committees and other forms of collaborative and participatory monitoring arrangements is difficult given the diversity of actors and values involved across programs and projects. Syme and Sadler (1994) suggest that such evaluations must be contextualized based on agreed-upon criteria for determining success as defined by those involved. As a result, Larson et al. (2010) report that good practices can be difficult to distill and evaluations have thus largely focused on "on-ground changes in bio-physical parameters as indicators of success" (e.g. Carr 2002; Larson and Smajgl 2006; Wallington and Lawrence 2008) – which may overlook the broader, often more subtle, benefits of monitoring committees.

Where such evaluations have occurred, reviews about the effectiveness of monitoring committees have been mixed (Macleod Institute 2000; Borjeson et al. 2006; Fish et al. 2011; Cronmiller and Noble 2018a). Eastwood et al. (2017) report that these types of approaches do not necessarily lead to improved environmental performance or to better outcomes for communities. Eastwood et al. (2017) identify several factors that hinder or constrain such participatory approaches, including the ability of more powerful and influential actors (e.g. industry proponents, a regulatory agency) to set agendas and veto decisions; a lack of organisational capacity and resources to ensure meaningful engagement of all members; stakeholder disillusionment about the impacts of monitoring on decisions and project operations; poorly conceived governance structures; limited duration of funding; and sustaining the initial enthusiasm to engage in the activities of monitoring committees (see also Blackstock et al. 2012; Waylen et al. 2015; Cronmiller and Noble 2018b; Muir 2018).

Additional challenges are often faced when engaging Indigenous groups in monitoring committees. Aside from the longstanding challenge of bridging different knowledge systems (Baker and McLelland 2003; Booth and Skelton 2011; Berkes 2018; Muir 2018; CCA 2019), other challenges identified in literature include power imbalance – a concern identified by Lawe et al. (2005) and Cronmiller and Noble (2018a) for certain monitoring committees in the Athabasca oil sands region; a lack of trust in the general monitoring process; inadequate community involvement in designing follow-up monitoring programs and helping shape the questions asked (and answered) through monitoring; the lack of involvement of community members in data collection; and high committee membership turnover (Noble and Birk 2008; Affolder et al. 2011).

3.2 PRACTICE

The following sections describe a small sample of monitoring committees and programs in Canada. The cases are meant to be illustrative of different approaches, practices, institutional arrangements, and outcomes. They were purposively selected to provide a snapshot of different approaches to and mandates of monitoring committees. Some of the committees profiled have explicit science-based monitoring mandates, whereas others are primarily oversight committees. Some are comprised of only industry and community membership, whereas others also involve government. The degree of independence also varies across cases. For each case, the monitoring committee or initiative is described, including its context and mandate, followed by its institutional arrangement, Indigenous engagement and funding (where applicable), and data management and reporting. Key observations are then made for each case that synthesize the practice and lessons learned. The cases are based primarily on secondary sources.

3.2.1 Wood Buffalo Environmental Association

The Wood Buffalo Environmental Association (WBEA) is an independent, partnered monitoring initiative in the Wood Buffalo region, north-east Alberta. Initially a task force, formed in 1985 by the province and industry in response to air quality concerns raised by the Fort McKay First Nations regarding oils sands activities, WBEA was formally established in 1997. WBEA is responsible for the ownership and operation of an air quality and deposition monitoring network in the Wood Buffalo region. WBEA operates in partnership and under contractual agreement with Alberta's Environmental Monitoring and Science Division and contributes data to

the provincial Oils Sands Monitoring Program. WBEA is focused on independent scientific monitoring. Its objectives are to build and maintain capacity for state-of-the-art environmental monitoring; support opportunities for stakeholder engagement and the development of strategic partnerships; demonstrate a commitment to traditional knowledge as an important source of knowledge and information; and establish socially and fiscally responsible business practices. WBEA monitors multiple indicators of ambient air quality and pollutant concentrations, as well as deposition monitoring through a long-term forest health monitoring program and an atmospheric pollutant deposition monitoring program.

Institutional arrangement: WBEA is comprised of a 38-member network of government (federal, provincial, and municipal), industry collaborators, environmental non-governmental organizations, and Indigenous groups. Members share a common mandate; however, for most industry participants, WBEA membership is part of a government requirement for regulatory compliance. Internally, a general members board and governance committee provide strategic direction and oversight for the association, while technical committees determine the strategic plans and direction for each of the WBEA's monitoring programs.

Indigenous engagement: As an independent community-led monitoring program, the WBEA collaborates with Indigenous communities. A traditional knowledge committee coordinates long-term, traditional knowledge-based, community monitoring programs. The community monitoring programs were created in response to concerns regarding changes in the quantity and quality of certain wild foods growing on traditional lands within the region. The program is designed to "twin" traditional knowledge and western science in environmental monitoring. In 2017, WBEA released the Community Odour Monitoring Project app for smartphones to allow anyone in the region to submit data related to odours observed in the air. Observations are combined with ambient data collected from air monitoring stations to increase understanding of air quality events identified by, and of concern to, the public.

Funding: WBEA is a registered non-for-profit organization, funded primarily by the province through the Oil Sands Monitoring Program. Based on its 2018-19 financial statement, WBEA's annual monitoring (ambient air, deposition, odor, traditional knowledge), data management, and administrative expenses were approximately $9.75 million[2]. Concerns have been raised by WBEA regarding insufficient funding to improve on certain aspects of the air quality monitoring network, including new equipment and program expansion.

Data management and reporting: Providing transparent and accessible data is one of the stated core values of WBEA. The organization operates and maintains digital data management system to make data available to stakeholders and the public. Each of WBEA's continuous air monitoring stations generates thousands of data points daily. Data loggers collect and transmit this data for storage in WBEA's central database for processing and quality testing before the generation of monthly compliance reports and distribution of data reports to all WBEA members and government. WBEA air monitoring data are available in an on-line database, managed by the province, which includes all of Alberta's ambient air quality data.

[2] https://wbea.org/about/financial-reports/

- **WBEA is recognized as a scientifically defensible monitoring program and is one of the more extensive integrated air and terrestrial monitoring system in Canada.**
- **Notwithstanding its large membership and regional scale, WBEA is a highly focused and targeted monitoring program. WBEA's targeted and standardized approach to data collection, adoption of indicators of relevance to decision makers, and quality-controlled monitoring data, mean that the program has been successful in linking-up with larger provincial frameworks and processes. WBEA's monitoring activities inform the air quality management framework under the Lower Athabasca Regional Plan.**
- **Although science-based, with specific monitoring priorities, a major success of WBEA is its responsiveness to local community concerns. This is reflected by the establishment of a number of Indigenous-led monitoring programs or studies responding to emerging community concerns about impacts to traditional foods, and the release of a smartphone app to collect public reports of air quality concern that are used to interpret and understand the significance of data from air quality monitoring stations.**
- **WBEA has been subject to several scientific reviews, which have been largely positive and report effective relationships with stakeholders and communities.**
- **Concerns have emerged about constrained funding to continuously improve monitoring program design and data collection instruments, emphasizing the importance of not only long-term support for data collection but also the need for resources to ensure continuous program improvement.**

Case study sources: Lott and Jones (2010); OSAP (2010); RSC (2010); Percy et al. (2012); CASA (2016); Wood Buffalo Environmental Association (2018); Wood Buffalo Environmental Association (2019); Cronmiller and Noble (2018a)

3.2.2 Alberta Biodiversity Monitoring Institute

The Alberta Biodiversity Monitoring Institute (ABMI) is an independent monitoring organization, jointly implemented by the universities of Alberta and Calgary, Alberta Innovates, and Royal Alberta Museum. ABMI monitors biodiversity based on species and habitat at more than 1,600 sites across the province. ABMI monitors change in wildlife and habitats (over 3,000 species) including terrestrial (e.g. plants, ecosites, soils) and aquatic components (e.g. water chemistry, wetlands), and measures and reports trends in biodiversity and human footprint. ABMI's goal is to provide scientific information on the state of Alberta's biodiversity to support natural resource and land-use decisions. ABMI was conceptualized in 1997 by a group of resource managers and scientists in recognition of a gap in knowledge for managing biota. It was incorporated as a non-profit in 2007.

Institutional arrangement: ABMI operates as an independent, arms-length corporate entity. It often collaborates with academic researchers, governments, First Nations, and industry to develop projects to address ecological issues and informs land use planning—such as its ecosystem services assessments. ABMI is member-based and currently has 13 members, including Alberta Environment and Parks, Alberta-Pacific Forest Industries Inc. ConoPhillips Canada, Encana Corporation, and the Nature Conservancy of Canada to name a few, who appoint a board to oversee operations. An external, international science committee provides oversight and strategic

recommendations on science decisions. ABMI is a distributed system, with each unit housed with one or more of ABMI's delivery partners - University of Alberta, InnoTech Alberta, and the Royal Alberta Museum[3]. ABMI operations is comprised of an Executive Office (interface between partners); Monitoring Centre (field data collection and verification); Processing Centre (specimen processing and storage); Science Centre (scientific auditing, advancing methods, training); Information Centre (facilitates access to information, communications, manages data); Geospatial Centre (develops footprint information, delivers and maintains geospatial data); and Application Centre (assesses ecosystem services, supports planning needs, consults on projects)

Indigenous engagement: Indigenous engagement is not a mandate of ABMI, although ABMI may partner with Indigenous groups on a project-by-project basis. There is no formal Indigenous representation on the board.

Funding: Long-term, stabilized funding has been a major challenge. ABMI's total budget for the 2017-18 fiscal year was approximately $12.9 million, funded by Oil Sands Monitoring, government of Alberta, program revenue from the ABMI Application Centre, private sector, and the federal government.[4]

Data management and reporting: ABMI data are open access and available online through a data portal, but specific monitoring locations are not public. ABMI is undergoing reorganization in data reporting to include regular trends analysis and reporting on human footprint data for defined regions of the province, and state of environment reporting for the Oil Sands Region. The new data interface will allow users to select relevant metrics (e.g. biodiversity intactness) and generate customised reports.

- **Scientific credibility is a key attribute of ABMI. This is ensured, in part, by an independent, scientific advisory committee that reviews of ABMI's monitoring designs and science decisions.**
- **ABMI's distributed delivery model allows it to capitalize on the strengths offered by each of its partners. This, in turn, helps facilitate more efficient delivery of data services.**
- **Standards and protocols for data collection and information management ensure consistency and comparability of monitoring data over space and time. Monitoring protocols and quality management plans are publicly available with all monitoring data.**
- **Large-scale monitoring programs require a large number of samples over many years to detect change. These are long-term commitments that require long-term financial support to track change and maintain a consistent methodology over time.**
- **Long-term monitoring initiatives must still be responsive to more immediate stakeholder information needs. Despite its credibility, ABMI has received some criticism (government, industry) for being an unfocused monitoring program, owing in part to the large number of indicators, and not meeting more immediate management and decision-maker needs. In response, ABMI conducted a stakeholder needs assessment to re-evaluate the extent to which it generates information products that are relevant and accessible to stakeholders.**

Case study sources: Huot and Grant (2011); ABMI (2015); ABMI (2016); AITF (2016); Cronmiller and Noble (2018a); Council of Canadian Academies (2019); Personal communication – ABMI

3 Figure source: https://www.abmi.ca/home/about-us/organization-centres.html

4 Based on ABMI's financial statement, available at https://www.abmi.ca/home/publications/501-550/545

3.2.3 Regional Aquatics Monitoring Program

Established in 1997, the Regional Aquatics monitoring program (RAMP) was a multi-stakeholder science-based monitoring program to further scientific understanding of aquatic ecosystems in the oil sands region, and to monitor the aquatic environment for potential effects related to industrial development. Included amongst RAMP's objectives were to monitor aquatic environments to detect potential effects and identify regional trends; collect baseline data to characterize natural variability in the aquatic environment; assess the accuracy of predictions in regulatory IAs; satisfy the monitoring required by regulatory approvals of oil developers; incorporate traditional knowledge into monitoring; and communicate monitoring results. Data collected from the Athabasca River and its tributaries, the Athabasca River delta, and regionally important lakes and wetlands included climate and hydrology, water quality, benthic invertebrates, sediment quality, fish populations, and acid sensitive lakes. A main driver for the formation of ramp was realization of the potential to streamline and improve monitoring activity in the oil sands region, based on a realization that duplication was occurring by oil sands operators in terms of their effects monitoring programs. The program contributed to improved integration of aquatic monitoring across the region and the identification of long-term trends. RAMP operated until 2012, when it was absorbed into the federal–provincial Joint Oil Sands Monitoring Plan.

Institutional arrangement: RAMP was governed by a multi-stakeholder steering committee comprised of 19 industry members, 2 First Nations and 1 Metis members, and 8 federal, provincial and municipal government agencies. The steering committee prioritized monitoring projects, managed the program's budget, reviewed performance against the programs' objectives, and communicated results. A technical committee, comprised of industry, government, communities, and consulting teams, were responsible for recommending monitoring programs and collaborating with an investigator team that carried out monitoring and ensured integration of data. A communications coordinator helped communicate results to local stakeholders and the scientific community.

Indigenous engagement: RAMP was a science-based monitoring program, focused on understanding long-term trends in aquatic systems. Indigenous groups comprised 3 of the 30-member program steering committee.

Budget: RAMP was funded by the Oil Sands Development Group, driven largely by industry partners. RAMP's budget in 2012 (its final year of operation) was $5.3 million – an increase of approximately $1.6 million over the previous year, and about $4.5 million above its first three years of operation.[5]

Data management and reporting: RAMP's data are accessible online through an open data portal (though far from user friendly), which allows for data queries related to hydrology, water quality, sediment quality, lake acidity, fish population, and benthic invertebrates. A web-based mapping system provides limited access to spatial data sets that include information on land use change and watershed boundaries as context to monitoring data. Data entered to RAMP's dataset were reviewed and quality controlled by a managing consulting team to ensure long-term data consistency and quality.

[5] http://www.ramp-alberta.org/ramp/terms+of+reference/ramp+budget+history.aspx

- Although established as a multi-stakeholder science-based program, RAMP suffered significant credibility challenges. Reports from RAMP largely concluded that the environmental impacts of oil sands development were negligible, which did not align with the experiences and concerns raised by local communities and Indigenous groups and the work of some independent scientists.
- RAMP's credibility was highly suspect by some members of the scientific community. The credibility problem was not so much the differences in science per se, as it was the limited transparency of RAMP's data, analyses, and monitoring protocols. This was exacerbated by perceptions that RAMP was industry controlled – given its largely industry-based membership.
- In a highly contested resource development context, industry-led or dominated monitoring committees such as RAMP can become easy targets and highly politicized – especially when there are differences between the monitoring results reported and the experiences of affected communities.
- Consistency in membership and administration are important to the long-term viability and credibility of monitoring committees. RAMP was troubled by inconsistent administration as new stakeholders came on board, which contributed to inconsistent financing, the absence of clear leadership, variable access to monitoring data, and monitoring studies of varying quality.

Case study sources: Kelly et al. (2009, 2010); Lott and Jones (2010); Donahue (2011); RAMP Review Panel (2011); Schindler (2013); Wallace (2013); Hodson (2013); Cronmiller and Noble (2018a); Personal communication: K. Munkittrick

3.2.4 Diavik Environmental Monitoring Advisory Board

The Diavik Environmental Monitoring Advisory board (EMAB) is an independent monitoring board established in 2001 to oversee the environmental monitoring of the Diavik diamond mine, NWT. The board is the result of a legally binding Environmental Agreement to ensure that the mitigation measures identified in the project's IA report were implemented and that adverse impacts are not occurring. EMAB does not conduct monitoring; it is an arms-length public watchdog of the regulatory process and the implementation of the terms of the agreement. Included amongst EMAB's responsibilities are reviewing environmental programs, reports, protection measures, compliance or monitoring reports, and data on environmental quality and providing recommendations on such reports; providing recommendations on the participation of Indigenous peoples and affected communities in monitoring programs; providing recommendations and facilitating implementation regarding the need for and design of traditional knowledge studies; facilitating programs to provide information to affected communities and the general public; providing a publicly accessible repository of information; providing a role for Indigenous peoples in the review and implementation of Diavik's environmental monitoring plans.

Institutional arrangement: EMAB is comprised five Indigenous representatives, three government members, and one Diavik representative – all parties to the agreement. EMAB operates independently from Diavik and other parties to the agreement but plays an important role in facilitating communication between the members. EMAB makes recommendations to Diavik, the regulators and other parties to the agreement. Recommendations are made when regulators raise issues, or when regulators and Diavik disagree on an issue or fail to address

environmental issues the board has prioritized. The agreement also that all recommendations made by EMAB are given full consideration and regulators and Diavik must respond within 60 days to address the issue raised or provide reasons for inaction.

Funding: EMAB functions as a non-for-profit society of the Northwest Territories. The organization is funded primarily by Diavik Inc. In the first two years of its operation, EMAB's annual budget was $800,000, with Diavik contributing $600,000, the Government of Canada $150,000, and the Territorial Government $50,000. A recent budget reported for EMAB in the fiscal year 2017-2018 was set at $531,840.

Indigenous engagement: EMAB serves as a conduit for Indigenous communities regarding Diavik's environmental performance, and the board itself is comprised of members appointed by each Indigenous government signatory. To address community concerns related fish health in the Lac de Gras, communicated to EMAB, Diavik established a community-based monitoring camp to actively monitor fish health in the region. In part through EMAB oversight, Diavik has strengthened its commitments to traditional knowledge in its environmental monitoring and management plans. This includes, among other actions, integration of traditional knowledge as part of Diavik's wildlife monitoring program design for Caribou habitat assessment. Guidance provided by community elders have been used in the selection of specific sampling sites for the vegetation and lichen monitoring program.

Data management and reporting: EMAB does not manage or maintain an extensive in-house data system; rather, it reviews Diavik's monitoring programs and management plans (e.g. water monitoring plan, aquatic effects monitoring program, air quality monitoring plan) and provides feedback and recommendations for action. Diavik's monitoring plans and reports are accessible through EMAB's library and website, ensuring access to the public and affected communities. EMAB does not quality control monitoring data per se, nor make raw data available.

- **EMAB is modeled after previous successful monitoring committees in the NWT (e.g. Ekati Independent Environmental Monitoring Agency), and there has been some success in facilitating the sharing of information and experience across committees.**
- **EMAB's independence, Indigenous membership, and establishment under a formally binding environmental agreement, ensures stronger oversight and adds an additional layer of social responsibility to ensuring compliance with the terms of the agreement. When a recommendation is made, Diavik and the regulators must respond within a set time frame to address the issue raised, which becomes part of the public record of accountability.**
- **Like many independent *watchdog* agencies, EMAB's role is not monitoring but rather reviewing project and regulatory performance and commitments and making information available to communities. This is an important role and helps ensure transparency in impact management and project performance; it does not contribute to monitoring per se and such organizations cannot replace the role of monitoring (i.e. data collection, analyses, trends reporting) agencies or programs.**

- **EMAB operates as an independent organization, but the bulk of its budget is provided by the project proponent, Diavik. Long-term, stable funding is a concern. EMAB regularly negotiates its annual budget with Diavik and in recent years EMAB's funding has been reduced. An important feature of the binding agreement, however, is that when EMAB and Diavik cannot agree on EMAB's budget a budget can be set by the federal Minister of Crown-Indigenous Relations and Northern Affairs Canada. This results in a mediated (and in one case, arbitrated) decision, the results of which have been reductions in EMAB's budget from $726,000 in 2011 to $487,140 in 2017. Even under formal, binding agreements securing long-term financial support for monitoring and follow-up activity can be challenging.**
- **The large degree of financial reliance on the project proponent to sustain its operations has raised some concern amongst EMAB's members about its ability to operate as a truly independent organization (i.e. controlling its own budget) and to carry out its mandate unfettered.**

Case study sources: Affolder et al. (2011). Environmental Monitoring Advisory Board (2017); Environmental Monitoring Advisory Board (2018).

3.2.5 Ni Hadi Xa, Gah cho Kue

Ni Hadi Xa (NHX) is an Indigenous-led, arms-length monitoring committee established in 2014 for the Gah cho Kué Diamond Mine, NWT. The committee was formed by way of a legally binding stewardship agreement between six Indigenous nations and De Beers Canada. The focus is on environmental monitoring and traditional knowledge monitoring. NHX was established following a decision by the parties involved on the need to provide monitoring support for those communities impacted by the mine's operations; to build positive relationships between the communities and the mine; and to provide a forum for community engagement in monitoring and management. Included amongst the NHX's objectives are to provide ongoing review of environmental monitoring programs and management plans; ensure Indigenous participation in environmental management and promoting traditional knowledge in monitoring; prioritize environmental issues and make recommendations to De beers; provide a formal mechanism to ensure De Beers' commitment to the agreement; and communicate about the mine and monitoring activities and reports.

Monitoring is comprised of three components: i) NHX has an environmental monitor who works at the mine site within the De Beers environmental team as an observer and reports back to NHX. The environmental monitor in engaged in water quality sampling; air quality sampling; soil sampling; wildlife surveillance; fish studies; site inspections; and spill and equipment assessments and reporting. ii)Technical reviews of the mine's monitoring and management plans (e.g. water license and land use permit amendments, aquatic effects plans, operating procedures for archaeological finds) are undertaken by both in-house resources and external third-party experts. iii) Traditional knowledge monitors (NHX employees) regularly observe and monitor change on lands close to the mine site.

Institutional structure and composition: NHX has a governance committee, which is its decision-making authority. The committee is comprised of seven land and environmental specialists: one appointed by each of the six Indigenous members, and one representing De Beers. All decisions are passed by motion and NHX operates

on consensus-based decision-making. Each nominee to the committee must have experience and be involved in land and environment matters, as well as regulatory matters. The appointment of specialist members means that the Indigenous communities benefit from collaborative decision-making while being represented by individuals with expertise and able to communicate directly with leadership.

Funding: NHX is primarily funded by De Beers Canada. In 2018, NHX reported an operating budget of $599,725. The annual budget has steadily increased to allow for program innovation, including a recent increase in funds for a traditional knowledge monitoring program.

Indigenous engagement: The NHX environmental monitor at De Beers is described as NHX's "eyes and ears" on site and is responsible for reporting to the NHX governance committee. A traditional knowledge monitoring framework guides the collection, recording, and reporting of Indigenous experience on the land. NHX employs a small team of traditional knowledge monitors who undertake monitoring activities through observations and data collected over an approximate 12-week per year period on the land near the mine; and through observations and data collected by community members participating in the On-the-Land Travel Program (OTLTP) – a program that provides an opportunity for parties to the agreement to engage in research and monitoring in an on-the-land setting, the goal of which is to strengthen and maintain cultural knowledge of the land, water, wildlife, plants and resources around the mine site. Additional community engagement includes meetings with community elders, information booths at community events, dissemination of annual reports, and public demonstrations led by traditional knowledge monitors

Data management and reporting: NHX does not manage an extensive monitoring database. Its annual reports and program reviews, and other reports related to the monitoring agreement are housed on the organization's website.

- **NHX provides an additional layer of oversight, over and above the regulatory instruments that govern Gah cho Kue, and forms part of a broader engagement initiative with Indigenous communities. NHX illustrates the value of binding agreements for monitoring between communities and industry, but also that such initiatives can function in absence of government participation – when there is a genuine interest for mutual collaboration.**
- **Like most monitoring watchdog initiatives established between proponents and communities, emphasis is on oversight and opportunities for community engagement and traditional knowledge integration – versus long-term monitoring (data collection) per se. The exception is a small team of traditional monitors, employed by NHX to report on field observations.**
- **Capacity (knowledge, expertise about project operations and impacts) can be a major challenge to Indigenous community engagement in monitoring committees. To address this limitation, NHX requires that members appointed to the governance committee are specialists and able to communicate with the communities about mine impacts and management practices.**
- **External, third party reviewers lend additional scrutiny, expertise, and credibility to NHX's reviews of project operations and mitigation performance.**

- **Unlike many monitoring committees, NHX has an environmental observer who works at the mine site, within the proponent's environmental management team, providing both direct inputs to monitoring practices and direct feedback to community members.**
- **Unlike the Diavik case, funding provided by the project proponent has allowed for continued development and innovation as evidenced by the increase in the traditional knowledge monitoring program and launch of the OTLTP**

Case study sources: De Beers Group (2020); Ni Hadi Xa (2017); Ni Hadi Xa (2020)

3.2.6 Elk Valley Environmental Monitoring Committee (EMC)

The Elk Valley Environmental Monitoring Committee (EMC) is an independent body established in 2015 as a permitting requirement under the British Columbia *Environmental Management Act* for Teck's coal mine operations in the Elk Valley. In 2013, the province issued a Ministerial Order requiring Teck to prepare an area-based management plan – the Elk Valley Water Quality Plan – to address the effects of historical and on-going coal mining activities on water quality and to guide future development activities in the Valley. The Order was issued in response to evidence of increasing concentrations of selenium, cadmium, nitrate, and sulphate in watercourses. Teck submitted the water quality plan in 2014. The provincial approval permit for the plan required the formation an independent environmental monitoring committee to review monitoring submissions and provide science-based and traditional knowledge guidance. The goal was to ensure robust aquatic monitoring submissions to the Ministry of Environment. The monitoring committee was required to be active throughout the life of Teck's mining operations in the Elk Valley.

The EMC is an independent body, with representation from the provincial government, Teck, Ktunaxa Nation Council, and third-party scientific expertise. It provides input on the design of environmental monitoring studies, review the results of those studies, and recommend changes to monitoring plans or request new supporting studies to address key issues. Its key objectives are to provide science-based and traditional knowledge guidance to Teck, the Ktunaxa Nation Council, and the Ministry of Environment; support the communication of environmental monitoring results to Ktunaxa Nation members; and provide advice ensuring continual improvement in monitoring activities The EMC is focused solely on the obligation set out under the water quality plan permit. The EMC operates as a non-regulatory body and its activities does not replace existing regulatory responsibilities of government agencies.

The EMC currently provides advice and input on several aspects, including Teck's adaptive management program, chronic toxicity testing, surface water quality, groundwater monitoring program, regional aquatic effects monitoring program, calcite monitoring, human health risk assessment, baseline studies, re-evaluation of limits, and third party audits.

Institutional arrangement: Membership is comprised of British Columbia Ministry of Environment and Climate Change Strategy, British Columbia Ministry of Energy, Mines and Petroleum Resources, the Interior Health Authority, Ktunaxa Nation Council, Teck Coal Limited, and an independent scientist. The independent scientist is selected based on consensus and provides input to the EMC on an as-needed basis. Teck is required to provide a written response to the EMC on how its advice on monitoring activities have been taken into consideration, and to regularly provide the committee with draft study designs for specific monitoring activities, and reports

detailing results of monitoring activities. Monitoring data are reported to the EMC prior to issuing final reports to the Ministry of Environment. An independent facilitator coordinates EMC meetings in addition to documenting all committee advice and input on water quality monitoring activities. The EMC is required under the permit to hold at least four meetings each year as well as an annual public engagement meeting.

Funding: The EMC is funded by Teck. Information about annual operating budgets could not be found in publicly available documentation.[6]

Data management and reporting: The water quality plan permit requires that monitoring data and analyses undergo third-party review and professional audit for completeness, compliance, monitoring program quality assurance, and based on provincial water quality guidelines and Teck's standards for data handling. The permit also requires annual, plain-language reporting of monitoring results which is to be approved by the EMC. The EMC also releases a public report that includes its input and advice to water quality monitoring and Teck's response to the input or advice as a means of public accountability. EMC does not collect data or manage a monitoring database. Under the water quality monitoring plan permit, data collection and reporting are the responsibility of Teck. Teck's website includes annual monitoring reports (including data tables, trends analyses) for each of its monitoring programs and EMC annual public reports. Raw data are available to the EMC and its membership, but not posted publicly.

- Approval permits and other regulatory instruments can be valuable drives for the establishment of monitoring committees and a means to ensure that monitoring programs are of direct relevance to the information needs of regulatory decision makers and future IAs.
- Formal rules of engagement can contribute to transparency in monitoring and serve to balance power amongst members. An independent facilitator coordinates EMC meetings and manages committee member input and advice on monitoring. Monitoring results are viewed by the committee before released to government.
- Independence and accountability of monitoring committees lend credibility to monitoring program results. This is ensured through EMC's engagement of third-party scientific expertise and data auditing and public reporting by an independent party that requires industry and government responses to recommendations.
- Monitoring committees function better when there is a clear mandate. EMC's mandate is established under a regional water quality plan permit, with clear linkages to both industry and government decision responsibilities.
- Good monitoring programs have flexibility to pursue new questions and issues and support the meeting information needs of its members. In collaboration with EMC, Teck implemented additional monitoring studies in two additional reservoirs that will contribute to the overall water quality management plan and to Teck's future impact studies.
- With good governance, monitoring committees can facilitate relationship building and collaboration between parties even though impacts may be adverse. Notwithstanding the adverse impacts of coal mining

[6] A request was submitted to Teck for information about the committee's budget. No response was received at the time this report was filed.

on water quality in the Elk Valley (esp. selenium concentrations), the EMC has been described a good working relationship between Teck and the Ktunaxa Nation Council.

Case study sources: Teck (2017); Personal communications: Swanson Environmental Services; Author's insight as a member of the Elk Valley Cumulative Effects Program and personal communications with Teck Coal and Ktunaxa Nation Council

3.2.7 Athabasca Community-Based Environmental Monitoring Program

The Athabasca Working Group (AWG) is a private partnership between the uranium mining industry and seven communities of the Athabasca Basin, under the umbrella of a formal environmental agreement. The AWG was created in 1993 in response to the recommendations emerging from a federal-provincial Joint Panel assessment on the effects of uranium mining on the environment, communities, and peoples of northern Saskatchewan. The panel report noted, among other things, that communities should be more directly involved in mining and impact management activities. In 2000, the AWG environmental monitoring program was established under the agreement to monitor the *off-site* and basin-wide impacts of uranium mining operations in the Athabasca basin. The monitoring program was established as a community-driven initiative, whereby community members are fully involved in data collection, identification of the environmental components that need to be assessed, and sampling locations. Community members collect samples that include air, water, fish, and animal and sediment sampling and have them analyzed by an independent analytical lab. In 2018, the monitoring program was rebranded as the Athabasca Community-based Environmental Monitoring Program (EMP), with a more community-specific focus.[7] The current program consists of traditional food studies completed in one or two communities each year, and local sampling in areas known to be used by traditional users of each community. The monitoring program is now coordinated by an independent Indigenous-owned environmental services company.

Institutional arrangement: The EMP operates under the authority of an environmental agreement, a private agreement negotiated between the uranium mining industry and seven Athabasca First Nation communities.

Indigenous engagement: The EMP is Indigenous owned and led and focused on gathering information from community members about the traditional foods they consume. In addition to water sampling, the traditional foods assessed include blueberries, bog cranberries, fish, barren-ground caribou, moose, snow-shoe hare, and spruce grouse. The EMP is described as a co-learning process. Community members are invited to be involved in the program by participating in interviews and traditional foods and in the sampling of traditional foods used for testing.

[7] The EMP is one of two major monitoring programs in the Athabasca region. The Eastern Athabasca Regional Monitoring Program (EARMP) was established in 2011 under the Province of Saskatchewan's Boreal Watershed Initiative – an initiative focused on assessing the ecological integrity of Saskatchewan's northern watersheds. EARMP was designed to address long-range environment information and potential cumulative impacts downstream of uranium operations and communities in the Athabasca region. The monitoring program consists of a joint technical monitoring program funded by the province and the uranium industry, and a community program funded by the province. The technical program is focused on monitoring water and sediment chemistry, fish health, and benthic invertebrates at four locations downstream of uranium operations and at three reference locations. The sampling is conducted by a local Indigenous-owned environmental services company. The community program is focused on the safety of traditional foods and relies on samples gathered by community members. Information is collected on water chemistry, fish flesh, berry chemistry, moose or caribou chemistry, and mammal organ chemistry. All samples are tested by an independent lab – the Saskatchewan Research Council. Results from both programs are reported annually to communities and publicly available on the program's website http://www.earmp.ca/index.html.

Funding: The monitoring program is funded by the uranium industry. The costs of the monitoring program are not publicly disclosed.

Data management and reporting: Data collection, management and reporting are managed by CanNorth, an independent and locally owned Indigenous environmental services company. Analyses (i.e. testing tissue samples for contaminants) are conducted by the Saskatchewan Research Council, an independent environmental lab. Results are reported to communities in the form of community meetings and report summaries. Annual studies, including data tables, are housed on the website of the environmental services company and Cameco Corporation. There is no consolidated data set.

- Community autonomy in environmental monitoring is a defining feature of the EMP. Independent data collection by communities, and analyses of those data by independent labs, adds significant credibility to the monitoring program and community trust in the data generated.
- For industry, the independent community-led monitoring program has helped establish trust between industry and northern communities and has been integral to increasing dialogue and cooperation and filling a critical knowledge gap in the community about local environmental impacts from uranium mining.
- Community-led monitoring programs can struggle with coordination and leadership, and high-turnover rates in membership and participation. This can limit the influence and value added of monitoring for all parties involved. The EMP is now coordinated by an independent First Nations environmental services company to coordinate monitoring and provide stability.
- As an independent, community-led program the CBEMP has no decision-making power or legal authority. Although results are analyzed by an independent facility, data collection is infrequent and not of a sufficient scientific rigor to inform regulatory decisions or verify mitigation effectiveness in the uranium mining industry. The program has been described by some researchers and industry as "comfort monitoring."

Case study sources: Cameco Corp (2020); CanNorth (2019); Affolder et al. (2011); Noble and Birk (2011); Personal communication: Cameco Corp, Des Nedhe Development, University of Saskatchewan researcher R. Frimpong.

3.2.8 Nunavut Socio-Economic Monitoring Committees

The Nunavut Socio-economic Monitoring Committees (SEMCs) were established in 2007 as a joint effort by the governments of Nunavut and Canada. The SEMCs were, in large part, established as a means to efficiently address project certificate requirements for project-specific monitoring requirements under the Nunavut Land Claims Agreement (NLCA). One SEMC was established for each of three regions: Qikiqtani, Kivalliq and Kitikmeot. SEMC's objectives are to ensure that development projects comply with their permits by meeting their socio-economic monitoring requirements during the IA and monitoring processes; bring together communities, governments, Regional Inuit Associations, and industries in a forum that encourages open discussion and open information sharing; collect and disseminate data that is validated by local and traditional knowledge. Each SEMC is thus tasked with monitoring general socio-economic trends and indicators in their respective region, and also providing oversight and support for the monitoring activities of project-specific socio-economic monitoring working groups. Under the NLCA, a project certificate issued by the Nunavut Impact Review Board may require project proponents to establish a project-specific socio-economic monitoring

working group and develop a project socio-economic monitoring plan. SEMCs provide a communication forum and an information bank to facilitate data access and support local communities and other stakeholders in monitoring efforts. An underlying principle of the SEMCs is to ensure monitoring efficiency and consistency within the territory. Monitoring efforts focus on a range of valued components, each comprised of several indicators. The most recent Hope Bay project socio-economic monitoring program report, for example, includes 60 socio-economic indicators across these various components.

Institutional arrangement: The SEMCs function in collaboration with the Government of Canada, Designated Inuit Organizations, Hamlets, and proponents. The Government of the Northwest Territories (Economic Development and Transport) is the lead agency on SEMCs and collects socio-economic data from across other government departments and sources and consolidates and disseminates that information to the committees and other interested parties – primarily through summary reports. Each SEMC is chaired by one of the territorial government's regional directors of community operations, coordinated centrally by the Department of Economic Development and Transport regional socio-economic coordinator, to ensure consistency in monitoring and reporting and alignment with the Nunavut General Monitoring Plan. The SEMCs hold several in-person meetings each year as required as well as annual public engagement meetings.

Indigenous engagement: SEMCs are government-led, but each regional SEMC is comprised of Regional Inuit Associations and Hamlet Associations, in addition to government agencies, industry proponents, and other interested parties.

Data management and reporting: Providing information on the monitoring activities of project-specific working groups to stakeholders, community members and the public is a primary obligation of the SEMCs. Regional SEMC websites contain information about data sources and data collection, upcoming events and programs, applicable regulatory information as well as monitoring results and annual reports from project proponents. The SEMCs also maintain an interactive socio-economic map for viewing socioeconomic data spatially, and by category.

- Socio-economic monitoring initiatives often struggle because of 'laundry-list' approaches to monitoring. Monitoring focused on a select few categories and indicators can facilitate standardization across regions and projects.
- Project proponents may have the financial capacity to monitor, but not always the means to conduct and coordinate monitoring in a way that is meaningful to both the project and to understanding broader regional context. Government engagement and coordination can ensure that monitoring capacity is available and that what is monitored is of relevance regionally and for tracking individual project performance.
- Coordination and leadership are common challenges to monitoring programs, and often a reason for either short-lived programs or programs that lack integration. An advantage of the regional monitoring committee structure, coordinated centrally by government, is that regional SEMCs can ensure consistency in data collection across major projects, across regions, improve issue identification, create regional standards for monitoring, increase efficiency in data management and reporting, and facilitate data sharing across communities and regions.

- Data acquisition can be challenging and is often limited in northern and remote contexts. Many of the indicators tracked by SEMCs are in the public domain, and regularly collected and maintained by government agencies. At the same time, data often need to be supressed, especially in small communities, to minimize risk of personally identifying information.

Case study sources: ERM Consultants Canada (2019); Government of Nunavut (2020); SEMCs (2019); Card et al. (2014)

3.2.9 Minto Mine Socio-economic Monitoring Program

The Minto Mine Socio-economic Monitoring Program (SEMP) is an arrangement between Minto Explorations Ltd, Government of Yukon (YG), and Selkirk First Nations (SFN) to monitor the socio-economic effects of mining operations and closure on local communities. The monitoring initiative was established in 2011 by way of a condition set out under an expansion project amendment approval, as required by the Government of Yukon and SFN. The primary purpose of the SEMP is to monitor the socio-economic effects of Minto Mine's construction, operations and closure. The monitoring program consists of two components: a socio-economic baseline assessment, and on-going measurements against that baseline. Includes amongst the program's objectives are to verify the predicted socio-economic effects as identified in the IA, including any unforeseen socio-economic effects of the project; evaluate the effectiveness of mitigation measures and inform adaptive management; document changing socio-economic conditions affecting or affected by the project; verify project-related commitments are implemented by Minto, YG and SFN; report the results of monitoring to Minto, YG and SFN; and inform future socio-economic effects assessment associated with the Mine expansion ad contribute to regional cumulative effects monitoring and management. A set of five core socio-economic conditions (population and health; material well-being; capacity, training and education; cultural well-being; sustainability and legacy) are monitored by the program for 16 valued components that identify important features or elements of these core conditions.

Institutional arrangement: The monitoring committee is tri-partite, collaborative effort involving Minto Exploration Ltd., Government of Yukon and Selkirk First Nations. The initiative is the first of its kind in the Yukon.

Data management and reporting: Monitoring activities include both qualitative and quantitative data collection undertaken by the Minto Mine (i.e. mine-specific socio-economic data), SFN-specific data obtained from community surveys every five years, Statistics Canada, and administrative and statistical data from the Yukon Government (regional and Yukon-wide). Data and information submitted by the parties must be in a format that can be shared publicly; consolidated annual monitoring reports are made available to the public. A working group assumes responsibility for synthesis and analysis of the data and information submitted by the parties and issuing a consolidated monitoring report annually. Five- year data sets are required to be included in annual reports (where relevant) for benchmark reference. Each party owns the data and information they provide (e.g. SFN owns the data collected in the household surveys) and determines the treatment and use of and access to those data.

- Monitoring committees can, in part, respond to deficiencies or gaps in regulatory follow-up and monitoring requirements. The SEMP is the first of its kind in the Yukon, ensuring follow-up and monitoring of socio-economic issues in a jurisdiction where IA provisions for follow-up and monitoring of projects are weak.
- Community-level data deficiency can be a major challenge to socio-economic monitoring initiatives in rural or remote areas. Securing sufficient data may require considerable investment in community-level surveys. Reference (historical) data can also be limited in some regions, but such deficiencies can be offset by the use of qualitative data that provide subjective perspectives and judgments about the relative state of past conditions. This was SEMP's solution to establishing a baseline or reference condition for communities, drawing on the retrospective input from community members where quantitative data gaps existed.
- Monitoring programs in rural or remote regions can be learning experiences. Clearly defined and consistent indicators are important, but there must also be a degree of flexibility and willingness to readjust indicators as monitoring programs become established. Indicators were revised several times under the SEMP initiative to better reflect available data, to eliminate duplication between certain indicators, and to eliminate indicators where data were not and would not be available in the future.
- OCAP principles or other agreed-upon data sharing and ownership provisions can build trust and balance power for monitoring committees that involve Indigenous groups alongside industry and government. Under SEMP, data collection and management are guided by Yukon government policies, which set standards for access to and ownership of data. This is especially important when data are collected about or in Indigenous communities.

Case study sources: Selkirk First Nation, Yukon Government, Capstone Mining Corp. (2018); Selkirk First Nation, Yukon Government, Minto Exploration Ltd. (2018); Personal communication: YESAB and MPY, based on author's engagement in a 2018 workshop and training session for Yukon government decision makers and practitioners on follow-up and mitigation good practices.

3.2.10 Trans Mountain Indigenous Advisory and Monitoring Committee

In 2016, Indigenous leaders from impacted communities approached the federal government and the governments of British Columbia and Alberta requesting Indigenous oversight over the Trans Mountain Expansion (TMX) project. The Indigenous Advisory and Monitoring Committee (IAMC) was established in 2017. It is comprised of 13 Indigenous members (representing 117 Indigenous communities and regions along the TMX route) and six federal government (National Energy Board) representatives to provide advice to regulators, monitor the TMX project and existing pipeline, and maintain a working relationship between Indigenous communities and the National Energy Board. IAMC's activities are focused on socio-economic impacts (e.g. impacts of pipeline construction work camps on Indigenous communities; Indigenous participation in economic development opportunities); marine shipping (e.g. traffic and spill potential in relation to Indigenous communities' ability to protect their rights and interests); and community engagement (e.g. integrating Indigenous perspectives into project monitoring, regulation and performance).

Institutional arrangement: IAMC operates at arms-length from the proponent and the proponent does not fund the committee's work. Indigenous participation on the IAMC is not an indication of Indigenous support for the project and does not represent the views (support or opposition) of the 117 individual Indigenous communities and regions along the project route. A technical advisor, communications manager, and legal counsel are

accountable to the members and work under their direction. IAMC also forms and oversees subcommittees or working groups to work on specific issues or regional concerns. The subcommittees undertake work that requires more expertise or focus on a particular issue. For example, IAMC established the Work Camps Working Group in response to concerns expressed by Indigenous representatives about the potential negative impacts that project work camps could have on Indigenous communities. The Economic Development Working Group was established to monitor project compliance with the pipeline approval conditions, including the provision of skills training and employment opportunities to Indigenous communities.

Indigenous engagement: Indigenous representatives comprise the bulk of IAMC's membership. An overarching goal is to integrate Indigenous knowledge, values and perspectives into project monitoring, regulation and performance. For example, a pilot program in 2017 established an Indigenous Monitoring Subcommittee to build a monitoring program that incorporates Indigenous interests and concerns in NEB pipeline inspections. IAMC monitors from one of the First Nations participated in NEB environmental inspections and safety inspections. A similar pilot project was established with a second First Nation in 2018.

Funding: For a five-year period (2017/2018 to 2021/2022), a total operating budget $64.7 million from federal sources has been allocated to the IAMC to support its work and the capacity of Indigenous groups potentially impacted by the TMX project to engage. Of this amount, $42 million is to support community capacity related to monitoring and oversight of TMX.

Data management and reporting: As part of its community engagement strategy, IAMC established a regional engagement coordinator pilot project to build relationships between the IAMC and Indigenous communities. Its primary function is to provide information to communities about IAMC initiatives and provide a means for community concerns about TMX to be brought to the attention of IAMC directly. IAMC does not maintain a monitoring database.

- Socio-economic monitoring committees for pipeline projects are rare when compared to mining or hydroelectric projects, owing in large to the linear characteristics of projects – often cutting across multiple jurisdictions and dozens (if not hundreds) of interests. This increases the complexity of issues that monitoring committees must deal with and the diversity of interests they need to represent.
- The IAMC program does show some early signs of progress and overcoming the challenges of linear projects. The solution has been to engage a limited number of representatives (from a large number of interests) – not to 'speak for' affected communities, but to serve as information conduits between the regulator and those affected. Sub-committees are established to address specific issues that may be brought to IAMC, often in the form of pilot programs to engage specific communities in monitoring and inspection activities.
- IAMC's strength is in relationship building between a government regulator and Indigenous communities in how pipelines and their impacts are managed, more so than long-term environmental monitoring per se.

***Case study sources*:** Indigenous Advisory and Monitoring Committee (2019); Card et al. (2017)

3.3 KNOWLEDGE SYNTHESIS

Monitoring committees are increasingly common across Canada for major resource development projects, but primarily in the context of mining operations. Experience from other resource development sectors is relatively limited. Monitoring committees are a valuable a means to obtain feedback, influence decisions and transmit information to communities and the public, such as monitoring results. When operating transparently and independently, monitoring committees can add legitimacy to project operations and impact management strategies. That said, in most all cases examined the connection to regulatory decision making was unclear – even for those monitoring committees established as watchdog agencies, where the focus is more often on making recommendations.

Literature suggests that to be truly motivated, project proponents must perceive that follow-up can be a positive factor in development and one that can result in improved risk management, reputation and in specific circumstances economic benefit. Relationship building with affected communities and integration of local knowledge is thus often a major focus of monitoring committees. Even when adverse environmental effects occur, experiences such as the Elk Valley monitoring committee indicate that strong relationships can be maintained.

In most cases examined, the monitoring committee emerged based on some sort of push from government – such as under water license plan permit for the Elk Valley case, or a project approval recommendation in the case of Minto Mine, Yukon. There are examples where proponents and communities have initiated collaborative monitoring arrangements in absence of any project-specific regulatory (or other) requirement to do so, but they tend to be the minority of cases and when they do emerge under such voluntary and open arrangements monitoring committees rarely tend to have a formal oversight role.

Monitoring committees responsible for data collection may operate very differently than oversight bodies, which may not have an inherent interest in seeing the original environmental management system succeed, as it was not responsible for its approval and implementation.

Monitoring committees are variably structured in terms of arrangements, funding, roles, and authority. In most cases, monitoring committees function based on a formalized agreement that sets out the committees' roles, mandates, funding arrangements, and relationships. Formalized agreements provide certainty to all parties involved and ensure clear lines of accountability.

Independence and accountability are thus key characteristics of effective monitoring programs. This is often expressed by way of independent scientific or third-party reviews in cases were monitoring data are being collected, and full transparency in monitoring committee recommendations and proponent and regulator responses in cases where committees play a primarily watchdog role. Independence can be compromised when monitoring committees are imbalanced (i.e. heavy industry interest) or when where their financial ability to meet their mandate hinges largely on funding from the industry they are established to oversee.

Indigenous engagement is often a main objective of monitoring committees, regardless of whether the committees are focused on data collection or oversight; however, in some instances committees are purely scientific in nature and with a strong science-based mandate – even with Indigenous membership.

At any given point in time, different stakeholders (participants, researchers, government) are likely to have different objectives and differing expectations. Committees established for monitoring (data collection) in absence of clear monitoring questions, scope, and relevance to decision makers (whether regulatory, community, or industry) are often short-lived or struggle to maintain financial support for their activities. Monitoring committees require agreement on the questions to be pursued, the indicators of most importance, and how findings are to be used and by whom.

A suite of factors for successful monitoring committees can be identified from the literature and cases examined, including: developing trust, maintaining communication, adequate and reliable resourcing, balanced representation, clear lines of accountability and transparency, guided by specific monitoring questions and mandates, adaptive to new information needs and circumstances, relevant to decision making, mechanisms for dispute resolution, and being supportive of community engagement.

4 INDICATORS TO MONITOR SOCIO-ECONOMIC EFFECTS

4.1 SCHOLARSHIP

Scholarly literature on good monitoring design warns about the tendency to collect data now and think later (Roberts 1991). This is what Lindenmayer and Likens (2010) describe as a laundry-list approach to monitoring, where anything and everything is monitored without any real, *a priori* consideration as to *why* a particular indicator is being monitored, the value of knowing, and whether there is any utility in understanding trends or changes in that indicator. Even in cases of ecological monitoring where key indicator species are defined, Lindenmayer and Likens (2010) report that only rarely is it explicitly stated what the indicators are indicative of. Laundry-list approaches run the risk of many things being poorly monitored, unsustainable (financially) monitoring programs, and data that are of limited value to detecting adverse change, understanding causal relations, and ensuring evidence-based decision-making. DeRoy et al. (2019) suggest that:

> *"fewer indicators that are highly inclusive and can capture fundamental interactions, from drivers of change to impacts on biocultural values, may be more effective that many indicators with narrow scope...Considering that fewer highly inclusive indicators may facilitate desired outcomes...better than many less inclusive indicators...indicators with strong cascading effects should be given priority"*

The key, overarching message here is that well-crafted monitoring questions are pre-requisites to the identification of indicators and data collection (Legg and Naggy 2006; Lindenmayer et al. 2007; Ball et al. 2013; Wong et al. 2019; DeRoy et al. 2019). Too often, monitoring programs are designed based on indicators (or data) are available, or easy to collect, rather than based on purpose-driven questions.

4.1.1 Indicators

Indicators are the most basic tools for analyzing condition change—they allow practitioners and decision-makers to gauge change efficiently by focusing on parameters that are responsive to change, generate timely feedback, can be traced effectively over space and time, and are linked to decisions or management actions. Petrov et al. (2013) describe socio-economic indicators as domain-specific or integrated data series that allow for a comparison of human well-being and its dynamics over time and over space, showing trends, changes, and fluctuations in rates of change (Mitchell and Parkins 2011; Force and Machlis 1997).

There are dozens of lists socio-economic indicators reported in the literature, characterized by Petrov et al. (2013) as eclectic lists, often with multiple variables organized into loose categories – many of which lack focus and confuse social processes (i.e. demographic, economic, legal, sociocultural) and effects (i.e. what is

experienced or felt by humans, such as health, quality of life, social cohesion, cultural well-being, livability of place) (Slootweg et al. 2001; Vanclay 2002). Rather than inventory socio-economic indicators, it is more useful to identify the basic principles for indicator selection and different frameworks for organizing indicators into meaningful categories to support socio-economic monitoring.

The choice of indicators must be specific to the monitoring questions posed, but final indicator selection is still highly influenced by data availability (Cairns et al. 1992). The highest-priority indicators are often those where there is already good scientific or local knowledge of how human activities and natural changes affect the indicator (Antoniuk et al. 2009). Numerous principles for indicator selection have been proposed, that are broadly applicable to both biophysical and socio-economic monitoring (e.g. Reid 2001; Ramos et al. 2004; Antoniuk et al. 2009; Larsen et al. 2010; Lindenmayer and Likens 2010; Mitchell and Parkins 2011; Noble 2015). A common message emerging from the literature is that good indicators are:

- clearly defined, reproducible, unambiguous, and understandable
- created transparently through a process of dialogue with stakeholders
- relevant to management decisions and/or policy objectives
- relevant to the values and aspirations of those affected (i.e. a specific community issue, concern, or goal)
- easy to convey to non-specialists
- sensitive to change
- indicative of the causes or sources of change and not only the existence of change
- able to give early warning about irreversible or undesirable trends
- reliable over space and time
- practical, in terms of data availability
- cost-effective to monitor
- able to be updated at regular intervals
- grounded in theory and science
- comparable to targets, benchmarks, or maximum levels of desirable change
- linked to data collection methods that are comparable.

Notwithstanding the above, Mitchell and Parkins (2011) emphasize the importance of narrowing down a small but representative set of indicators to those that are most pragmatic, and that can "condense real-life complexity into a manageable amount of meaningful information" (Larsen et al. 2010, p. 23).

What should be monitored is context-specific (Noble and Storey 2005; Jones and Fischer 2006; Wong et al. 2019), but the literature does suggest several frameworks or approaches for selecting and organizing indicators. At the most basic level are what Petrov et al. (2013) refer to as *domain-based* approaches, whereby indicators are identified and organized into specific categories or themes that are deemed useful for the specific socioeconomic context of interest. Mitchell and Parkins (2011), for example, report on a study by Alberta Innovates to identify categorical indicators pertinent to resource-dependent areas. A total of 11 categorical indicators were identified: livelihood, security, human capital, health, housing, demographics, community capacity, community economic diversity, natural/recreational amenities, cultural preservation, and political factors. Each category consisted of a variety of more specific indicators.

Based on a survey conducted by the Arctic Human Development Report, and a survey of various indicator frameworks, Petrov et al. (2013) suggest the following domains as relevant for monitoring and measuring the socio-economic effects of resource development in the Arctic: human health; material well-being (income and wages); employment & participation; social well-being and cohesion; population dynamics (demographics and migration); cultural vitality (including traditional activities and closeness to nature); empowerment and fate control; and education and human capital.

There is a growing awareness of the importance of Indigenous contexts when selecting indicators for socio-economic monitoring and in the design of monitoring programs. The basic premise is that socio-economic indicators must be place-based and tightly coupled with the ecological environment, reflecting the important relationship between Indigenous peoples and the natural environment regarding socioeconomic (and cultural) well-being. DeRoy et al. (2019) suggest the need for a "biocultural approach", arguing that the typical approach to indicator development fails to capture fundamental values and ties to the natural world that have supported social-ecological systems over the long term. DeRoy et al. do not prescribe specific indicators, rather they suggest the need select indicators that are culturally salient, supportive of place-based relationships, inclusive, sensitive to impacts, perceptible, and linked to human well-being (Figure 1).

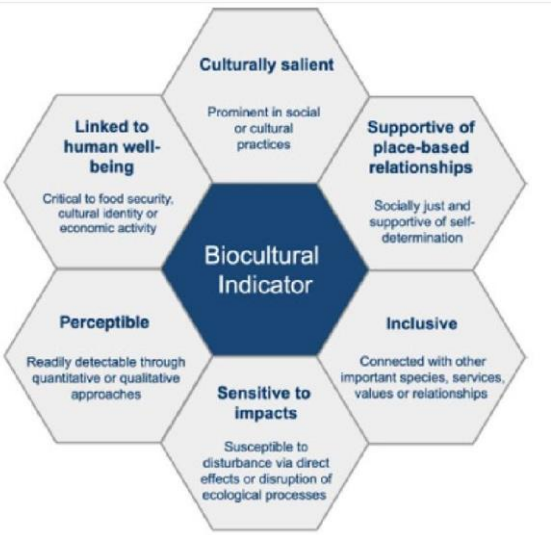

Figure 1. Biocultural indicator categories (DeRoy et al. 2019)

4.1.2 Collection methods

Literature does not identify the 'best' monitoring data collection methods for socio-economic indicators but notes that the methods used are typically based on those used in the social sciences – namely economics, geography, and sociology (Vanclay 2002; Burge 2004; Mitchell and Parkins 2011). Based on a survey of the literature, Petrov et al. (2013) report that data collection methods are typically comprised of secondary source data methods (e.g. regular reviews of census data, local economic reports, community plans; hospital/health statistics; crime statistics, etc.); regular community or household surveys; workshops or focus groups; community meetings; and ethnographic studies, to name a few. Data are often analyzed to identify or track the concerns, capacities and aspirations of local residents and economic indicators are incorporated into standard analytical procedures, such as cost benefit, input-output and other fiscal analyses. In more recent years, Petrov et al. (2013) report an increasing trend in the use of qualitative and community-based methods in socio-economic data collection, including community leadership in local townhall meetings and surveys (e.g. perception surveys, quality of life surveys), while Heikinheimo et al. (2017) report on the utility of social media as a complementary source of information to traditional surveys and means to monitor shared content to track key issues.

4.1.3 Data standards

Data standards are one component of a much larger data context – data governance. In absence of data governance there is often no sustainable data strategy, meaning that data collection can become disorganized and project focused; resort to firefighting mode (i.e. constantly redirected to address specific, sometimes one-off issues as they occur); not focused on longer-term data utility; or redundant, leading to wasted resources and incompatible data across programs or organizations (Fisher 2020). Data governance is about establishing the processes within, or across, organizations and monitoring programs to support data policies and standards. It ensures that the same data standards and policies are defined and applied. Data governance, and associated data policies, define what to do and what not to do with regard to data – data standards are more detailed rules on how to do it – such as metadata standards, naming standards, data modeling standards, reporting standards, standardized metrics, and other data architecture standards (Sun 2011).

There is no consolidated set of data standards identified in the literature for monitoring – literature on data standards tends to focus on specific types of data, such as standards for spatial data, standards for health and population data, standards for water quality data, and so on. Standards are largely found in industry- or sector-specific guidance, such as the Canada-wide Framework for Water Quality Monitoring or Canada's Pulp and Paper Effluent Regulations. A key message from researchers is the importance of standardization (indicators, collection methods, models) to ensuring dependable, accurate and quality data for assessing trends and measuring long-term change (Le Quoc 2015).

Roach and Walker (2017) argue that if monitoring is to inform decision makers then it needs to adopt consistent approaches to promote the development of credible and comparable data. This recommendation is based on their analysis of a sample of aquatic monitoring programs conducted under federal IAs, which showed major discrepancies in reporting parameters, variability in the detection limits used, and even different units of reporting. Ball et al. (2013) observed similar challenges based on a sample of 35 federal IAs in the South Saskatchewan watershed, reporting considerable variability in indicators and data reporting even amongst project in the same class.

Wong et al. (2019) reviewed recent monitoring guidance and practices and identified seven foundational attributes for quality monitoring data and the indicators the represent. The attributes were drawn from scholarly research on monitoring principles (e.g., Culp et al. 2000; Munkittrick et al. 2000; Vaughan et al. 2003; Dube et al. 2006; Kilgour et al. 2007; Squires et al. 2010; Beliaeff and Pelletier 2011; Van Oudenhoven et al. 2012; Ball et al. 2013; Dubé et al. 2013), combined with literature on eSystems design for optimal end-user experience (Petrie and Bevan 2009). Wong et al. (2019) argue that similar to good software interface design that considers the goals of the user, monitoring programs must ensure certain data and indicator characteristics in order to meet the needs of its users. Although developed for biophysical systems and within the context of understanding cumulative change, the principles are broadly applicable to all monitoring systems (including socio-economic) intended to inform management decisions and enable understanding of system change and response to stress (Table 1).

Table 1. Quality attributes of monitoring program data and indicators

Consistency:	The presence (or absence) of parameters monitored across different programs must be consistent.
Compatibility:	It must be possible to integrate or compare monitoring data across programs or data sets; that is, consistency in the approach to data collection and analysis.
Observability:	Data must be of sufficient scale and resolution to allow tracking of baseline change over time and/or across space.
Detectability:	Data or parameters must allow for the early detection of change in baseline conditions or potential threats to the system of concern.
Adaptability:	Data must be useful for understanding or detecting change at multiple spatial scales and the indicators applicable to multiple project or disturbance types.
Accessibility:	Data must accessible, retrievable, and available in a usable format with clear metadata standards.
Usability:	Data must meet multiple end-user needs, including project proponents and regulatory decision makers.

Boyle and Dowlatabadi (2006) provide specific operational-level guidance on establishing data standards, suggesting that for *each indicator* the following information is identified:

- *definition:* what is the indicator
- *rationale:* why the indicator has been chosen
- *metrics(s):* how the indicator is to be measured
- *method(s):* how to retrieve or collect data and report it
- *timing:* when to retrieve, collect and report data
- *information needs:* which information should be collected
- *responsibility:* who is in charge of measuring the indicator

When collecting socio-economic data, it may be the case that certain data (and indicators) are context specific – i.e. issues and priorities may vary from one community and socio-economic context to the next. At the same time, adopting data standards and ensuring a degree of consistency in what is monitored allows for benchmarking and understanding the local in the context of the regional. Even for socio-economic components, data standards are important to understanding change over time, the significance of that change, and comparing across communities to understand local o regional patterns or trends (Boyle and Dowlatabadi 2006).

There are, of course, additional data standards to be considered when monitoring socio-economic indicators. For example, standard guidelines are needed to ensure ethical treatment of data, meaning that personal identifiers must be removed before reporting. Problems can also arise where the numbers are small, such as in some rural and remote communities, where any data collected at the local level may be personally identifying. This means that all monitoring programs that involve primary data collection on socio-economic variables must consider rules for data sharing and rules for data ownership. In the case of the Minto mine socio-economic monitoring program, discussed earlier, for example, each party owns the data and information they provide – i.e. the mining

company owns the data it collects on site; the First Nation owns the data collected from community surveys – and each data owner determines the treatment and use of and access to those data.

A starting point for developing data standards for access and ownership for any socio-economic monitoring program that involves communities is OCAP® standards; these are the *de facto* standards for data collection involving First Nations:

> ***Ownership*:** A community or group owns information collectively in the same way that an individual owns his or her personal information.
>
> ***Control*:** First Nations, their communities, and representative bodies are within their rights in seeking to control over all aspects of data collection and information management processes that impact them.
>
> ***Access*:** First Nations must have access to information and data about themselves and their communities regardless of where it is held, which may be achieved, in practice, through standardized, formal protocols.
>
> ***Possession*:** First Nations, their communities, and representative bodies must have the opportunity to have the physical control of data, by which ownership can be asserted and protected.

4.2 PRACTICE

Several guidance documents are available for socio-economic monitoring, often program specific (e.g. guidelines for population health monitoring). Guidance prepared by Boyle and Dowlatabadi (2006) for the design of socio-economic monitoring programs in Nunavut, specifically for communities near mining projects, is particularly useful and designed based on a hierarchical relationship comprised of themes – priorities – comparable indicators – indicators that are more context specific – and indicators specifically relevant to the project at hand (Table 2). The full suite of indicators identified by Boyle and Dowlatabadi are included in Appendix A. Although developed for Nunavut and for mining developments, many indicators are broadly applicable to other regions and communities and the framework is adaptable to other resource sectors.

The *types* of indicators suggested by Boyle and Dowlatabadi (2006) appear to reflect what is typical of current socio-economic monitoring programs. Based on a scan of a small number of monitoring initiatives across Canada for example, several common indicators emerge that can be categorized in eight domains (Table 3). This list is not meant to be comprehensive, but it likely reflects the types of indicators most often considered in socio-economic monitoring programs.

Although these domains differ from those proposed by Boyle and Dowlatabadi (2006), the indicators are similar – they are the *usual suspects* in terms of indicators of community health and well-being (e.g. wellness index; health services; cohesion; safety); employment and income (e.g. workforce characteristics; income levels); community services and infrastructure (e.g. housing; social services); and Indigenous land use (e.g. use types, rates, patters, quality of traditional foods), to name a few – and similar to the categories and indicators identified in previous reviews of socio-economic monitoring programs by Petrov et al. (2013) Larsen et al (2010).

Table 2. Example framework for classification of indicator categories, priorities and indicators for socio-economic monitoring

Attribute	*Definition*	*Example 1*	*Example 2*
Indicator category	Broad thematic categories to organize monitoring efforts	Individual and family well-being	Culture and relationship to the land
Priorities	Community context matters, but there are some common priorities and goals that are broadly applicable across all communities	Meeting basic needs Healthy families and relationships Productive activity and positive lifestyle choices Ability to cope with problems or adapt to changes Healing for those with difficulties	Transfer of Indigenous language, knowledge, skills and important values to youth Opportunity for going out on the land, and harvesting country food Maintenance of a traditionally based economy
Comparable indicators	Indicators that can be collected for all communities and can be directly related to common priorities and goals Common indicators are also - relatively easily available - comparable *across* communities and over time	Percent of families and people living below the low-income measure Number, percent of police or social service calls related to domestic violence, alcohol, drugs, youth Suicide, attempted suicide rate per 1,000	Percent Indigenous population Ability to speak Indigenous language
Additional indicators	Additional indicators that can be directly related to common priorities and goals. Additional indicators: - may require some additional effort or resources to collect - comparable over time, but may not be comparable across communities	Distribution of social service consultations, by reason Health issues Percent sales and price of fresh foods	Number of young hunters Number and participation in community feasts and cultural activities Country food consumption Exports of country foods
Additional indicators – activity specific	Additional indicators that relate to a specific project or activity, specifically the interaction between community priorities and anticipated impacts and benefits from a nearby project Additional (activity specific) indicators: - may require some effort or resources to collect - comparable over time, but may not be comparable across communities	Well-being indicators for mine employees and their families	Hunting frequency and resource sharing for mine employees

Source: Boyle and Dowlatabadi (2006)

The scan of monitoring programs indicates that monitoring data tend to be derived from multiple sources – secondary and primary – depending on the specific indicator, but this information (and data collection methods) is not always specified. Several common sources included: government departments and agencies; census data; community profiles and municipal governments; educational, health, and social service agencies and programs; community-based monitoring; and community surveys, to name a few.

The scan also revealed few protocols for data sharing and access. Exceptions were for data collected through community-based monitoring – and usually for traditional knowledge – whereby consent was to be secured before data are collected and that members agree on who should have access and how the information is to be used. This was the case for the Wood Buffalo Environmental Association (discussed earlier in this report), and the Minto Mine, Yukon.

The framework proposed by Boyle and Dowlatabadi (2006) is a common-sense approach to identification and prioritization of monitoring indicators; however, practice seems to align with the laundry list approach - with few specific questions identified to direct socio-economic monitoring and indicator selection. The rationales for indicator selection were rarely identified – indicator selection appeared to be based on data availability and what is 'typical' for the component of concern. This observation is consistent with previous work by Card et al. (2014), who report that when socio-economic monitoring is identified or documented in Canadian IA the details on how monitoring occurs, and the rationales are rarely provided. Similar observations are reported by Aura (2016) based on review IAs completed in the James Bay Northern Quebec region, noting that monitoring programs are often included in the assessments and a condition for approval, but the rationale for the indicators and the specific questions to be answered by monitoring were consistently absent.

Table 3. Typical monitoring components and indicators derived from a scan of 14 Canadian IAs and monitoring committees*

Components	*Typical Indicators*
Economic and Business Development	Gross Domestic Product: total; sector Revenues: tax revenue and royalties Annual spending on goods and services Capital investments: amount Local business: ownership; revenues; employment; start-ups Community and Impact Benefit Agreement contributions Contracts awarded to Aboriginal businesses Industry expenditures in community Payments to Aboriginal groups
Employment and Income	Employment rate: by sector; Indigenous; gender Workforce: local workforce size; Indigenous workforce size; community labour market; non-resident workers Nature of work: seasonality; skill level; part-time Employee retention: by gender; Indigenous Employment income: per capita; by source; by community; personal; household; Indigenous; by gender Employment satisfaction: perception
Education and Training	Educational services: availability; enrollments; capacity; level; teacher- Educational attainment: community; by gender; Indigenous; attendance Skill development: hours of training completed by employees and contractors; accessibility to training for Indigenous peoples; apprentiships and other programs (participation rate) Education investments: level of investments in school-based initiatives
Community Health and Well-being	Community wellness index Medical services: frequency of visits; capacity; service ratio; wait times Emergency services (police/ambulance/fire): availability; use Social services: type; frequency of use; capacity; service ratio; wait times Healthy child development: teen births; suicide rates; children in care Cohesion: engagement in community; volunteer rates; sense of belonging Recreation: service and infrastructure availability; use; programming Public safety: violent crimes; petty crimes; perceptions of safety; crime rate Social maladies: substance abuse and addictions; communicable diseases; Human health risks: from consumption of water, fish, caribou, and other Community stability: net migration Cost of living: housing, heating, food price index

Components	*Typical Indicators*
Community Services and Infrastructure	Community services: type; frequency of use; capacity; service ratio; perceived quality Social services: type; frequency of use; capacity; service ratio; wait times Housing stock: availability; quality; price; rental costs; property values Community investments: by proponent; government Recreation: service and infrastructure availability; use; programming Traffic: volume; travel times; accidents Transportation infrastructure: quality Waste disposal: volume; capacity
Cultural and Heritage Resources	Archaeological and sacred sites: number; perceived quality; use; values Heritage resources: number; perceived quality; use; values Level of support for cultural activities: financial; infrastructure; programming Perceptions of change in culture and traditional lifestyle Language
Indigenous Use of Land	Use of land and resources for traditional purposes: use types; changes in use types or patterns; access; changes in access Traditional foods: availability; quality; taste; cost; travel distances; changes Participation in traditional land use activities: harvest data; household Industrial footprints: undisturbed land and access Environmental quality: observed changes in land, vegetation, wildlife, fish, plants, berries
Population Demographics	Population: levels; change; structure; dependency ratio Migration Ethnicity

***Gahcho Kue mine environmental screening – Ni Hadi Xa; Elk Valley environmental monitoring committee; Minto mine socioeconomic monitoring program; Trans Mountain Indigenous advisory and monitoring committee; Diavik diamond mine socio-economic monitoring plan – Natural Resources Canada; Kitikmeot socio-economic monitoring committee – Hope Bay socio-economic working group; Qikiqtaaluk socio-economic monitoring committee – Mary River socio-economic working group; Kivalliq socio-economic monitoring committee – Agnico Kivalliq socio-economic working group; Bipole III socio-economic monitoring program – Manitoba Hydro; Keeyask generation project socio-economic monitoring plan – Manitoba Hydro; Lower Churchill (Muskrat Falls) socio-economic effects monitoring plan – Nalcor Energy; Sisson project follow-up and monitoring program, New Brunswick – Northcliff Resources; Labrador-Island transmission link – Nalcor Energy; Communities and Diamonds (CAD) report, 1996-2011, Northwest Territories**

4.3 KNOWLEDGE SYNTHESIS

Scholarship and practice suggest that institutional organizations can be robust and monitoring programs genuinely collaborative, but monitoring is still largely ineffective in absence of an overarching conceptual framework that is guided by specific monitoring questions and clear articulation of *what* to monitor and *why* it is important – and to *whom*.

- Defining *why* monitor (i.e. the specific monitoring questions and information needs) is a pre-requisite to indicator selection; good science and hence good monitoring starts with good questions. Distinguishing between more immediate and longer-term monitoring needs and objectives is important when selecting indicators. What is feasible to monitor (i.e. indicator selection) must be tempered by available data, predictive tools, monitoring effort in a given region, and the amount of resources available to invest.

- Lack of clarity about end-user needs can lead to ineffective monitoring programs or to the collection of excessive amounts of overly detailed data for too many indicators; but the information needs of end-users are not always well-articulated.

- Socio-economic monitoring programs often end up with a laundry-list of indicators. Good practice suggests that indicators are domain specific, mutually reinforcing, allow for a comparison of human well-being and its dynamics over time and over space (e.g. trends, changes, fluctuations in rates of change). It is important to narrow down the suite of possible indicators that are useful for answering monitoring questions to a small but representative set that condense the complexity of socio-economic (and socio-ecological) systems into a manageable amount of meaningful information.

- Indicators selected for socio-economic monitoring must be mapped to local priorities and values and developed through dialogue. First, define what is important to the community, then define what you want to know through monitoring and what decisions you want to be able to make and the information needed.

- When monitoring programs engage Indigenous groups, it is essential that socio-economic indicators are place-based and tightly coupled with the ecological environment. Place-based does not mean that indicators are not comparable. In any given monitoring program, there must be a range of socio-economic indicators that are comparable across communities (i.e. to the region), comparable within the community, and specific to the types of issues or project actions and disturbances of concern.

- Data standardization is important for long-term, robust monitoring programs. Standardization ensures that indicators (and the data generated) are consistent, compatible, observable, detectable, adaptable, accessible, and usable. But data standards are one component of a much larger data context – data governance. Attempts at data standardization and unlikely to be successful in absence of a larger system of data governance.

- Basic OCAP principles should be respected when monitoring programs involve Indigenous groups.

5 DETERMINING THE EFFECTIVENESS OF MITIGATION IN FOLLOW-UP

5.1 SCHOLARSHIP

Simply put, "effectiveness" is how well something works or whether it works as intended and meets the purposes for which it is designed (Sadler 1996). Following-up on the effectiveness of mitigation is important to sound IA; however, analyses of IA practice globally indicate that mitigation measures prescribed in the IA may not be achieving their anticipated objectives (Sanchez and Gallardo 2005); the objectives or intended outcomes for many mitigation measures are only vaguely stated or not stated at all (Tinker et al. 2005); unanticipated impacts receive little attention in mitigation reviews (Nielsen et al. 2012); and the criteria for verifying whether a specified mitigation measure is effective post-IA are lacking in most impact statements (Bassi et al. 2012).

The importance of establishing procedures to assess the effectiveness of mitigation measures is widely discussed in the literature (Gallardo et al. 2015), but the development of measures for evaluating the effectiveness of mitigation is largely impact or action specific. For example, evaluating the effectiveness of road mitigation measures on wildlife (van der Grift et al. 2013; Ottburg and van der Grift 2019) and in wetland habitats (Bager and Fontoura 2013); debris flow mitigation strategies in mountainous regions (Xiong et al. 2016); noise mitigation from traffic (King and O'Malley 2012) and industrial projects (Postorino and Mantecchini 2016); and pipeline mitigation for moose and other large mammals (Dunne and Quinn 2009).

Nearly three decades ago, Canter et al. (1991) reported that evaluations of the effectiveness of planned or implemented mitigation has received limited attention in IA. The authors proposed an approach for the evaluation of mitigation – which was largely post-project monitoring – but provided little actual direction by way of criteria or principles for determining the effectiveness of mitigation. There remains limited guidance on broad criteria or principles for determining the effectiveness if mitigation in follow-up that cuts across specific environmental components or project or disturbance types. Even in specific fields of practice, such as road mitigation measures for impacts to wildlife, van der Grift et al. (2013) report a paucity of approaches focused on guidance for determining mitigation effectiveness.

Gibson et al. (2005) indicate that the effectiveness of mitigation commitments depends on their success in reducing the significance of anticipated risks and damages. Noble and Storey (2005) and Gallerdo et al. (2016) similarly suggest that verifying the effectiveness of mitigation is, fundamentally, about understanding whether actual effects were subsequently reduced to an acceptable level or avoided because of mitigation measures. Of course, this is easier said than done – especially in absence of long-term monitoring programs. Even then, verifying whether mitigation effectively reduced a project's impact, and distinguishing a project's impact from other effects or conditions changes, can be tricky. For example, mitigation measures may be effectively reducing or eliminating project effects but adverse changes in indicator condition may still be detected due to the effects

of other activities; in other instances, the effects of a project simply cannot be distinguished from the effects of other variables (Ortolano and May 2004).

A scan of the literature reveals several common observations about the requisites for effective mitigation programs that may provide a foundation for developing a more generic set of principles:

- Appraising the effectiveness of mitigation through follow-up hinges on two basic questions: i) was the proposed mitigation program implemented; ii) did the mitigation program succeed in meeting its goals? (Ortolano and May 2004).
- Evaluating the effectiveness of mitigation through follow-up requires that mitigation prescriptions are accompanied by specific objectives or targets in terms of what they are to achieve, over what time period, and how their effectiveness is to be measured (van der Grift et al. 2013; Noble 2015; Andronak 2017).
- Understanding effectiveness of mitigation through follow-up requires collaboration between those who plan, design, construct and manage projects and scientists who study the responses of environmental variables to mitigation measures (van der Grift et al. 2013).
- Following-up on the effectiveness of mitigation must focus not only on "what was wanted" but also on whether there are unwanted or unanticipated outcomes (Marshall 2001; Noble and Storey 2005).
- The duration of ex-post plans is a key determinate of whether mitigation is sufficient, meaning that the duration of mitigation planning activities should reflect the true duration of a project's potential effects – this is typically well-beyond the life-cycle of a project and may even be 30 to 50 years in duration when dealing with potential cumulative effects (Hegmann et al. 1999; Nicolaisen and Driscoll 2016; Muir 2018).
- Good mitigation plans and measures are adaptive, recognizing that mitigation developed during the project planning stages may not be successful in practice (Sanchez and Gallardo 2005; Tinker et al. 2005).
- Evaluating mitigation effectives through follow-up requires that IA practitioners and regulators are precise in the way that mitigation strategies, mitigation commitments, or mitigation requirements are formulated; statements such as "*the proponent will exercise supervision and control during construction to prevent bank erosion*"; "*the proponent should give special consideration to use of machinery in sensitive riparian zones*"; or "*the proje ct will be carried out in such a way to ensure as minimal disturbance as possible to sensitive habitat*," are of little value to sound impact mitigation design, implementation, and verification (Aura 2018).
- Compliance as a mitigation verification instrument is important but insufficient; it rests on a simplified assumption that by complying with stated legislation or regulations, impacts are either avoided or sufficiently small enough to be deemed acceptable (Thiessen 2019).
- Effective mitigation plans and measures are accompanied by sufficient resources and clarity of roles and responsibilities to ensure implementation (Gallerdo et al. 2016).

- Effective mitigation plans and programs reflect a mitigation hierarchy, from impact avoidance, minimization, and restoration to compensation, accompanied by clear rationale when any 'lower level' mitigating action on the hierarchy is the only viable option (Noble 2015; Morrison-Saunders 2018; Muir 2018)
- Mitigation measures are most effective when they serve to *enhance* environmental outcomes or conditions. Generating positive outcomes of benefit enhancement should be at the top of the mitigation hierarchy to ensure steps towards community and ecological sustainability (Gibson 2006; Bond et al. 2013)
- Evaluating the effectiveness of mitigation through follow-up should consider practicality and cost-effectiveness of the mitigation strategy, views of the public and stakeholders, and whether the mitigation favored (in order of importance), proactive avoidance, minimisation and/or reduction, restoration, or compensation (Bassi et al. 2012).

5.2 PRACTICE

There is no clear, authoritative guidance on the best principles or criteria to determine the effectiveness of mitigation in follow-up. There are also few examples from practice that are transferable beyond specific project context or specific impacted parameters. Presented below are two snapshots from practice that illustrate broader principles for following-up on mitigation effectiveness – the first example illustrates a set of project-specific approval conditions for a cultural management plan, aimed to ensure meaningful mitigation and verification; the second example is a set of generic principles for mitigation design, developed to assist regulatory decision makers and practitioners in IA information input and IA quality reviews.

5.2.1 National Energy Board conditions for the North Montney Mainline project cultural management plan

The National Energy Board's (NEB 2015) report on NOVA Gas Transmission Ltd.'s application for the North Montney Mainline Project provides some insight to the matters that constitute, and the prerequisites for evaluating, the effectiveness of mitigation through follow-up programs. In 2013, NOVA Gas Transmission, a subsidiary of TransCanada Pipelines, submitted a proposal to construct and operate the Montney Project – an approximate 306-km pipeline – as part of its energy infrastructure development program in northeast British Columbia (TransCanada 2013). The NEB's review of the project concluded that the IA was unsatisfactory, so the NEB's attention focused on a number of ex-post planning and mitigation requirements as possible solutions to the shortcomings of the impact statement. Included amongst the NEB's requirements was the development of a cultural management plan and that mitigation measures be designed to eliminate or reduce potential adverse impacts "to the greatest extent possible" (NEB 2015, 103). Although a very poorly articulated objective, there are a number of good-practice considerations that can be extracted from the NEB's report of the project's IA for ensuring successful follow-up on mitigation effectiveness. These are discussed in detail by Muir (2018), and include the following:

- Mitigation measures are to be categorised and evaluated based on a mitigation hierarchy that consists of avoidance, minimisation, restoration and offsetting. Before moving from one level to the next in the hierarchy, the cultural management plan must include details that sufficiently substantiate that there are no effective mitigation measures that could satisfy a particular level on the hierarchy.
- The analysis and reasoning for selecting a specific mitigation measure on the hierarchy must address three sequential questions for determining the adequacy of the mitigation solution: is the mitigation 'effective'; is the mitigation technically feasible; and is the mitigation economically feasible?
- When mitigation is focused on impacts that cannot be avoided, there must be a description of how the cultural management plan will determine the effectiveness of such measures and each mitigation measure must be accompanied by specific criteria to assess its effectiveness.
- A methodology for determining the effectiveness of mitigation must be described, accounting for such matters as when and under what conditions corrective actions should occur.
- An operation plan for the participation of Aboriginal peoples in the implementation of monitoring must be part of the cultural management plan, and he Aboriginal monitoring program would be involved in developing specific measurements to evaluate mitigation performance and implement corrective action.

5.2.2 Effective mitigation guidance for Yukon Major Projects Office

In 2017, Aura Environmental was contracted by the Executive Council Office, Major Projects Yukon, to develop guidance and provide direction to Yukon Government departments on what constitutes 'high quality' assessment input that is consistent with departmental and corporate mandates and is meaningful and useful for IA and to project assessors under the Yukon Environmental and Socio-economic Assessment Board. Part of this work involved the identification of good-practices for mitigation formulation – i.e. the pre-requisites to being able to determine whether a specific mitigation action is effective. Drawing on international practices and the experience of Yukon practitioners, the following foundational principles were proposed as good practice principles for mitigation input to IA processes (Aura 2018):

☑ Mitigation actions clearly demonstrate the *nexus* between the proposed mitigation and the effect of concern, and is commensurate with the level of risk, vulnerability of the affected component, and magnitude of the effect.

☑ Mitigation prescriptions reflect a hierarchical consideration of viable options, including options to enhance; options to avoid; options to minimize or reduce; opt ions to restore; options to compensate.

☑ Consideration is given to the known or anticipated efficacy of the mitigation prescriptions, including uncertainties, and any potentially adverse side effects: based on previous, similar projects or assessments; based on scientific or technical literature; based on expert judgement, with appropriate substantiating evidence.

☑ Mitigation prescriptions must set out criteria (e.g. targets, benchmarks, desired conditions, or objectives) that are *measurable*, *reportable*, and *verifiable* and against which the efficacy of a prescribed mitigation action can be evaluated.

☑ Consideration is given to the scientific and technical (design) feasibility of the mitigation: based on the significance of the adverse effect; based on the size or scope of the project under consideration; based on the best available science and technology.

☑ Mitigation actions support (or at least do not contradict or undermine) existing regulations, land use plans, or established management objectives.

☑ Where there are uncertainties *and* the potential for significant adverse effects, mitigation actions are part of a larger process of adaptive management.

5.3 KNOWLEDGE SYNTHESIS

Following-up to assess mitigation effectiveness is based on one or more of:

- ***Procedural effectiveness*:** the degree of compliance with established rules, regulations, standards or guidelines
- ***Substantive effectiveness*:** whether certain goals or stated objectives were achieved and may be assessed directly based on indicator performance or indirectly based on demonstrated changes to the project or management plan
- ***Transactive effectiveness*:** desired outcomes are achieved with the least time and resource cost (Glasson et al. 2005; Morrison-Saunders and Bailey 2009; Theophilou et al. 2010)

Based on the literature and brief assessment of practice, criteria for determining the effectiveness of mitigation measures are project, context, or valued component or indicator specific. There is no set of criteria that can be used universally to assess whether a prescribed mitigation action is effective. For example, criteria or indicators for assessing the effectiveness of a riparian habitat buffer on sediment loading in a stream are very different than the criteria or indicators that might be useful for determining whether regional wetland compensation is effectively offsetting for loss of wetland function in the local project environment. There is no single recipe for determining whether a prescribed mitigation action is effective; such a determination is specific to the mitigation action and the environmental indicator or component in question.

However, when impact- or component-specific metrics are developed to assess mitigation effectiveness, literature and guidance does suggest a number of generic good-practice principles for how mitigations are designed and approached to increase the likelihood of a desired outcome. At a minimum, there is a need to consider:

- ***Clarity of the mitigation prescription:*** mitigation actions (or approval conditions) must be unambiguous and stated in such a way that they can be verified, and include such factors as:
    - what the mitigation action is/was and its relevance to the impact
    - when the mitigation will be/was implemented and expected/actual timeline in system response
    - how the mitigation will be/was implemented and relevant scientific or Indigenous knowledge rationale

    - the responsible party for implementation
    - the specific standards, benchmarks, or objectives against which system response are measured
    - resource allocation (financial, human) for mitigation and monitoring effectiveness

- ***Application of the mitigation hierarchy:*** evidence of the mitigation hierarchy, staring with impact enhancement measures (positive impact) followed by avoidance, minimization, restoration, and compensation
    - rationale is provided for the level of mitigation, including assessment (e.g. scientific, design/technical, timelines, economic, standards/regulations), as to why a higher level of the hierarchy cannot not be achieved

- ***Collaborative approaches:*** evidence of collaborative approaches to impact mitigation design, implementation, and monitoring where the impacts being mitigated are for components affected by other proponents or of concern to communities or Indigenous groups.

6 INSTITUTIONAL ORGANIZATIONS TO SUPPORT GOOD FOLLOW-UP

6.1 SCHOLARSHIP

Continuous learning is a key benefit of IA follow-up (Wathern 2013), whereby results are used to increase the effectiveness of future IAs and mitigation planning and improve efficiencies. Andronak (2017) similarly identifies the benefits of follow-up as an opportunity improve the "next project." This presumes that the knowledge generated through follow-up is, at a minimum, relevant to decision making, credible, accessible, and transferable. Several science-based initiatives to support long-term monitoring have emerged across Canada over the last 20 years or so, including for example the Cumulative Impact Monitoring Program in the Northwest Territories, monitoring programs in the Peace-Athabasca-Slave River and Yukon River watersheds, and more than a dozen monitoring programs and organizations in the Lower Athabasca region of Alberta, among others (see Dubé and Wilson 2013; Dubé et al. 2013; Cronmiller and Noble 2018a). However, numerous studies conclude that long-term monitoring data are either absent or insufficient, or so fragmented that their value to impact evaluation, management, and decision support is limited (e.g. Spence et al. 2007; Squires et al. 2009; Lott and Jones 2010; Vörösmarty et al. 2010; Schindler 2010; Dube et al. 2013; Dubé and Wilson 2013; Hutto and Belote 2013; Wong et al. 2019). Institutional arrangements, more so than data per se, thus present the most significant opportunities and challenges to follow-up and translating results to future IAs.

There are some well-known and fundamental components of successful monitoring (e.g. Reid 2001; Kilgour et al. 2007; Lindenmayer and Likens 2010), but there is limited consolidated literature on the institutional or organizational arrangements that best support long-running follow-up and monitoring programs to ensure their influence. However, lessons can be drawn from literature across diverse fields, including institutional arrangements for watershed management (e.g. Sheelanere et al. 2013; Noble and Basnet 2015), regional aquatic effects monitoring frameworks (e.g. Dube et al. 2013), biodiversity monitoring initiatives (Lindenmayer and Gibbons 2012), and scholarship focused on monitoring agencies (e.g. Ross 2004; Affolder et al. 2011; Biber 2011), to name a few. These may not be the *only* principles and characteristics for successful institutional organizations for monitoring, but they are cross-cutting themes from multiple disciplines.

6.1.1 Mandate for monitoring

The function of an agency or organization for conducting or coordinating monitoring is crucial to a monitoring programs' success or failure. There must be a clear mandate for monitoring and its value-added clearly established. Woinarski (2012) argues that specific organizations or institutions are needed to coordinate monitoring, including brokering the necessary partnerships that are fundamental to the success of long-term monitoring programs. Zerger and McDonald (2012) and Garnett (2012) argue that such institutions must also have a mandate to maintain registries of data sets and map what is being monitored and where. This mandate

must include setting appropriate questions for monitoring, identifying new or emerging information needs, ensuring relevance to decision making, maintaining monitoring partnerships, and effectively communicating monitoring information to end users (Lindenmayer and Likens 2010). When long-term, ambient monitoring is one of several tasks of an agency or organization, it is likely to be the first task traded-off when resources or scarce or when policy objectives and priorities shift. Biber (2011) argues that this is especially the case for government agencies, and also many publicly funded monitoring committees, where shorter-term results are often the favoured performance-based metrics over longer-term commitments to ambient monitoring. Monitoring organizations are most successful when monitoring (and related tasks) is their primary mandate.

6.1.2 Continuity and longevity

Environmental monitoring requires long-term organizational commitment to ensure consistency and continuity in *what* is monitored and *how* it is monitored. Numerous researchers describe monitoring data and programs across as so fragmented, limiting their value to tracking and understanding long-term change (e.g. Spence et al. 2007; Schindler 2010; Dube et al. 2013). The challenge is that monitoring may be occurring in any given region by different actors, at different scales, using different indicators, and for a variety of purposes (Lott and Jones 2010; Lindeman et al. 2011; Hutto and Belote 2013), resulting in incompatible data and a lack of metadata standards (Vörösmarty et al. 2010; Garnett 2012; Ball et al. 2013; Dubé and Wilson 2013). Continuity requires establishing commitment and reliability on the part of the institutional actors that conduct or supervise monitoring (La Porte 1996). Standardization of indicators, monitoring guidance, and metadata are needed to ensure the long-term utility of monitoring programs.

6.1.3 Partnerships

Institutional organizations to support successful monitoring are based on partnerships (Lindenmayer and Likens 2010; Biber 2011). Sheelanere et al. (2013), based on an analysis of monitoring and assessment programs in the South Saskatchewan watershed, report that for such programs to succeed there must be partnerships that engage the various stakeholders, but with clearly defined roles and responsibilities. Biber (2011) suggests that partnerships, which also engage those organizations that do not normally conduct monitoring, allows for improved sharing and updating of monitoring results in management and decision making. It also serves to address the compatibility of monitoring data (see Ball et al. 2013) and establishing similar monitoring protocols to maximize data usability. According to Lindenmayer and Gibbons (2012), based on an analysis of international biodiversity monitoring research and practice, "*it is clear that successful monitoring programs will often be those that connect...two or more of the following: universities, government agencies, non-government organizations and community groups*." Lindenmayer and Likens (2010, 1321) report that "*well-developed partnerships between these groups of people are needed to validate policy-relevant and management relevant projects, as well as contain the scientific and statistical rigor required that ensure results are robust and conclusions are workable and defensible*."

6.1.4 Guiding questions and a conceptual model

Successful monitoring programs are underpinned by carefully crafted questions and objectives, rather than political directive (Lindenmayer and Likens 2010; Wong et al. 2019). Questions must be scientifically tractable and focused on policy and resource management issues and challenges – questions must be developed through collaborations among scientists, managers, decision makers and other information users (Lindenmayer and Likens 2010). In practice, however, there is a tendency for monitoring to be "planned backwards on the collect now, think later principle" (Roberts 1991), resulting in monitoring that is poorly focused and unable to deliver meaningful outcomes (Legg and Nagy 2006). Good monitoring programs and organizations are guided by an overarching conceptual model, representing the key components of a monitoring program, important questions, information flows, and information needs. A conceptual model serves to guide ongoing data collection and analysis, helps ensure that monitoring information needs are being met, and is a focal point for discussions among monitoring partners about monitoring and management decisions (Lindenmayer and Likens 2010).

6.1.5 Decision relevance

Good monitoring programs are integrative of good science and good management (Russell-Smith et al. 2003) and provide information to managers in clear and easily understood formats (Radford et al. 2012). A real risk to monitoring organizations is focusing on indicators or variables that are not actually connected to the underlying issues or resources of management interest or regulatory significance. Lindenmayer and Likens (2010) and Russel-Smith et al. (2003) suggest that scientists and those 'doing' monitoring are not always aware, or understand, nature and timelines of the information needs of managers, decision makers, and other end users. Conceptual guidance on what a monitoring program (or monitoring committee) is to achieve, and who or what are to be informed by the results, is essential to longevity and influence (Hobbs 2012; Montambault and Groves 2012). Monitoring programs *must* be scientifically sound, but what is being monitored, and the questions asked, must also align with the information needs and timeframes of decision makers, proponents, and those responsible for regulatory approvals (Hegmann and Yarranton 2011; Jones 2016). This will ensure social (and political) relevance for what is being monitored and how monitoring programs are designed (Burgman et al. 2012; Biber 2011). That said, rarely in project IAs when proponents are required to conducting monitoring of specific parameters are proponents provided with the specific questions (i.e. monitoring needs) that decision makers or regulators want answered.

6.1.6 Accessible data

Monitoring results must be accessible to be useful. Accessibility is an enduring challenge for many monitoring programs and organizations. In particular, there is limited sharing of data collected by project proponents through their IA monitoring programs (Wong et al. 2019). The recent Expert Panel's (2017) review of federal IA suggested the need for legislated or regulatory instruments to require a central, consolidated, and publicly available database to house all baseline and monitoring data collected for IA purposes. Morrison-Saunders et al. (2003) agree, in that accessibility requirements are important prerequisites to monitoring programs; however, mandating that data are made available does not ensure that such data are usable or useful.

6.1.7 Meaningful information

Many monitoring programs generate data that are not collated or available in formats that are unusable (Murray et al. 2018). Open data sources or platforms can easily become *data dumps* – i.e. data rich but information poor. Equally important to data provision is data processing and information generation – products that are standardized and useful to end users. Many decision makers, communities, and proponents simply do not have the capacity or knowledge to analyze data and identify key trends or limits (Biber 2011). Monitoring programs or organizations that provide quality data are useful, but not as useful as ones that also provide information (i.e. knowledge synthesis, trends reporting) based on those data. To ensure capacity to provide information products, organizations like the Norwegian Hydrographic Service (www.kartverket.no) and the UK Natural Environment Research Council (https://nerc.ukri.org/) make data freely available to all end users but information products, such as maps, trends analysis, or requested compilations of data, are provided on a fee-for-service basis.

6.1.8 Science independence

Although monitoring must be responsive to the needs of decision makers, proponents, communities, and managers, monitoring must not be dictated solely by those interests and timeframes (Lindenmayer and Likens 2010). Cronmiller and Noble (2018b) argue that "*a degree of independence is needed in the design and functioning of any monitoring program, thus providing a niche for innovative science, an opportunity to pursue new questions as knowledge is gained, and stakeholder assurance as to the credibility of monitoring results*." Scientific autonomy is especially important in regions characterized by multiple land uses, values, interests, and controversial resource development (Cronmiller and Noble 2018a). Science independence increases the perceived credibility of monitoring results (Biber 2011). In the NWT, for example, Wong et al. (2019) identified reluctance amongst proponents to use monitoring data collected by other proponents, preferring instead to collect their own data or to use data generated by more independent authorities. Science independence is needed to develop the models and identify the indicators for effectively predicting the impacts of environmental and social disturbance. Such scientific efforts are long-term and well-beyond the scope of the science applied during the scope and short timelines of regulatory IA. But to ensure uptake by the practitioner community, the science from long-term monitoring initiatives must pay attention to the needs of practitioners and regulatory decision makers.

6.1.9 Institutional arrangements

The above principles lead to the question of what the most appropriate arrangement is to support long-term monitoring programs. The literature does not provide a direct answer to this, but several models are suggested. Biber (2011), for example, explores the relative strengths and limitations of government agency-led versus independent monitoring programs and organizations. Government agency-led monitoring requires a clear organizational mandate for monitoring, can help coordinate monitoring across government agencies, and usually requires some sort of central information clearinghouse and coordinating committee. That said, Bieber (2011) argues that government agency-led monitoring organizations are often challenged by an inherent pressure within many governments to focus on programs that deliver immediate or short-term results, rather than those that require long-term commitments. Coupled with the challenge of evaluating whether monitoring is "effective," this often leads agencies to underinvest in long-term monitoring versus activities that are more easily assessed.

An alternative model discussed by Biber (2011) is a separate, independent agency whose primary goal is monitoring. Bieber suggests that separation or institutional independence refers to politics, budgeting, and agency culture – the organization may still, in practice, be closely intertwined within a larger agency. This separate agency my not necessarily conduct the monitoring itself, but it may serve a coordinating role. The advantages of independence are continuity (Freeman and Farber 2005), expertise (because the agency primarily focuses on monitoring); incentive to conduct effective monitoring (because of administrative separation from other potentially conflicting activities); and reputation as an "unbiased" provider of information (Bieber 2011). On the downside, when monitoring organizations are separate the distance between the "science" and the "decision makers" is increased and monitoring less connected to the decisions it is supposed to inform.

Cronmiller ad Noble (2018b) expand on Bieber's (2011) classification, drawing on the nearly 100-year history of monitoring organizations in the Lower Athabasca. Rather than focus on *who* should be responsible for monitoring, Cronmiller and Noble (2018b) suggest three distinct approaches regarding *how*, conceptually, long-term monitoring programs are integrated with frameworks and systems designed to support management and decision making (Figure 2) – each with their relative strengths and limitations (Table 4).

Distributed monitoring system: Monitoring responsibilities for different environmental components are delegated to a different monitoring program or organization. A coordinating government agency works in consultation with monitoring programs and organizations to determine the monitoring requirements for environmental components and a common, overarching vision or mandate for the monitoring strategy. The basic premise is that monitoring data generated by each monitoring program or organization, and in some cases analyses, are funneled through a coordinating, responsible government agency where they are brokered to inform management actions and decisions.

One-window monitoring system: Monitoring is implemented and maintained by a single agency or organization, usually a government agency or organization with a mandated responsibility for monitoring. The premise is that the monitoring organization becomes as "1-stop-shop" for data collection and information to support decision making.

Independent exploratory system: Monitoring is regional and needs-based, emphasizing scientific understanding of trends and changes in complex systems. There is a heavy investment in industry and region-specific "studies," focused primarily on advancing science. The premise is a structured scientific approach to effects-based studies to strengthen science, build better predictive models, and to generate information that could be used to support a more robust management system.

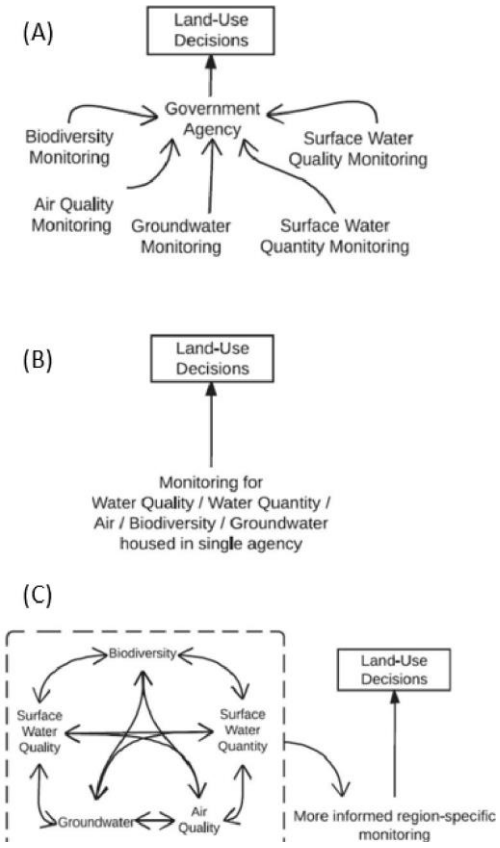

Figure 2. Distributed (A), one-window (B), and independent (C) monitoring arrangements (Cronmiller and Noble 2018b)

Table 4. Relative strengths and weaknesses of distributed, one window and independent monitoring arrangements

Model	Strengths	Weaknesses
Distributed	Monitoring results seen as more credible and transparent due to independence of industry (in some cases government)	Program objectives may not be designed to answer questions aligned with industry or government's management or knowledge needs
	Can capitalize on existing scientific and technical expertise specific to individual monitoring components	Can be slow to respond to new data needs to support emergent problems or crisis situations
	Minimizes need for creation or maintenance of new government infrastructure, capital, or institutions	Reliance on multiple, external organizations to mobilize data for regulatory decisions increases vulnerability (e.g. performance, credibility, funding commitments).
	Longer term stability, due to existence external to government mandates	Limited data integration across monitoring programs; difficult to ensure data compatibility
One window	Supports a shared or common vision for monitoring	Focus on specific problems, priorities or agency mandates at the cost of longer-term understanding.
	Assurance that monitoring design is responsive to specific needs of decision makers	Less likely to detect or report significant adverse effects under the "status quo" scenario.
	Centralized allocation of resources, with less administrative and organizational complexity	More susceptible to legal challenge if a project is denied due to threshold exceedance, and to public criticism about transparency and quality of science.
	Greater opportunity for data integration, coordination, and compatibility of data	Vulnerable to influence and change due to political whims and shifting economic priorities.
Independent	Thresholds perceived as more defendable with science-based monitoring and detection limits	Types of questions asked are often different than those asked by land-use and regulatory decision makers.
	Longer term focus on cause–effect understanding and range of natural variability	Data inaccessibility or delayed availability to end users (industry, government) due to primary focus on scientific timelines vs. regulatory decisions.
	Enhanced science credibility due to independence from government or industry mandates	Longer term, cause–effect focus not responsive to immediate or emergent decision-making needs
	Responsive to new knowledge and able to adapt quickly to pursue new science questions	Unclear how much time and financial resources required to generate concrete answers
	Financial independence of specific projects or government programs and lending perceived credibility	Funding sources may be unstable, if not linked to a specific government program or long-term commitment

Source: Cronmiller and Noble (2018b)

There is no single approach that will work best in all contexts but suggest that a hybrid organization may be most effective – i.e. an independent, nongovernment, one-window model for monitoring, interpretation, and information delivery (Cronmiller and Noble 2018b). Such organizations may be established as centers, perhaps even affiliated with a university or consortium of universities, where the long-term, science-based expertise and capacity exists for data management, data quality control, and data distribution systems. Cronmiller and Noble argue that although such an organization would operate independently of industry and government, to ensure transparency and scientific credibility, it "*might be governed by a distributed (multisectoral) board of directors to ensure that monitoring data are directly relevant to the needs of decision makers and regulatory processes*." Such an organization would be nimbler than a distributed monitoring arrangement, and able to more rapidly respond to advances in science and shifts in decision maker information needs. The authors do not recommend a specific financial model for such an organization, but drawing on Sheelanere et al. (2013), they suggest a collaborative model of both in-kind and long-term financial commitments from the public and private sector, including granting agencies, coupled with shorter term funding or commissioned "studies" to meet emerging industry or regulatory needs.

6.2 PRACTICE

There is much to be learned from the long-term monitoring organizations in the Athabasca region of Alberta, and the Northwest Territories. Monitoring initiatives in these regions can serve as basis for understanding the opportunities and constraints of different organizational structures and lessons learned for sustaining monitoring programs and translating results to future IAs.

6.2.1 Case Study # 1 – Lower Athabasca, Alberta

The Athabasca region is perhaps one of the most heavily monitored regions in North America and home to more than a dozen institutional organizations for monitoring since the mid-1990s (Lott and Jones 2010) – some of which have lasted for decades and others have been short-lived. A study by Cronmiller and Noble (2018a) examined the institutional and programmatic arrangements of monitoring programs in the Athabasca region. The first, formal monitoring organizations in the region were formed in the early 1900s, but most did not emerge until the late 1990s. The history and evolution of monitoring in the region in five phases, each reflecting specific monitoring mandates and institutional arrangements and a diversity of monitoring organizations (Figure 3):

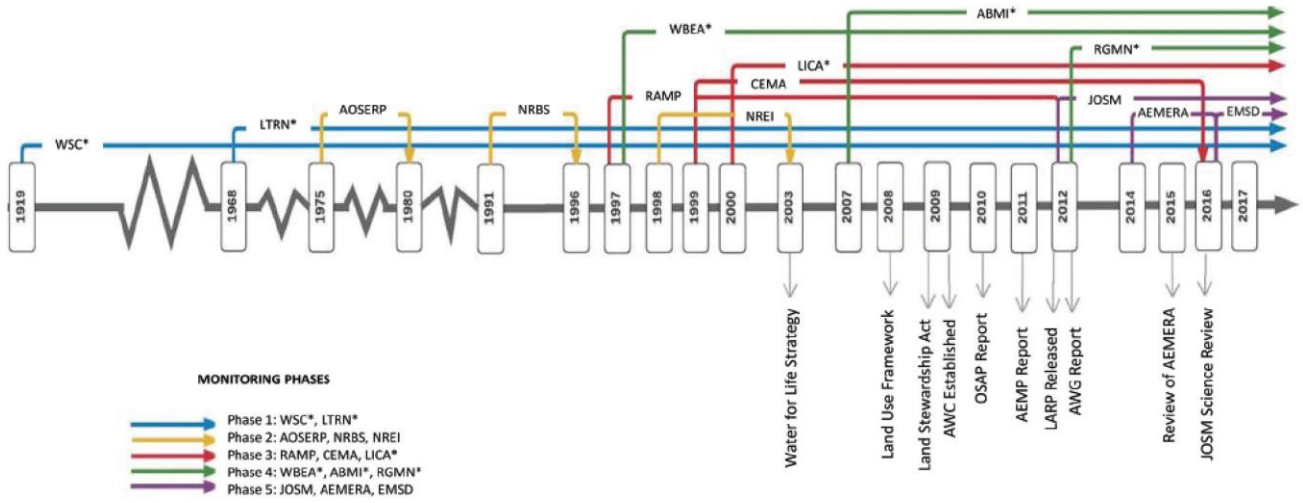

Figure 3. Evolution of monitoring programs and organizations in the lower Athabasca (Cronmiller and Noble 2018a)

- *Phase 1 - Establishment of long-term monitoring programs*: e.g. Water Survey Canada (WSC); Long-term River Network (LRTN)
- *Phase 2 - Emergence of shorter-term, regional science-based studies*: e.g. Alberta Oil Sands Environmental Research Program (AOSERP); Northern Rivers Basin Study (NRBS); Northern Rivers Ecosystem Initiative (NREI)

- *Phase 3 - Multi-stakeholder and consensus-based programs*: e.g. Regional Aquatics Monitoring Program (RAMP); Cumulative Environmental Management Association (CEMA); Lakeland Industry and Community Association (LICA)
- *Phase 4 - Component-specific monitoring for targeted science or decision support needs*: e.g. Wood Buffalo Environmental Association (WBEA); Alberta Biodiversity Monitoring Institute (ABMI); Regional Groundwater Monitoring Network (RGMN)
- *Phase 5 - Search for oversight, coordination and integration*: Joint Oil Sands Monitoring (JOSM); Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMRA); Environmental Monitoring and Science Division (EMSD)

Three specific regional monitoring programs in the Athabasca were profiled earlier in this report: Wood Buffalo Environmental Association (3.2.1), Alberta Biodiversity Monitoring Institute (3.2.2), and Regional Aquatics Monitoring Program (3.2.3). Based on the history and evolution of these and other regional monitoring programs in the Lower Athabasca, Cronmiller and Noble (2018a) make several observations about the institutional organizations to support meaningful monitoring and following programs:

- Cross-agency differences hamper efforts to support integrative monitoring. Notwithstanding recommendations from the NRBS in 1996 that monitoring activities be integrated to identify priorities and avoid duplication, the years following saw the contradictory inception of monitoring programs independent of one another and each with their own mandate and monitoring protocols.

- The emergence of AEMERA and JOSM, as integrative institutional models, were unable to fully resolve the disparate monitoring programs and organizations in the region and came up significantly short as publicly accepted, government-led monitoring organizations. Both organizations lacked transparency in longer-term vision, lacked clarity about roles and responsibilities, lacked full stakeholder engagement, and failed to establish clear leadership

- Multi-stakeholder initiatives help ensure trust and validity in environmental management, but they are not a panacea for effective environmental monitoring. RAMP, for example, started as an industry-only initiative and evolved to include more stakeholders; however, it still suffered from transparency issues, industry control, and the lack of a science focus.

- The size and complexity of some multi-stakeholder initiatives can impede their ability to define clearly agreed-upon monitoring goals and to make timely policy recommendations. Power struggles in CEMA between industry, First Nations, and environmental organizations, contributed to conflicts over what constituted credible monitoring results.

- Monitoring programs tend to be more effective when focused on a limited number of indicators that are of direct relevance to decision making. Notwithstanding WBEA's 38-member organization, its monitoring activities are highly targeted on a few key indicators of air quality and deposition, with results linked directly to province-wide monitoring and regulatory processes for the oil sands industry.

- Scientific autonomy is essential to the credibility of monitoring programs. Criticisms about industry and government influence over monitoring have emerged repeatedly in the Lower Athabasca, leading to questions about the credibility of monitoring results and even to the disbandment of some monitoring programs. RAMP, for example, was seen as industry controlled; WBEA and ABMI, in contrast, are independent science-based organizations and perceived as credible by communities, governments, and industry.

- Pursuing the right questions has been an enduring criticism of monitoring programs in the Lower Athabasca, with monitoring results coming up short in supporting regulatory decision needs. Despite its scientific credibility, ABMI, for example, has been criticized for being an "unfocused monitoring program ... planned backwards on the collect [data] now, think-later principle" (Lindenmayer and Likens 2010).

6.2.2 Case Study # 2 – Cumulative Impact Monitoring Program, Northwest Territories

The NWT Cumulative Impact Monitoring Program (CIMP) was established by the Government of the Northwest Territories to function as a regional monitoring organization across the Mackenzie Valley. Section 146 of the *Mackenzie Valley Resource Management Act* provides the legislative mandate for CIMP. The main purpose of CIMP is to support resource management decisions, including project IA and mitigation, by furthering the understanding of environmental impacts trends.

CIMP is guided by a steering committee of First Nations, Inuvialuit, Métis, and federal and territorial government representatives and relies on partnerships with research organizations, universities, and communities to: i) develop monitoring and research priorities; ii) coordinate, conduct and fund research and monitoring; iii) communicate results and information to decision-makers; and iv) facilitate an audit every five years on the IA process (CIMP 2015). Monitoring activities supported by CIMP are focused on key geographic areas and valued components with priority attention to fish, caribou, and freshwater (CIMP 2015; GNWT 2015). CIMP disseminates the results of monitoring and research primarily via reports, articles published with research partners, and online data portals – specifically the NWT Discovery Portal, Inventory of Landscape Change, and the Mackenzie Data Stream[8].

Recent audits of CIMP's performance indicated much needed improvements in demonstrating the program's relevance to regulatory decision making (GNWT 2010, 2015). Notwithstanding agreed-upon monitoring components, the audits emphasized the importance of identifying the information needs and priorities of decision-makers and refining them into key impact monitoring questions that will guide monitoring and ensure meaningful information to regulators. The audit results highlighted the expectation that components and impacts are not only monitored, but that the information generated through long-term monitoring functions as valuable input to future IA and management decisions.

[8] NWT Discovery Portal: http://nwtdiscoveryportal.enr.gov.nt.ca/geoportal/catalog/main/home.page; Inventory of Landscape Change: https://www.enr.gov.nt.ca/en/services/cumulative-impact-monitoring-program-nwt-cimp/inventory-landscape-change-webviewer; Mackenzie Data Stream: https://mackenziedatastream.ca/

In response to the audits, CIMP funded a study to assess regulator's information needs to make decisions regarding effects and project IAs under the *Mackenzie Valley Resource Management Act*, and to identify key areas for organizational improvement to increase the relevance of monitoring data to future assessments and impact management decisions. The study examined multiple dimensions of CIMP's activities, including specific indicators for monitoring, detectability limits, database accessibility, data compatibility, end user needs, and institutional supports (see Arnold et al. 2019; Wong et al. 2019).

Regulatory instruments, organizational capacities, identification of priority components for monitoring, and data sharing platforms were found to be well advanced; but four overarching institutional needs were identified to ensure that CIMP results are useful to informing future IAs and regulatory decisions:

- ***Standardizing monitoring requirements for a minimum set of common indicators:*** Although CIMP has identified priority components (e.g. freshwater), there remains considerable variability within and between government, community, and proponent environmental monitoring in terms of the indicators used and monitoring methods. Further, government monitoring programs are coarse, focused on baseline conditions and detecting gross change; their precision and focus did not align with proponent and decision maker needs for assessing baselines and the potential impacts of individual projects during regulatory reviews. Wong et al. (2019) recommended that CIMP, through the GNWT, introduce standardized monitoring guidance for a minimum set of parameters, whether affected or not by a specific project, that all monitoring programs must include (i.e. community monitoring, government monitoring, and embedded in terms of reference for project IAs). These indicators and/or parameters must be useful for detecting early warnings of change, which can trigger more intense and focused monitoring efforts to support regulatory decisions and impact management at the project scale.

- ***Means to require, and manage, open data:*** Requirements already exist for data sharing in the NWT. The requirements are that data must be provided – there is no specification of what must be provided and in what format. Thus, notwithstanding the Mackenzie Data Stream to house data, Wong et al. (2019) found that monitoring data (especially data from project IAs) was either not accessible or not available in a usable format. The study recommended that CIMP focus its efforts on making publicly available a limited set of data for key indicators, while protecting the sensitivity of proprietary information associated with some proponent- and community-based monitoring programs. Further, the study recommended that it was not sufficient to simply house a common data set, but that CIMP should play a larger role in the analysis and interpretation of data (i.e. to identify and map key trends) – thus providing a standard data product for use by proponents and decision makers. Arnold et al. (2019) found that for those data that are publicly accessible, communities and decision makers (including community boards and IA review panels) lack the capacity (knowledge, resources, time) to understand and interpret those data to inform decisions and mitigation needs.

- ***Overarching conceptual model to guide monitoring:*** The most significant need identified by Wong et al. (2019) to ensure a meaningful program of monitoring and decision support was an overarching, conceptual model for monitoring. Monitoring is ongoing through government initiatives, various community-based programs, and by project proponents under their licensing requirements. All are reporting data potentially relevant to CIMP's priority components; however, there is no conceptual

model to guide monitoring activities. Successful monitoring programs or organizations require an overarching conceptual model that, at a minimum, identifies the types of monitoring questions to be asked, guides and provides knowledge from the hypotheses tested, and ensures timely and meaningful output to support management actions and decisions at the project scale.

6.3 KNOWLEDGE SYNTHESIS

Institutional constraints, more so than scientific ones, often pose the most significant barriers to long-term monitoring and knowledge transfer in IA. Institutional organizations to ensure the results of long-running follow-up programs are informative for future assessment, management and decision processes are those that:

- have a clear mandate for monitoring;
- ensure consistency and continuity in *what* is monitored and *how* it is monitored;
- are based on well-developed partnerships to validate policy-relevant and management relevant monitoring initiatives;
- are underpinned by carefully crafted questions and objectives, rather than political directive;
- are scientifically tractable and focused on real policy and resource management issues and challenges of community and regulatory significance;
- make data open and accessible;
- provide data interpretation, including analysis and synthesis of key trends;
- demonstrate political and industry independence in design and functioning, providing stakeholder assurance as to the credibility of monitoring results; and
- ensure opportunities for innovative science and the ability to pursue new questions as knowledge is gained.

There is not a single approach to monitoring that is uniformly applicable to all monitoring programs. However, three broad systems of modeling can be identified based on recent practice: distributed, one-window, and independent. A hybrid organization that capitalizes on the strengths of thee models, while avoiding the limitations, may be most effective – i.e. an independent, nongovernment, one-window systems for monitoring, interpretation, and information delivery. Such organizations may be centers or consortiums, with long-term, science-based expertise and capacity for data management, quality control, analysis, data distribution systems.

At a minimum, literature suggests that monitoring arrangements require a clear vision, agreed-upon monitoring questions, a coordinated multi-stakeholder approach to setting objectives, balancing scientific autonomy and monitoring design with the needs of stakeholders and decision makers, and a clear governance process. Several challenges and caveats also emerge from recent scholarship and practice:

- There is a tendency to invest in shorter-term studies with more immediate, issue-specific payoffs at the expense of understanding cause–effect relationships for longer term benefit.
- Monitoring programs too tightly coupled with government or industry priorities can be criticized for responding more to political needs than to science and communities.

- Making monitoring data available does not ensure its utility to future IAs or decisions; monitoring organizations must provide data synthesis and interpretation of data trends (i.e. information) for meaningful decision support.
- Coordination of monitoring interests and data can prove problematic under all types of monitoring systems, but they are likely to be more pronounced in independent and distributed systems.
- Simply housing monitoring programs under one umbrella or organization does not itself ensure better integration or usefulness for decision making.
- Coupling of large-scale, long-term environmental monitoring organizations and programs with localized and shorter-term monitoring efforts of project proponents and development permitting processes, are foundational to understanding and effectively managing environmental effects.
- Being responsive to regulatory and decision-maker needs is important but monitoring programs must support longer-term science needs for understanding complex systems.

7 RECOMMENDATIONS TO THE IMPACT ASSESSMENT AGENCY

The following recommendations are offered to support the Agency in its development of new and improvement of existing follow-up and monitoring initiatives and practices. The recommendations are based on the lessons emerging from the review of scholarship and current practice of follow-up and monitoring and considering also the recommendations made by the Expert Panel for the Review of Environmental Assessment Processes. Recommendations are presented in order from the most immediate and micro-level to the longer-term and macro-level strategies and actions.

7.1 LEADERSHIP ON GOOD IA PRACTICE

The basics of good practice are routinely missing from IA. Institutional and legal reform have received much more attention in recent years than the nuts-and-bolts of doing good IA. Notwithstanding the recognized need for better follow-up and monitoring, there has been little attention to such basic matters as *how* mitigations are formulated (i.e. whether they can actually be verified), setting targets, applying the mitigation hierarchy, and how to design good monitoring programs. Improving the current state of basic IA knowledge is a necessary starting point for better follow-up and monitoring. Practitioner training (both inside and outside government) often focuses on understanding acts or regulations, but not always on how to *do* good IA. The following actions and initiatives are recommended:

10. The Agency should lead the development of **operational guidance** (principles, templates, good-practice examples) and offer regular practitioner training on **basic IA principles**, including:
    a. formulating mitigation statements and commitments with a level of detail such that they can be followed-up and verified
    b. applying the mitigation hierarchy
    c. design of monitoring programs, including indicator selection, that are meaningful to verifying mitigation effectiveness and detecting unanticipated impacts.
11. Whether internal to the Agency or through a third-party, the Agency should strengthen **oversight and review of IA quality** to ensure that:
    a. mitigation actions contained in impact statements are presented in such a way that they can be verified, this includes ensuring that all mitigation commitments (or requirements) provide clear

direction on what, how, who is responsible, timing, and how the effectiveness of the mitigation action will be verified

b. mitigation actions identified in impact statements are based on the mitigation hierarchy, with clear rationale provided for the level of mitigation prescription on the hierarchy

c. monitoring recommendations included in impact statements or approval conditions provide clarity on what a proponent is to monitor, how it is to be monitored, the standards for reporting monitoring data, and the specific questions or issues that the monitoring program is to be designed to answer or address.

7.2 STANDARDS FOR MONITORING INDICATORS AND DATA

Tracking change over time requires (at a minimum) that monitoring data and indicators are consistent and compatible, and collected and reported using standard methods. Data standards are essential. It is not possible (nor is it desirable) to set data standards for all indicators – and not all indicators need to be monitored. Monitoring programs must be feasible if they are to be sustainable, and the indicators monitored must be indicative of baseline change and generate information that is useful to end users – including the Agency, regulatory decision makers, and project proponents. To accomplish this, is it necessary to provide guidance on standard indicators for new monitoring initiatives, determine what are the questions that monitoring programs initiated or promoted by the Agency need to answer, and better coordinate the monitoring that occurs under project IA. The following actions and initiatives re recommended:

12. The Agency should identify a **limited set of key indicators** (biophysical, socio-economic) to be monitored in project IAs and by monitoring committees or other permitting authorities as applicable, such that a **common baseline** can be established for tracking change and informing future IAs. This need not be a comprehensive list of indicators and may be piloted on a regional scale. The indicators should be:

    a. determined by the Agency in consultation with other government agencies, the practitioner community, and researchers – but they must ultimately be of value to federal decision making, permitting, and other areas of federal responsibility

    b. guided by a conceptual framework for monitoring, with clearly articulated monitoring questions

    c. accompanied by a consistent methodology for data collection and standards for data reporting

    d. indicative of change in important components or features of biophysical or socio-economic environments

    e. relevant to impact management or regulatory decisions made by the federal government and project proponents.

13. The Agency should improve **coordination of project IA terms of reference** to ensure that:

a. the indicators are inclusive of those identified by the Agency as key indicators to be monitored to track baseline change and inform decisions

b. other indicators being assessed and identified by proponents, or recommended for monitoring under approval conditions, are consistent across projects, especially for those projects operating in the same region and affecting the same components

c. the methodologies used for monitoring and reporting, and reporting formats, are consistent such that data can be compared.

7.3 ENABLING ACCESS TO MEANINGFUL DATA

Access to credible and usable monitoring data is a major challenge to good IA follow-up, to tracking change, and to understanding the impacts of development actions. Lessons from the Northwest Territories and South Saskatchewan, coupled with lessons from scholarly research, suggest that proponents are generally not willing to openly share monitoring data, especially if there is concern about loss of proprietary information or the misuse of data that may cause undue damage to corporate image. Research and practice also indicate that mandating that data be made available is important but not sufficient – i.e. data are sometimes provided in protected formats such that they are not usable. Data repositories are also identified in literature and recent IA reform recommendations as important to monitoring and learning; however, this is easier said than done – data collected by proponents are variable in standards and measure, and simply housing laundry lists of data is unlikely to translate into useful information. Based on current scholarship and lessons from practice, the following actions and initiatives are recommended:

14. The Agency establish a **strategy for data governance**, including policies that establish

    a. financial structure for long-term operation, data maintenance and support

    b. roles and responsibilities for data sharing, including data privacy and ownership and treatment of data from communities or Indigenous groups

    c. roles of other federal agencies and departments in data contributions

    d. quality control standards and policies

    e. reporting standards, methods, and metadata standards for key indicators.

15. The Agency should establish a **centralized data repository or network of repositories** for monitoring data. The repository should:

    a. house a limited set of standardized data for key indicators deemed to be of importance for tracking regional trends in valued system components (biophysical and socioeconomic) and providing context for understanding and interpreting project impacts

    b. contain data provided by proponents through IA monitoring requirements [*see recommendation 4*] in addition to data provided by monitoring committees [*see recommendation 7*] or organizations and other government agencies and programs

c. be publicly accessible and open access

d. have a user interface that allows for retrieval, categorization, basic mapping and generation of other simple information products

e. include metadata and information on data collection methods and protocols

f. be periodically reviewed by an independent party for quality control

g. be managed by a centralized monitoring agency or network of monitoring agencies [*see recommendation 8*].

7.4 INSTITUTIONAL ARRANGEMENTS TO SUPPORT MONITORING

Not all monitoring can be conducted under the auspices of project IA. Longer-term monitoring focused on regional trends is needed to monitor change, advance the science of impact prediction, and establish the regional context and limits for understanding project-based impacts and monitoring results. This may not be solely the responsibility of the Agency – or a single entity – but such monitoring arrangements should be overseen or coordinated by the Agency. There are many different models and arrangements, and pilot testing may be required to determine a model that works best over the long-term. Monitoring committees are increasingly common in Canadian IA, but they vary considerably in scope and function, membership, and what is monitored. Monitoring committees typically emerge in regions with major, and often controversial, resource sector activity (e.g. Athabasca oil sands region, Northern Saskatchewan uranium mining, Elk Valley coal mining) or where underlying governance systems provide the supporting framework and mechanisms to establish such committees (i.e. northern co-management regulatory regimes). A consistent message across all monitoring arrangements, however, is that those making decisions and evaluating the nature and importance of change often require interpretation of data (i.e. information products) – not simply data sets – suggesting a more active role for monitoring agencies or committees. To strengthen existing institutional arrangements for monitoring and support existing ones, the following actions and initiatives are recommended:

16. When a project follow-up and monitoring program is recommended under the *IAA*, and when a formal request is received from an Indigenous community within the local to regional project environment, the Agency should, on a case by case basis, require by way of IA approval and permitting conditions the establishment of a **local monitoring committee** that engages both industry and communities in collaborative monitoring activities including project impact management oversight, data collection, and project and environmental performance reporting. This would require that:

    a. a formal process be established for Indigenous communities adversely affected by a project to request that a monitoring committee be formed, including criteria to guide case by case determinations (e.g. significance of potential environmental impacts, potential for cumulative impacts, impacts to local social environments and Indigenous lands and livelihoods, opportunity for collaborations between multiple Indigenous groups)

    b. monitoring committees focus on a select set of key indicators as identified by the Agency, with standardized data and reporting requirements [*see recommendation 3*], in addition to any

indicators or issues deemed by the monitoring committee to be of local or community-specific interest

c. monitoring data for Agency-required indicators are made publicly available in a centralized data repository or network of repositories [*see recommendation 6*], with additional monitoring committee data made available as per negotiated data policies and agreements that protect data ownership and confidentiality of proponent and community interests

d. the Agency establish clear rules for financial support for monitoring committees, ensuring that they are sufficiently resourced by major contributions from project proponents, and serve as an arbiter when problems emerge

e. the Agency develop practical guidance (e.g. toolkits, template agreements, reporting templates) for monitoring committees as a resource for Indigenous communities and project proponents who are engaging in collaborative monitoring efforts – whether in the form of community-based monitoring programs or oversight committees

f. the Agency periodically evaluate monitoring committee performance in terms of monitoring, data quality, governance, and community engagement in project impact management activities.

17. The Agency should establish a **centralized monitoring agency** to manage the types of monitoring activities (i.e. data collection, repositories) noted above. This monitoring agency:

a. should be overseen by a national science and governance advisory committee, comprised not only of scientists but also practitioners from the private sector, community leaders, and regulatory decision makers, to determine and periodically review monitoring questions, objectives, and key indicators

b. should be established as a network, coordinating and building on the monitoring capacities and expertise that already exist in monitoring agencies, committees, provinces, and universities across Canada, and operate similar to the Nunavut regional socio-economic monitoring committees (i.e. regional networks or nodes), but with direct Agency linkages and dedicated resources to ensure that data standards and indicators align with federal monitoring and decision support needs

c. should be financed largely by the federal government but with major cost recoveries through such practices as fees for information product requests (e.g. for commercial data requests or complex requests) and nominal project monitoring and data management registration fees for proponents, with major cost savings through partnering with the ongoing monitoring activities of existing monitoring agencies and universities.

18. The centralized monitoring agency or network should do more than serve as a repository and system for data management and coordination, it should also provide **science leadership** including

a. trends analyses and identification of baseline conditions and critical limits to inform threshold, monitoring requirements, and mitigation needs

b. advancing new methods and improving upon existing tools for monitoring and predictive modeling

c. development and provision of basic information products to the public and upon request (with fee for service) to commercial users

d. a resource center for project proponents and potentially affected communities requiring data and interpretation

e. expert advice on IA quality reviews, data standards, and to decision makers.

APPENDIX A

CRITERIA: (SEE SECTION 2.2 FOR DETAILS)	ALL INDICATORS MUST BE RELEVANT AND USEFUL	EASILY AVAILABLE COMPARABLE ACROSS COMMUNITIES AND OVER TIME	AVAILABLE OR REQUIRE COLLECTION COMPARABLE OVER TIME WITHIN A COMMUNITY	AVAILABLE OR REQUIRE COLLECTION COMPARABLE OVER TIME WITHIN A COMMUNITY
CATEGORY	**PRIORITIES**	**COMPARABLE INDICATORS**	**ADDITIONAL INDICATORS**	**MINING-SPECIFIC INDICATORS**
Individual and family well-being	▪ Meeting basic needs ▪ Healthy families and relationships ▪ Productive activity and positive lifestyle choices ▪ Ability to cope with problems or adapt to changes ▪ Healing for those with difficulties	▪ Percent of families and people living below the Low Income Measure ▪ Number, percent of RCMP calls related to domestic violence, alcohol, drugs, youth ▪ Suicide, attempted suicide rate per 1,000	▪ Distribution of social service consultations, by reason ▪ Health issues (descriptive) ▪ Percent sales of fresh foods, "junk" foods	▪ Well-being indicators for mine employees and their families
Housing	▪ Adequate quantity and quality of housing ▪ Affordable housing	▪ Net bedrooms required in social housing ▪ Percent social housing units that are short 3 or more bedrooms ▪ Ratio of private to public housing stock	▪ Percent of population in or waiting for social housing ▪ Percent of social housing below standard ▪ Average housing operating costs	▪ Change from baseline in ratios of private to public housing stock, and people in private and public housing
Culture and relationship to the land	▪ Transfer of Inuit language, knowledge, skills and important values to youth ▪ Opportunity for going out on the land, and harvesting country food ▪ Maintenance of a traditionally-based economy	▪ Percent Inuit population ▪ Ability to speak Inuktitut/ Inuinnaqtun	▪ Number of young hunters ▪ Number and participation in community feasts and cultural activities ▪ Country food consumption ▪ Exports of country foods	▪ Hunting frequency and resource sharing for mine employees
Education and Training	▪ Basic literacy ▪ Increased levels of formal education and trade certification ▪ Capacity to take up job opportunities ▪ Options for learning	▪ Highest level of schooling (% distribution) ▪ Grade 10, Grade 12 completion rates ▪ Number of Inuit teachers (per 100 students)	▪ Availability and completion rates of adult programs ▪ Number of apprenticeship positions ▪ Diversity of learning options	▪ Percent of population with Grade 10 education ▪ Percent of local residents employed as supervisors or managers ▪ Number of non-employees benefiting from training offered by mining company

CATEGORY	PRIORITIES	COMPARABLE INDICATORS	ADDITIONAL INDICATORS	MINING-SPECIFIC INDICATORS
Livelihoods and Income	▪ Increased employment ▪ Reduced poverty and reliance on social assistance ▪ Money management ▪ Opportunity for traditional livelihoods	▪ Employment rate ▪ After-tax median family income, by family type ▪ Social assistance payments per family	▪ Ratio of job opportunities to people not employed ▪ Youth perceptions and hopes for employment	▪ Percent of employed working in mining-related jobs ▪ Reasons for mine employees leaving jobs
Economic Development and Self-reliance	▪ Increased total income/revenues ▪ Local business development ▪ Focus on sustainable development ▪ Maintenance of a traditional/dual economy	▪ Total community income, per capita income ▪ Economic dependency ratio	▪ Total number of businesses, percent local ▪ Ratio of private to public jobs ▪ Diversity of services offered by business sector	▪ Percent of businesses dependent on mining contracts
Community Infrastructure	▪ Improved transportation links ▪ Adequate recreational facilities and group meeting space ▪ Affordable rental commercial space ▪ Accessible tele-communications	▪ Freight costs (per kg) ▪ Average rental rate commercial space (per square foot)	▪ Age and quality of recreational facilities and public buildings (descriptive) ▪ Public access computer-hours (per week)	▪ Change in freight costs from baseline
Municipal Services	▪ Safe, efficient service delivery and use (water, heating oil, electricity) ▪ Capacity to meet future demand (water treatment, sewage treatment, landfill, energy)	▪ Consumption rates per capita (water, heating oil, electricity) ▪ Days of service interruption	▪ Water quality violations and warnings	▪ Change in expenditures for services from baseline
Community Well-being	▪ Safety and security for residents ▪ Adequate support resources and programs ▪ Community spirit and cooperation ▪ Equity (income, social, distribution of changes) ▪ Healthy environment	▪ Crime rates by category (per 1,000) ▪ Family income distribution ▪ Ratio of average number of people in non-social housing to social housing	▪ Diversity and participation in programs related to health and wellness (descriptive) ▪ Number and attendance at community-wide events	▪ Income distribution for mining families

CATEGORY	PRIORITIES	COMPARABLE INDICATORS	ADDITIONAL INDICATORS	MINING-SPECIFIC INDICATORS
Governance and Leadership	▪ Control over priority issues, and effective lobby ▪ Transparency and accountability ▪ Community involvement and leadership development ▪ Capacity for long-term and strategic planning	▪ Overall financial position of the Hamlet (per capita)	▪ Annual turnover rate in Council and Committees ▪ Representation of Elders and youth on Council and Committees (%)	

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