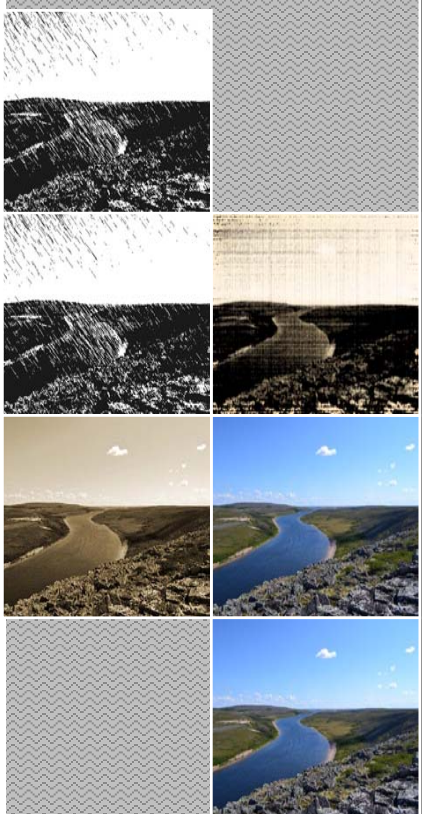
Report Three



# High-Level Aquatic Cumulative Effects Monitoring Framework and Preliminary Program

Developing a framework for watershed-based cumulative effects monitoring in the Baker Lake Basin

*Final Report*

Presented to Aboriginal Affairs And Northern Development Canada
Nunavut Regional Office
By Aarluk Consulting Inc. in Association with ESSA Technologies
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# Project Team: Report 3

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# Introduction

## Need and Purpose for Development of a Framework

The water monitoring information that is currently produced in Nunavut by a variety of industry, government, Inuit and academic institutions is not integrated and cannot be used to monitor watershed cumulative effects. There is a clear need for a monitoring framework, first, to provide for sharing of data and consistency among institutions, and second, to integrate individual monitoring initiatives into an overall coordinated approach for monitoring cumulative effects in Nunavut watersheds. Such a framework must address the obligations under the Nunavut Land Claim Agreement (NLCA) to monitor changes in water on Inuit Owned Land (IOL) and support the rights of Regional Inuit Associations (Kitikmeot Inuit Association, Kivalliq Inuit Association, and Qikiqtani Inuit Association) to have water flow, quantity and quality substantially unaffected in IOL. At present no such framework exists in Nunavut.

In this report, *monitoring framework* is defined on the basis of the assignment's Statement of Work as *the core monitoring activities of data collection, analysis, reporting and review as well as the associated management structure and roles and responsibilities for designing and implementing these core activities*. The term *monitoring program* is used in the report in conformity with the definition of program provided by the Treasury Board of Canada,[1] and as such is broader than a monitoring framework. A monitoring program would include the core framework activities as well as the broad governance, management, capacity, resourcing and stakeholder considerations that need to be addressed in order for the framework to be effective.

The purpose of this assignment was to examine *how* to develop a High Level Aquatic Cumulative Effects Monitoring Framework for watersheds in the Baker Lake Basin. The product is intended to be an outline of the key considerations, questions, structure and processes involved in developing and implementing a High Level Framework.

## Scope of Assignment

The original scope of this assignment was limited to development of a High Level Cumulative Effects Monitoring Framework for Baker Lake Basin and of scenarios for implementation of the Framework. However, an effective and realistic monitoring framework could not be developed

[1] "Program is a group of related resource inputs and activities that are managed to meet specific needs and to achieve intended results, and that are treated as a budgetary unit." (http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=18218&section=text#appA)

without consideration of its broader monitoring program. Thus, the scope of this assignment was modified to include:

- development of the general concept for the Monitoring Program as well as the High Level Framework; and,
- identification of the first steps required for implementation of the Program and Framework, rather than a focus on implementation scenarios for the Framework.

Development of a long-term monitoring Program is a major undertaking that will require several years, committed resources and champions, as well as significant involvement of government agencies, private sector developers, the public, the scientific community and Inuit organizations. This report provides an initial foundation for development of such a Program, identifying key program elements including the High Level Framework, and outlining how to go about development of the long-term Program. The Program and High Level Framework for the Baker Lake Basin is to serve as a pilot for all watersheds in Nunavut. The completed Program and Framework, once developed, is intended to be a management tool with a stable management structure, which can be flexibly applied to current and future management priorities for watersheds, incorporating both scientific knowledge and *Inuit Qaujimajatuqangit (IQ)*.

The main focus of the present work is at the watershed level. However, the Baker Lake Basin has several watersheds. Thus the term watersheds is used in the report.

The Report is written as a non-technical overview for managers, decision-makers and stakeholders. Details on the numerous complex technical, governance and capacity considerations that underlie the proposed Program and Framework are provided in the Appendices.

## *Approach*

The Program and Framework was developed using expert and client knowledge, and used very modest resources compared to those used to design cumulative effects monitoring programs for the oil sands or the NWT Cumulative Effects Monitoring Program (CIMP). Although public and stakeholder involvement is necessary to build a credible and widely supported program, this was not part of the present scope of work. Thus the proposed High Level Framework should be considered preliminary; stakeholder review and approval will be needed before it can be finalized. In addition to expert knowledge about lessons and best practice for development of a cumulative effects monitoring program, the Framework drew on two background reports prepared under this current project by Aarluk Consulting – on the aquatic monitoring data and programs that currently exist for the Baker Lake basin[2], and on the current and future stressors of the aquatic environment in the study area[3]. The research for these background reports was

[2] Aarluk Consulting Inc. January 2013. *Historical Monitoring of the Aquatic Environment in the Baker Lake Watershed*.

[3] Aarluk Consulting Inc. January 2013. *Documented and Anticipated Stresses on the Aquatic Environment of the Baker Lake Watershed*.

limited largely to identifying the sources of data and stressors and did not involve an analysis of the quality, gaps or usefulness of the data for monitoring cumulative effects.

Development of the Framework started with consideration of best practices and lessons from other cumulative effects monitoring initiatives. Based on these findings, the project team concluded development of the core program elements (i.e. a high-level framework) was not enough. To succeed, all elements of a cumulative effects monitoring program need to be considered from the beginning, especially those related to:

i) management and governance arrangements;

ii) constraints and realities of resources, capacities, stakeholder interest and management support; and

iii) technical and management activities for collection, use and management of monitoring data (i.e. core part of the Program).

Thus, this final report provides three main approaches and tools and for development of a successful monitoring program – one that addresses each of the areas above. These are:

- A structure and process for considering key elements involved in designing and implementing the core part of a program. The structure is presented in three Framework Tables. Working through these tables organizes the information that program developers need to ask and answer in order to design the basic data collection, analysis, reporting and review parts of a monitoring program.
- A preliminary logic model of the activities, results and management functions involved in a monitoring program. The model includes governance and management functions as well as continuous improvements functions. The model is based on the program logic models of the federal government and provides a picture of the entire program. Refining and developing the logic model will give program managers a roadmap of the steps to take to achieve desired results and thus may facilitate a program getting support and funding from senior management.
- A practical strategy for developing a program that is based on the reality of resource and capacity limitations, so that it is realistic, can be implemented, uses a simple set of indicators, and starts from current realities - i.e. very little funding, limited coordination, little integration of monitoring activities or consistency of methods and parameters. Specific parts of this overall strategy are detailed in the various principles, considerations and strategies outlined in the report, and these have been integrated into all aspects of the Program and Framework presented in the report.

This report is organized into four parts. Part 1 presents the context and background information that provides the rationale for the Program and Framework. Part 2 provides a picture of the overall Monitoring Program of which the Framework is part. Part 3 outlines the High Level Framework, and Part 4 presents key implementation considerations and recommended next steps – all of which relate to the overall Program.

# Part 1: Current Situation and Context

Part 1 of the report provides the context and rationale for the Framework. The state of knowledge, lessons and best practices for developing a watershed monitoring framework are reviewed in Section 1 below. What is currently known about the stressors and available monitoring data for Baker Lake watersheds is identified in Section 2, and the current institutional arrangements for monitoring in the watersheds are identified in Section 3. The material presented in Part 1 is based on a number of focused literature and document reviews, and provides a summary of the two previous project reports as well as several technical papers, analyses and databases. For further details, see the *Appendices* at the end of this report, and the two companion reports produced by Aarluk Consulting under the current assignment.[4]

## 1. State of Knowledge and Context of Best Practice

### *1.1 Technical Aspects – Best Practice*

The state of scientific and technical understanding and current identification of best practices relevant to developing watershed monitoring programs to assess and manage cumulative effects are summarized below. Further details on the theory and approach underlying the Framework are provided in Appendix 1.

No standardized technical approach is accepted for monitoring of cumulative effects at the watershed level. Two broad-based approaches for monitoring of cumulative effects are recognized in the literature: a stressor-based (SB) approach for prediction of potential impacts of a proposed development on future conditions of Valued Ecosystem Components (VECs); and an effects-based (EB) approach[5] for measuring the actual condition of VECs, including the cumulative effects of existing stressors.

In either case, the success of the approach is tied in large measure to the appropriate identification of Valued Ecosystem Components (VECs) and the indicators of specific elements of their condition. The Monitoring Program and Framework for Baker Lake will be a combination of EB – for broad measurement of conditions in the watershed, and SB – for

[4] Aarluk Consulting Inc. January 2013. *Historical Monitoring of the Aquatic Environment in the Baker Lake Watershed*; and Aarluk Consulting Inc. January 2013. *Documented and Anticipated Stresses on the Aquatic Environment of the Baker Lake Watershed*.

[5] Also referred to as Environmental Effects Monitoring (EEM).

measurement of potential cumulative effects of new developments, where possible (given the limitations in anyone's ability to foresee the future).

Likewise, no accepted standard approach exists for designing and implementing a monitoring program for cumulative effects at the watershed level. There is no agreement yet on the objectives, scope, principles or components of such a monitoring program. Currently, monitoring programs focused on understanding how watersheds work focus on two key objectives:

- Clarifying river system components and trends; and
- Relating such trends to measurable sources of environmental stress in the watershed.

However, the approaches that different researchers, and programs, use for measuring and analyzing data to address these two objectives vary considerably. Specifically, there are a number of challenges that must be considered in developing a standardized approach to monitoring watershed-based cumulative effects, including:

- Determining the issues of scale for watershed cumulative effects and how they can be managed;
- Exploring how reference conditions can be established to effectively account for background trends and natural variability; and
- Understanding which environmental components and indicators should be monitored and assessed for watershed cumulative effects assessment.

Current best practice for integration of SB and EB approaches involves four steps for gradually moving monitoring from an EB focused approach to a SB and CEA (cumulative effects assessment) focused approach, which is by its nature much more complex. These steps, along with the expected time line needed to establish these steps, are as follows:

- *Step 1:* Development of consistent monitoring in the basin, using a set of core indicators (short-term);
- *Step 2:* Development of a series of triggers for endpoints that lead to management actions for adaptation and enhancement of the monitoring program (medium term);
- *Step 3:* Development of a series of relationships that link the drivers to the responses (and provide a series of predictions for endpoints (long-term);
- *Step 4:* Development of cumulative effects model (very long-term).

Ongoing monitoring efforts under the Canadian Watershed Network (CWN) are currently focused on Step 1 – development of consistency in indicators, protocols, and in data collection, analysis and reporting. We suggest that cumulative effects monitoring activities in the Baker Lake basin also focus on Step 1 for at least the next 5-10 years.

The technical success of watershed-based approaches largely depends on identification of appropriate VECs, indicators and targets. A core set of VECs and indicators need to be established that can be used for both watershed and local monitoring. The selection of a core set of VECs and indicators is essential to provide scientific rigour, consistency, and the ability to roll up to the higher level scales in time and space necessary for assessing cumulative effects.

The condition of Valued Ecosystem Components (VECs) reflects all of the stresses (natural and anthropogenic) that affect them. When multiple stressors affect a VEC, there is a need to understand the role(s) of the different stressors in causing the overall effect, which informs decisions on how to reduce and manage cumulative effects. This requires establishing the specific links between the stressors and the condition of the VECs, which can require a level of effort that may be greater than that needed to just identify and quantify changes from the reference condition. This work applies at the local scale to stresses from local human activities.

## *1.2 Governance and Management Aspects – Best Practice*

Implementation of watershed-based cumulative effects monitoring programs requires collaboration and coordination of numerous institutions and stakeholders. This section outlines the key management and governance considerations and lessons to take into account in development of the High Level Framework. Further details are provided in Appendix 2.

No established regulatory framework exists to support successful and effective monitoring for cumulative effects in watersheds in Nunavut or elsewhere in Canada. Monitoring is currently conducted through unrelated and fragmented administrative and institutional initiatives that seriously compromise the effectiveness of regulatory instruments for managing cumulative effects.

Key lessons on governance and management experience from watershed and regional monitoring programs in other jurisdictions – e.g. from Oil Sands monitoring in Alberta, the NWT Cumulative Impacts Monitoring Program, and the Arctic Borderlands Ecological Knowledge Co-operative in Alaska, Yukon and NWT – that inform development of a cumulative effects monitoring program and framework for Baker Lake include the following:

- Transparency is key for public acceptability – public involvement and confirmation in the selection of VECs and program design is essential, and the data produced by a monitoring program must be publically accessible, comparable and quality assured;
- Strong scientific direction is essential - scientific considerations need to be fully integrated into the design, analysis, evaluation, reporting aspects of monitoring;
- Traditional knowledge, local knowledge and community observations are important elements, and, as is the case with scientific knowledge, should be fully integrated into the program;
- The program scope needs to cover and emphasize analysis, evaluation, reporting and communication, and not be narrowly focused on data collection;
- Sustainable long-term funding is needed, and a contribution and role for industry in funding is an essential element of this;
- The on-going review and evaluation of monitoring systems is critical to ensure programs are not static but respond to evolving needs and knowledge, and also are able to correct shortcomings and flaws.

# 2. Current Situation in the Baker Lake Basin

## *2.1 Key Existing and Future Stressors in Baker Lake Watersheds*

An analysis of stresses related to the aquatic environment in the Baker Lake Basin indicates that the three key stressors on aquatic conditions in the watersheds for the foreseeable future are:

- existing and future mining exploration, development and operations (including associated road, housing and other infrastructure): existing and new mining developments are located in the lower reaches of the watersheds relatively close to the community of Baker Lake, while exploration is more widely distributed across the watersheds;
- existing and future discharges from the Hamlet of Baker Lake;
- existing and future effects of climate change on aquatic conditions in the watersheds: these stresses occur broadly throughout the watersheds and affect natural conditions and also can act cumulatively with development stresses.

Stressors of most developments are localized; climate change effects however, are likely to be widespread and sizeable enough to mask localized affects of some development stressors.

For further details see Appendix 4, and the companion Aarluk report *Documented and Anticipated Stresses of the Aquatic Environment of the Baker Lake Watershed.*

## *2.2 Historical and Existing Monitoring in Baker Lake Watersheds*

An assessment of past and current monitoring programs relevant to the aquatic environment in the Baker Lake basin suggests that:

- Limited monitoring of the aquatic environment of the Baker Lake watersheds has been carried out; what has been done focuses mainly on mining developments and on the Hamlet of Baker Lake;
- Collection and analysis of aquatic data in the watersheds is fragmented and is being done by a range of private, public and academic parties with no or limited coordination; thus VECs, indicators, and parameters are inconsistent and not comparable from one source to another;
- Historic and existing monitoring data and programs within the Baker Lake watersheds do not provide the information needed to understand the Baker Lake watersheds system: we do not know what is going on in the watersheds, and therefore it is not possible at the present time to develop an appropriate framework for monitoring cumulative effects in the watersheds. Before designing a long-term framework and program for monitoring, we must first understand what is currently occurring within the watersheds, otherwise known as an accumulated state assessment. This is the intent of Phase 1 as described in the Framework.

For further details see Appendix 3 and the companion Aarluk report *Historical Monitoring of the Aquatic Environment in the Baker Lake Watershed.*

# 3. Institutional Arrangements for Monitoring Cumulative Effects in Baker Lake Watersheds

There is no established regulatory regime for watershed level monitoring in Nunavut or anywhere in Canada. In both Nunavut and Canada monitoring is currently conducted under unrelated and fragmentary administrative and institutional initiatives, i.e. within a complex and ineffective regulatory environment. However, basin-wide studies, some of which support watershed management regimes, have provided insights into management challenges and management requirements, especially as they apply to cumulative effects. For example, the 1996 *Northern River Basin Study* prepared by the Alberta Government provides a summary statement that is reflected in subsequent studies in the Yukon River and Mackenzie River basins:

> *Current monitoring in the basins is not designed to address cumulative effects assessment needs. There remain inconsistencies across agencies with regard to scientific design, collection-analysis-data handling /storage and reporting protocols that would benefit from coordination, integration and standardization.*

In these basins, initiatives are underway to address these deficiencies, although it is premature to judge how effective they will be over the longer term.

Current players for aquatic monitoring in Baker Lake Watersheds include:

*AANDC:*

- holds provincial-equivalent responsibility for monitoring and water management until devolution;
- specific responsibilities related to watershed-based cumulative effects monitoring include:
  - monitoring compliance with terms and conditions of water license and various land permits (surface lease, quarrying permits) for developments;
  - Secretariat and lead department responsible for implementation of Nunavut General Monitoring Plan (NGMP);
  - key coordination role with federal agencies for major projects (role clarified and further expanded under proposed Nunavut Planning and Project Assessment Act-NUPPA);
  - responsibilities of the AANDC Water Resources Division for developing and maintaining water monitoring networks in Nunavut, collecting and analyzing water quality and quantity data, working with stakeholders to develop standardized water management processes, and planning for water resource use and protection; AANDC Inspectors monitor water quality at development sites in the Baker Lake Watersheds, including mine sites and the Hamlet of Baker Lake.

*Environment Canada*

- collection of hydrologic and meteorological data for watersheds, as well as limited location-specific data for water quality, sediment and benthic data.

*Department of Fisheries and Oceans*

- collection of data on population and harvesting of arctic char, as well as some limited, location-specific water quality, sediment and benthic data that is mostly related to char.

*Transport Canada*

- monitoring compliance with terms and conditions of NIRB project certificate and other regulatory permits.

*Department of Environment (Government of Nunavut)*

- monitoring of terrestrial wildlife (e.g. caribou), and collection of information on climate change.

*Department of Economic Development and Transportation (Government of Nunavut)*

- supporting community level monitoring, and coordination of Regional Socio-economic Monitoring Committees (SEMCs), including the Kivalliq SEMC.

*Nunavut Water Board (NWB)*

- issuing, renewing, amending or canceling water licenses. The Nunavut Water Board is an Institution of Public Government with responsibilities for the use, regulation and management of freshwaters in Nunavut as described in Article 13 of the Nunavut Land Claims Agreement (NLCA). The powers of the NWB are enacted through Bill C-33, the Nunavut Water and Nunavut Surface Rights Tribunal Act (NWNSRTA). Once a license is issued enforcement and compliance is under the jurisdiction of AANDC.

*Nunavut Impact Review Board (NIRB)*

- monitoring compliance of projects with their Project Certificate, and supporting regional SEMCs.

*Kivalliq Inuit Association (KivIA)*

- collecting data on traditional knowledge and development proposals, conducting follow-up on IIBA commitments, and collaborating with AANDC Water Resources on collection and analysis of baseline water quality at development sites in the Baker Lake watersheds.

*Private sector companies owning mining developments (e.g. Meadowbank and Kiggavik projects)*

- establishing detailed baseline data including traditional knowledge of baseline conditions, and conducting ongoing monitoring of aquatic conditions in local area near mine development such as water quality and quantity (surface and groundwater), fish and fish habitat, and wildlife and terrestrial effects.

*International and Canadian Academics*

- collecting a variety of scientific, socio-economic and traditional knowledge data at specific locations for their own research purposes; most of this data is a one-time or limited time sample, rather than sampling for ongoing monitoring.

The key players involved in data collection, analysis and reporting for aquatic parameters are AANDC, Environment Canada, Department of Fisheries and Oceans, and the Government of Nunavut. Also the private sector needs to be involved later on – with monitoring at the local level that relates to watershed monitoring. The role and capacity of Environment Canada and Department of Fisheries and Oceans have been reduced due to changes in regulations and budget cutbacks in recent years. Important players with advisory or approval roles related to watershed monitoring include NWB and Department of Economic Development and Transportation.

Both Government of Nunavut (GN) and KivIA have important roles to play, but their roles need to be discussed and developed with them. With regard to KivIA, it needs to be determined whether they should be part of an advisory group, or a key player with active involvement in data collection, analysis and reporting. With respect to the Government of Nunavut, questions on their role include which specific agency(ies) within GN should be involved and how they should be involved – Economic Development and Transportation for their involvement in community monitoring, and/or Department of Environment for their involvement in *IQ* work.

AANDC has a major role to play in coordination, collaboration and analysis of information; no agency other than AANDC has the capacity or mandate to take on the role of integration among the various agencies.

For further details on sources and capacities of government, institutions of public government and academic organizations that are involved in monitoring, see Appendix 5. For details on the project-specific monitoring program funded and undertaken by the private sector for the Meadowbank project, see Appendix 6.

# Part 2: Introduction to the Aquatic Cumulative Effects Monitoring Program

A full program for aquatic cumulative effects should include:

- A statement of the long-term vision, timeline, scope and purpose of the program and the linkage of the program to higher level policies and outcomes of partner organizations;
- Committed multi-year resources and funds tied to expected results – often a logic model is developed to show the logical sequence for achievement of results from inputs to activities all the way to high level results (or ultimate outcomes);
- Identification of the primary beneficiaries and users of the monitoring products;
- A governance structure – the accountability and responsibilities of the multiple partners, advisors and stakeholders involved in different functions of the program. The key stakeholders and their roles and responsibilities would be identified. Functions of the monitoring program could include: coordination and management, design and implementation of monitoring activities, provision of scientific and traditional knowledge expertize, stakeholder engagement, program review and continuous improvement;
- A performance measurement and continual improvement strategy – ongoing tracking and reporting on progress and achievement of results, and review and improvement of the program through monitoring and evaluation;
- Technical considerations – overview of the technical objectives, scope, components and phases, VECs, indicators, data sampling and sources, analysis and reporting approach; and
- Specification of the delivery approach – how the monitoring information will be collected, analyzed, reported and improved, and who will do this.

Development of the Monitoring Framework within this report mainly covers the final two points above – i.e. technical considerations and delivery approach. It is beyond the scope of this assignment to develop the full Program; however, some idea of the Program is needed in order to develop the Monitoring Framework. Preliminary assumptions and approaches outlined by the Project Team regarding the Program in order to develop the Framework are the following:

***Program Vision:*** In the long term we would expect the program to provide information on cumulative effects needed for land use planning, resource development decision-making and sustainable development policy-making at the territorial and regional levels. The monitoring information produced by the Program would be consistent with the mandate of the Nunavut General Monitoring Plan – i.e. mainly baseline information that would require additional analyses by users for their specific policy or impact assessment purposes. Thus, we have assumed that the Program would not have complex indicators or information incorporating the values, policy targets or impact assessment hypotheses directly used by NPC, proponents, regulators, KivIA or NIRB for their mandated decision-making.

***Program Resources***: The actual resources and capacities currently involved in collecting, analysing and reporting relevant aquatic monitoring data for the Baker Lake Basin were not assessed but are known to be limited. Also the resources of key federal players (AANDC and Environment Canada) have been reduced over the past few years. The future resources and capacity are unknown. Thus we assumed that:

- The monitoring resources and capacity of the players identified in Section 3 above would not change for the foreseeable future – so the Program needs to be based on existing resources and budgets, at least for a few years until it is able to demonstrate value and get more resources;
- Opportunities for optimizing existing resources exist – by enhancing and improving coordination and collaboration of monitoring activities among the key players to serve common watershed management purposes;
- Opportunities for optimizing monitoring by private sector and other third parties exist – by having data collection done by third parties in local areas serve watershed management needs as well as private sector interests.

***Basic Logic Model***: The basic structure of a logic model for the program is shown in Figure 1 below, and complies with guidance from the Treasury Board of Canada[6]. The contents in the model are very preliminary and need review and refinement by the key partners and stakeholders of the program.

***Primary Beneficiaries***: All the key players identified in Section 3 above would be involved in the Program. The main users of the monitoring data are assumed to be regulators, KivIA, AANDC water resource managers, NIRB, NPC, private sector, and the public.

[6] http://www.tbs-sct.gc.ca/cee/tools-outils/rmaf-cgrr/guide03-eng.asp

# Figure 1: Preliminary Logic Model of Aquatic Cumulative Effects Monitoring Program for Baker Lake Basin

**Inputs**

- Initially – existing resources and partner capacities
- Budget increase in 3-5 years for permanent baseline monitoring program
- Secure long-term funding for cumulative effects monitoring program for key watersheds and the Basin ( program consists of baseline monitoring + intense monitoring of changed conditions + special studies on causes of changes)

**Activities**

| **Program Management and Coordination** | **Monitoring Data Collection** | **Monitoring Analysis and Reporting** | **Program Review and Improvement** |
|---|---|---|---|
| • Coordination processes, mechanisms, tools<br>• Governance Structure – organizations, roles and responsibilities<br>• Links to project-level monitoring<br>• Stakeholder engagement<br>• Integration of Science and TK into monitoring<br>• Ongoing work planning and budgeting | • Design baseline data collection – VECs, indicators, sampling, protocols<br>• Implement baseline monitoring<br>• Community involvement<br>• Track scientific and TK triggers for changes in conditions<br>• Design intense monitoring for changed conditions and special studies on causes of change | • Analysis approach, protocols, and tools for baseline, changes in conditions and causes of changes<br>• Technical QA/QC<br>• Integration of science and TK<br>• Format, template, scale and presentation mode<br>• Access and distribution of analysis | • Design of Performance Measurement Strategy<br>• Monitoring, evaluation of progress and results<br>• QA/QC of designs and implementation<br>• Standardized of protocols and consistency of data<br>• Shifts from interim to permanent program<br>• Triggers for changes in conditions and special studies |
| **Outputs** | | | |
| Program management and coordination arrangements established | Data collection designed and implemented | Data analysis and reporting designed and implemented | Program review and improvement systems in place |
| **Immediate Outcomes** | | | |
| Program efficient– delivering on time and budget | Data collection efficient | Data analysis efficient | Improvements to program ongoing – data consistency and analysis quality |
| **Intermediate Outcomes** | | | |
| Program effective – partners supportive and collaborative, stakeholders supportive, program delivering desired monitoring data | Data collection effective - high quality & consistent data VECs/indicators suitable | Analysis and reporting effective – timely, meets user needs | Full monitoring program established, i.e.: permanent baseline monitoring, triggers for intense monitoring of changed conditions and special studies on causes<br>Program achieving desired quality of monitoring products |

**Ultimate Outcome**

Users have appropriate information to understand the aquatic conditions and trends in watersheds in the Baker Lake Basin and in local areas near development stressors and to determine the relative contribution of climate change versus developments to changed conditions near developments.

# Part 3: High Level Aquatic Cumulative Effects Monitoring Framework for the Watersheds of the Baker Lake Basin

Part 3 of this report defines the broad elements of the High-Level Watershed-Based Monitoring Framework, as well as the operational processes and considerations required for further development and implementation of the Framework.

Section 4 below outlines the key strategies and assumptions on which the Framework is based. Sections 5 to 7 present the foundational elements of the High-Level Framework. These foundational elements are in keeping with best practice for watershed cumulative effects monitoring described in Sub-section 1.1 above and include:

- a statement of the objectives for the Framework;
- a statement of scope; and
- a set of principles.

Sections 8-11 present the structural components and elements involved in implementation of the Framework and include:

- the phases of development of the monitoring Program;
- the key questions and sub-questions each phase of the program is designed to answer;
- the set of elements covered in the framework structure.

Section 12 gives an overview of the operational processes and considerations to be used in implementing the Framework. These processes are based on the management considerations and current institutional arrangements outlined previously in sections 1, 2 and 3 of the report.

It is important to recognize that the High-Level Framework is based on desk research, and on the knowledge provided by experts and the client group. This High-Level Framework cannot be considered complete until management partners, stakeholders and the public have reviewed it, participated in its development, and are in agreement with the essential elements of the framework.

## 4. Framework Strategy:

The Framework is based on the following strategic considerations:

1. *A strategic focus on the consistency of data and integration and coordination of action*s: This requires establishment of mechanisms and protocols for collaboration, coordination and integration of activities among various monitoring institutions involved in data collection, analysis, reporting and distribution.

2. *A strategic focus on resourcing*:
   In order to demonstrate relevance and justify the application of resources, monitoring *activities* need to generate useful information and results through the development of analysis and reporting procedures from the very start.

3. *A strategic* focus *over the first few years on*:

   Preparing an integrated, accumulated state assessment to understand what is occurring in the watersheds, including the development of baseline upstream and downstream of existing and proposed new developments[7]; and

   Consistency and sharing of data among institutions and establishment of testing of institutional arrangements for developing a coordinated and integrated monitoring program among key players. Governance and management initiatives over the first few years would involve:

   - establishment of coordination and collaboration mechanisms for the key partners involved in aquatic monitoring activities in the watersheds (e.g. private sector, AANDC, Environment Canada, Department of Fisheries and Oceans, the Government of Nunavut, KivIA); and
   - coordination and analysis of existing monitoring data and programs of government agencies and coordination of monitoring done by private sector for existing and proposed developments. Limited or no effort would be placed on new data collection and analysis; new data would only be collected if it is essential for understanding what is occurring in the watershed.

4. *A future strategic focus, once conditions within the watersheds are more fully understood, on*:
   Development and implementation of a permanent Monitoring Program consisting of baseline monitoring, intense monitoring of changed conditions and special studies on causes of changes. The Program would define permanent VECs, locations, sampling frequency, analysis and reporting protocols, roles and responsibilities, etc.

## *4.1 Strategic Management and Institutional Considerations*

The establishment of management and institutional arrangements should:

1. Build on existing *frameworks*, institutional arrangements and initiatives of the NGMP, Kivalliq Socio-economic Monitoring Committee (SEMC), project-level monitoring of Meadowbank and other relevant government, academic and private sector monitoring initiatives, as follows:

[7] If budget permits the assessment should also identify the “hot spots” resulting from climate change and development stressors.

    - use the monitoring program of the Meadowbank project as a starting point for development of monitoring of local stressors;
    - use existing broad-scale data and monitoring programs (e.g. for hydrology, meteorology, char fish, etc) as a starting point for development of the Monitoring Program for watersheds.
2. Emphasize coordination of efforts and data consistency among partners and stakeholders, and focus on development of coordination and collaboration roles and responsibilities for the Aquatic Cumulative-Effects Monitoring Program.
3. Promote a practical, continuous improvement approach to development and implementation of the Monitoring Program, and use a plan-do-check-review cycle to develop and implement Program plans.
4. Ensure monitoring plans and initiatives are feasible and address capacity and resource constraints. Given the multi-stakeholder nature of the Program, ensure that the expectations for data collection and analysis by different stakeholders are within their capacity and resource constraints.

### *4.2. Strategic Technical Considerations*

Establishment of the technical part of the Framework should include the following:

- Commencement of an interim baseline data collection program;
- Assessment of the interim data to characterize the range of natural variability for indicators of VECs and climate change and to figure out how big a change is beyond natural variability[8];
- Development of VECs, indicators and targets for permanent monitoring of the baseline;
- Gradual development and implementation of a permanent Aquatics Monitoring Program consisting of:
    - baseline monitoring (at basin, watershed and local levels), with assessments of baseline data to understand the status and trends in water conditions and whether conditions are beyond variability targets (at the basin level for climate change and local level for developments);
    - intensified baseline monitoring that is triggered when VEC conditions are beyond variability targets (at the local level for developments);
    - Special studies on causes of changes (at the local level).

## 5. Framework Objectives

The Framework is intended to provide relevant information for government, private sector and public users who rely on it to inform their decisions and management actions. However, the

[8] E.g. natural variability for some VECs could be +/- 2 standard deviations of the mean

specific monitoring needs of users have yet to be defined. Two interim science and traditional knowledge objectives are proposed, based on the state of knowledge of conditions, stressors and monitoring institutions for the Baker Lake watersheds. Other objectives and analytical requirements will be added in the future. The two science and traditional knowledge objectives relate to:

- understanding conditions and trends of the river systems; and
- determining the contribution of various environmental stresses in the watersheds (i.e. development activities and climate change) to measurable and perceived changes in the system's current conditions and trends.

To be consistent with the approach to monitoring frameworks within the NGMP, these two proposed objectives have been framed in terms of monitoring results (outcomes), as follows:

1. Adequate information is collected, analyzed and made readily available for users to understand the aquatic conditions and trends of both the broader Baker Lake watersheds and the local areas near specific stressors; and
2. Adequate information is collected, analyzed and made readily available for users to understand the contribution of localized developments as distinct from the contribution of climate change stressors to changes in natural conditions of the aquatic environment in local areas near development stressors.

# 6. Framework Scope:

The scope of the framework is defined by the following parameters:

*Temporal timeframe*: 20 years;

*Geographic boundaries*: from Nunavut boundaries downstream: no trans-boundary effects are anticipated within this twenty-year timeframe;

*Stressors covere*d: three key stressors of:

1) mining exploration, development and operations;
2) Hamlet of Baker Lake; and
3) climate change;

*Scales and linkages*: the Framework will measure and link monitoring done for different purposes at three scales:

- Basin scale – monitoring of climate change effects on water quantity, quality and flow in the Basin[9];
- Watershed scale – monitoring of natural conditions in the watersheds; and

[9] Because climate change effects and research are so broad, the Basin scale is recommended.

- Project development scale – monitoring of actual conditions and effects of development stressors (i.e. mining and Hamlet of Baker Lake) at locations upstream and downstream of developments.

*Valued Ecosystem Components (VECs) covered in the Framework*: aquatic VECs and one or two key land-based VECs with important aquatic interactions.

## 7. Principles:

The following principles are based on generic principles for watershed monitoring which have been refined and tailored to fit the specific characteristics of the Baker Lake watersheds:

- A multi-stakeholder approach to monitoring will be employed whereby private proponent companies, Kivalliq Inuit Association, Hunters And Trappers Associations, communities (i.e., Baker Lake), federal and territorial government departments, Nunavut Institutions of Public Government, and national and international academic researchers contribute to monitoring and data collection to support the objectives of the Framework;

- Adaptive management approaches will be used to modify Program design and implementation where necessary to accommodate changes in policy and priority, technology, regional environmental conditions (e.g. climate change) and incorporate new scientific insights, and to improve predictive tools by comparing predicted impacts to actual changes measured through monitoring;

- A risk management approach to monitoring will be employed whereby development activities and works or undertakings that pose a higher risk to the aquatic and related environment are monitored to a greater extent than those considered to be of lower risk;
- Monitoring conducted pursuant to the Framework will be based on both scientific knowledge and *Inuit Qaujimajatuqangit (IQ*, and standardized as appropriate to allow comparison across data sources;
- Given the multi-stakeholder approach to data collection, rigourous QA/QC programs must be designed and implemented to ensure there is comparable data for analysis;
- The location of monitoring stations for monitoring reference conditions and for monitoring conditions at sites impacted by human activities should be located so that meaningful comparisons can be made to distinguish development project and initiative-specific changes from broader trends, changes and cycles in baseline conditions;
- Adjustments to operations, monitoring and regulatory approvals will be supported by documented rationales that are available for review by all stakeholders and the public;
- Monitoring results must be available and peer reviewed to ensure transparency and optimal knowledge translation, exchange, review and comment;
- Information will be recorded and reported in languages easily understood by affected stakeholders.

### 7.1 Approach[10]

The following are key elements of the approach to Framework development:

- Monitoring will be conducted using established and accepted methodologies with the degree of sampling and analytical rigour established according to the level of risk to the environment;
- Monitoring associated with development initiatives and projects will apply a *Before After Control Impact* (BACI) study design that is statistically valid;
- Monitoring of harvested species (e.g., fish species, caribou, muskox, furbearers, etc.) will be according to standard population management approaches implemented by the departments, agencies, and Nunavut Institutions of Public Government (i.e., Nunavut Wildlife Management Board) responsible for management of the species;
- Monitoring of migratory avian species will be conducted according to applicable protocols established pursuant to international treaties and agreements;
- Monitoring of species at risk will be according to the approaches and protocols referred to in the applicable recovery plans for specific species.

## 8. Framework Phases

The phases of Framework development address how the Framework will evolve as knowledge is gained, and relevant information needs change, over the 20-year period. Three phases of development are proposed to gradually integrate and adjust current monitoring programs and add new elements.

*PHASE 1:* Monitoring to understand what is going on in the watersheds, and initiating baseline for mining developments likely to occur within 5 years.

In this phase an Interim Monitoring Program would be designed and implemented with the aim of providing sufficient knowledge and capacity to be able to design a permanent Baseline Monitoring Program for the watersheds and for upstream and downstream of developments. [11]

*PHASE 2:* Monitoring of the environmental conditions within the watersheds, through establishment of a Permanent Program (indicators and reference sites) for measuring 1) natural conditions in the watersheds, and 2) actual conditions in locations affected by developments.

In this phase a Permanent Baseline Monitoring Program would be designed and implemented for the watersheds and upstream and downstream of developments based on the outcome of

[10] See Appendix 1 for other technical design principles.

[11] In technical terms this means preparation of an accumulated state assessment (to understand what is occurring in the watersheds) and development of baseline upstream and downstream if existing and proposed developments likely within the next 5 years.

Phase 1. The aim of the Permanent Program is to provide information about how much natural variability there is in baseline conditions, when changes outside of normal are occurring (i.e. warning triggered) and how important the changes are (i.e. monitoring of changed conditions to determine their extent and magnitude). The monitoring started during Phase 2 would form the core part of the Monitoring Program and would continue for the duration of the Program.

*PHASE 3:* Monitoring studies to identify the causes of divergence from natural conditions and the relative contribution of specific activities.

In this phase, specific monitoring initiatives would be designed and implemented to understand the causes of changes from natural conditions and specifically the contribution of climate change and local development activities to these changes.

# 9. Key Questions

The key questions that need to be answered to meet the objectives of the Framework are:

- What is the natural condition[12] of the watersheds (as reflected in the measured values of a core set of indicators) at locations that serve as reference sites for the watersheds?
- What are the conditions of local areas within the watersheds that are affected by various human activities?
- In situations where conditions in the watersheds diverge from natural conditions what are the relative contribution of human developments and climate change to the effects?

These key questions may be broken into the following sub-questions that need to be answered during each of the Phases outlined above. Sub-questions are mainly developed for Phase 1; we anticipate that more sub-questions will be developed for Phases 2 and 3 during implementation of Phase 1. The questions are organized by scale: Watersheds, Basin and Project.

## *Phase 1*

In Phase 1 the questions are designed to either start an Interim Program of baseline data collection or to develop the information needed to design a Permanent Monitoring Program. Monitoring would be done at all three levels.

***Watershed Scale:***

- *Interim Data Collection Question* – What is the natural condition of the water quality, quantity and flow at the watershed scale (based on consolidation and analysis of existing data and reference sites)?

[12] Natural conditions would be established from historical and current data at reference sites that are distant from and considered unaffected by human developments.

- *Program Design Questions* – What core set of indicators, reference sites and data protocols are needed to measure the natural condition of the water quality, quantity and flow at the watersheds scale?
    - Using existing monitoring data and sampling sites, what indicators for water quality, quantity and flow can be collected and analyzed by government (AANDC, EC, DFO and GN) and other key partners to provide a basic understanding of conditions for Baker Lake watersheds?
    - Are there any critical gaps in the existing baseline information on water quality, quantity and flow that need to be filled in order to understand what is going on in the watersheds?
    - What is the range of natural variability of baseline conditions for water quantity, quality and flow?

***Basin Scale:***

- *Interim Data Collection Question* – What is the effect of climate change on water quality, quantity and flow in the Basin (based on collection and analysis of existing climate change VECs and indicator data and sample sites)?
- *Program Design Questions* – What set of indicators, reference sites and data protocols are needed to measure the effects of climate change on conditions in the watershed?
    - What is the state of knowledge about the effects, VECs and indicators for measuring the effect of climate change on water quality, quantity and flow in the Basin? What data and sample sites exist for these?
    - Do any additional VECs, indicators and locations need to be sampled and analyzed to understand the effects of climate change on conditions in the watersheds (e.g. permafrost, precipitation, lake ice, and hydrology)?

***Project Scale:***

- *Interim Data Collection Question* – What is the actual condition of the watershed upstream and downstream of locations with existing and proposed developments (based on consolidation and analysis of data from existing sampling sites of government and private sector)?
- *Program Design Questions* – What set of indicators, reference locations and data protocols are needed to measure actual conditions of the watershed upstream and downstream of locations with existing and proposed developments?
    - What existing monitoring data is being collected by government, private industry and others for locations near existing and future developments? Which of these relate to the core set of watershed indicators and which to project specific conditions?
    - Using existing monitoring data and samplings of Meadowbank and other project level monitoring programs (e.g. Kiggavik), what indicators for water quality, quantity and flow can be collected and analyzed by the private sector to understand

baseline conditions at locations affected by development activities? How do these relate to core set of watershed indicators?

- What is known about proposed future developments – i.e. location, timeframe, scale and potential aquatic impacts (type of emissions, downstream "footprint" and project- specific VECs, indicators, etc.)?
- Are there any critical gaps in the information for future developments or project-level monitoring programs of existing developments (Meadowbank, Baker Lake community) that need to be filled to be able to establish a baseline of actual conditions upstream and downstream of actual developments (the baseline needs to include core watershed indicators as well as indicators for project-specific potential effects)?
- What is the range of natural variability of baseline conditions for water quantity, quality and flow upstream and downstream of developments?

## *Phase 2*

In this phase the knowledge gained during Phase 1 is used to design and implement the Permanent Monitoring Program. The Permanent Program would be regularly reviewed and improved as it is implemented. The questions for the Permanent Program relate to routine monitoring, monitoring of changed conditions, or monitoring of climate change parameters. The Permanent Program would involve monitoring at all three levels.

***Watershed Scale:***

- *Routine Monitoring Question* – What is the natural condition of the water quality, quantity and flow at the watershed scale (as measured by a core set of indicators at reference locations with coordinated data protocols)?

***Basin Scale:***

- *Climate Change Monitoring Question* – What is the effect of climate change on water quality, quantity and flow in the Basin (as measured by a set of key climate change indicators at reference locations)?

***Project Level:***

- *Routine Monitoring Question* – What is the actual condition of the watershed upstream and downstream of locations with existing and proposed developments (as measured by set of core watershed indicators and indicators for project-specific potential effects)?

***Basin Scale(for Climate Change) and Project Scale(for Developments):***

- *Change in Conditions Questions* – What are the changes in natural conditions when the baseline is beyond natural variability?
    - What mechanisms and triggers need to be put in place to provide an early warning of changes in natural conditions in a) the Basin due to climate change, and b)

locations affected by developments, considering also that *IQ* or community-based monitoring could be important here?

- What monitoring and special studies are needed to measure changes in conditions beyond natural variability in a) the Basin due to climate change, and b) locations affected by developments?

### *Phase 3*

In this phase the questions relate to understanding the causes of divergence from natural conditions in locations affected by development. Investigation of these questions involves special studies to determine the contribution of different stressors to changes in conditions identified through the Permanent Monitoring Program established in Phase 2. These special studies would be done for the Project level. In addition, special analysis of climate change data collected at the Basin level may be needed to make it applicable to localized conditions of specific developments.

***Project Scale:***

- *Causes of Change in Conditions Question*: What are the relative contribution of human developments and climate change to changes in conditions in locations affected by development?
  - What set of scientific and *IQ*-based indicators need to be monitored and analyzed to establish divergence from natural conditions at locations affected by developments? (This question could be covered as part of monitoring studies of change in conditions in Phase 2 above; it is included here to ensure that specific indicators for Phase 3 studies link to those of the Permanent Monitoring Program designed in Phase 2).
  - What measurements and analyses need to be undertaken to determine the relative contribution of climate change versus development stressors to divergence from actual baseline conditions at locations affected by developments? (Data collected for special studies should link to the Watershed and Basin data collected by the Permanent Monitoring Program).

## 10. Framework Structural Elements

The Framework has similar elements to those of NGMP frameworks (i.e. NGMP integrated frameworks for socio-economic monitoring). They include the following.

*Valued Ecosystem Components of aquatic ecosystems, and related indicators:* Valued Ecosystem Components are the components of concern that would be monitored. Initially these components would be the relevant aquatic components identified by the NGMP. However, the final set of VECs used in the Permanent Monitoring Program should be tailored more specifically to the Baker Lake Basin and user needs. The final set of VECs need to be selected and approved by key partners, stakeholders and the public and thus requires a multi-stakeholder participatory process. Indicators are the specific elements and parameters of the VECs that would be used to assess VEC conditions.

*Measureable Indicators and Targets*: In the Framework the measureable indicators are the detailed and specific parameters that will be monitored. Targets are the level of health of natural conditions that are considered acceptable as defined by regulation, policy, land-use plans, NLCA or predicted effect levels of approved development EIAs. In the Monitoring Program at least two different levels of measurable targets need to be established: those for the range of acceptable variability of natural conditions and those for the probable effects of development activities or climate change.

*Key Sources*: The name(s) of organizations' with relevant data available on Framework indicators and parameters.

*Baseline Data*: A summary of the available data.

*Sampling*: The location of sampling sites and the date and frequency of data collection.

*Roles and Responsibilities*: The organization(s) responsible for collecting, analyzing and reporting monitoring data and for reviewing and improving the Monitoring Program.

## 11. Framework Tables

The structural elements described in Sections 8 to 10 above would be combined as shown in Tables 1, 2 and 3, which are presented at the end of Part 3 below. Table 1 presents the summary structure for both the watershed and project-level Monitoring Programs. It identifies how the watershed and project-level Monitoring Programs are linked for the core part of the Program established in Phase 2, which involves permanent monitoring of baseline conditions, including monitoring of the natural variability in conditions and changes in conditions. Table 2 presents the complete structure for all three Phases of a Monitoring Program for Watersheds and the Basin. Table 3 shows the complete structure by Phase for a Project-Level Monitoring Program. The tables presented in this report include headings and examples of the types of information required; actual monitoring information and data will need to be filled in using the processes and considerations outlined below in Sections 12 and Part 4 of the report.

In Table 2 (Watershed and Basin Monitoring) the structure has three broad categories of information: VECs and Indicators (black headings), Baseline Information (blue headings) and Monitoring Protocols (green headings). These broad categories are broken into sub-categories and headings as shown in the Table. It is important to note that the sub-headings change slightly for each Phase. For example, in Phase 1 the initial VECs and Indicators are the generic indicators already defined by NGMP in its framework and State of Knowledge reports. However, by the end Phase 1, the natural conditions in the watershed will be better understood; thus VECs and indicators tailored to the specific conditions of the watershed would be identified and used for Phase 2. Some examples of VECs and measureable indicators and parameters are provided in the Table, but only for purposes of illustration.

In Table 3 (Project Level Monitoring) the structure also has three broad categories of information: VECs and Indicators (black headings), Development Information (orange headings) and Monitoring Protocols (blue heading).

# 12. Operational Considerations

This section outlines the high-level considerations on how the Watershed and Project Level Monitoring Tables will be populated. By systematically working through and populating these Tables, the basic contents of the Framework will be developed and decisions about how to implement it will have been made. The Framework Table for each Phase will be worked through at the start of the Phase, and should be refined and improved over time as they are utilized.

The discussion below focuses on considerations related to the design and implementation of Phase 1 of the Monitoring Program. It should be noted however that most of these processes and considerations also apply to Phases 2 and 3. The processes and considerations outlined below are based on the State of Knowledge and Context of Best Practice outlined in Section 1 above, in the Appendices of this report, as well as in the following three key documents:

- *Water Monitoring Business Plan, Northwest Territories and Nunavut* (INAC, 2003)
- *2010 Nunavut Hydrometric Network Review* (Kerrwood Leidal Associates, for INAC)
- *Memorandum of Understanding on Hydrometric Monitoring for Nunavut, between Department of Environment (DOE) and Department of Indian Affairs and Northern Development (DIAND),* February 2010.

## *12.1 Initial Considerations: Participants and Available Resources*

Before working through the populating of the Framework Tables for Phase 1, participants involved in the process and the resources available for monitoring need to be identified.

***Who*** – All the key players and advisors identified in Section 3 above should be involved in populating the Framework for Phase 1 (i.e. AANDC, Environment Canada, DFO, Government of Nunavut, NWB and KivIA). In addition, scientific and traditional knowledge and stakeholder considerations need to be included in the process. Roles and responsibilities for these are discussed below.

***Available Resources*** **–** The actual and anticipated resources and capacity available for monitoring over the next one to three years need to be established, and the Interim Monitoring Program designed within this context. In addition to looking at the regularly identified resources for monitoring activities, there may be several other sources and resources within organizations to consider. For instance:

- Within AANDC, all five lines of business in its water monitoring business plan may have relevance and resources for watershed monitoring[13] (these business lines still apply, despite cutbacks since the plan was originally developed);
- Budget cuts in the past few years have led to more collaboration with third parties on data collection and focusing of resources around anticipated developments, although at present the utility of the monitoring data from third parties is limited, as they are usually collected for specific proponent requirements with little or no consideration for multiple users;
- While data generated on a cost-recovery basis or for special studies and purposes is often not the most suitable for all needs in terms of special and temporal representation, they are sometimes the only data available for a particular region.

## 12.2 Considerations Related to Purpose and Methodology

***Purpose*** **–** The purpose of Phase 1 is to implement an Interim Monitoring Program and design a Permanent Monitoring Program that answers the key questions presented in section 9 of the repot. Specifically, monitoring, research and analysis done during this phase should focus on identifying:

- the core set of VECs and indicators for baseline monitoring (at Watershed and Project levels);
- the locations for reference sites for watersheds upstream and downstream of developments;
- the VECs, indicators and locations for reference sites for monitoring climate change effects (at Basin level)
- the range of natural variability for baseline conditions in watersheds.

***Methodology*** **–** The most efficient way to populate the watershed and project-level Frameworks is through a workshop process involving the key partners, advisors and technical specialists. The focus initially should be on the Watershed Framework; work on the Project-level Framework would commence once the Watershed Framework is complete. Two workshops should be sufficient to develop an acceptable version of the Watershed Framework: a first workshop to discuss concepts and produce a rough version of the populated Framework, and a second workshop to produce a final version of the Framework. In advance of the workshops some background research (e.g. on available resources, quality and utility of historic and existing monitoring data) would need to be done. Consultations with stakeholders will also be essential.

[13] According to *Water Monitoring Business Plan, Northwest Territories and Nunavut* (INAC, 2003), AANDC's five business lines are:

- water quality/quantity baseline network
- specific water monitoring studies
- applied research
- interpretation and provision of information
- partnership and public participation

## *12.3 Management Considerations*

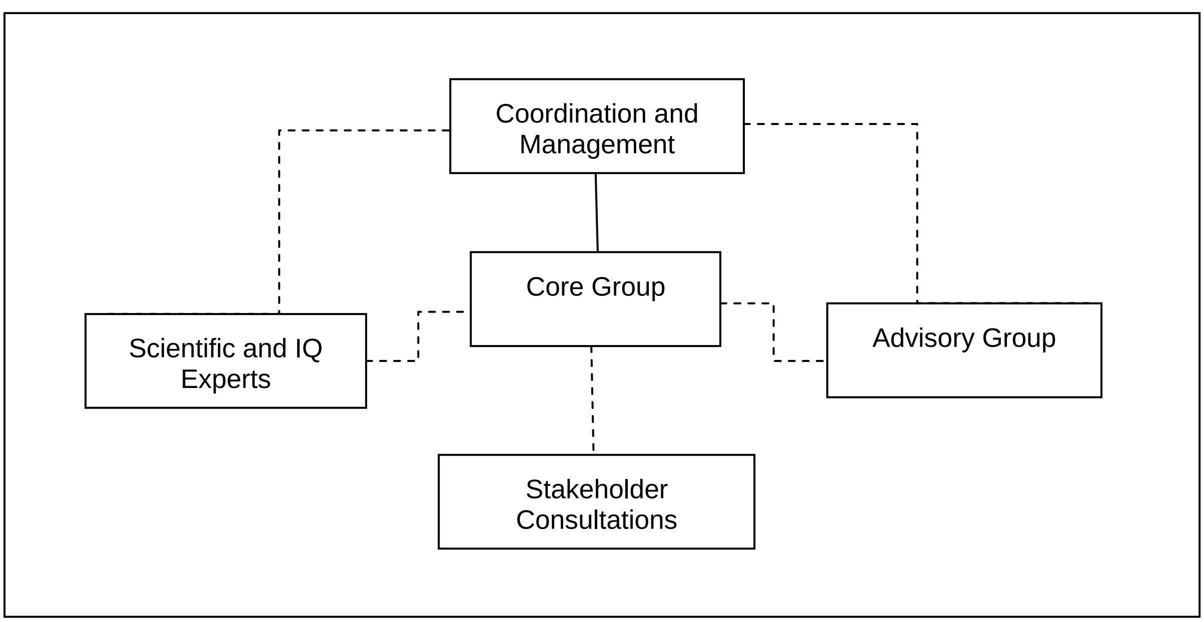
*Roles and Responsibilities for Populating the Phase 1 Framework*

The primary roles and suggested organizations for populating the Phase 1 Framework are:

| | |
|---|---|
| Coordination and Management: | AANDC |
| Core Group: | Organizations involved in populating the Tables – AANDC, Environment Canada, Department of Fisheries and Oceans, possibly KivIA and Government of Nunavut; representatives of Meadowbank, Kiggavik and community of Baker Lake also should be part of the core group for populating the Project-level Framework. |
| Advisory Group: | Organizations involved in concept discussion in the first workshop and in reviewing results – NWB, KivIA and Government of Nunavut. |
| Scientific and TK Experts: | External third party scientists and *IQ* specialists should be brought in to participate in both workshops. |
| Stakeholder consultations: | Private sector and Baker Lake municipality and community members should be consulted. |

*Management Structure*

For purposes of populating the Phase 1 Framework, a simple and informal organizational structure is suitable for the functions listed above. A simple structure like that presented below should form the basis of ongoing collaborative arrangements that eventually will be formalized.



## 12.4 Technical Considerations

Appendix 1 following the main body of this report provides further technical considerations for populating the Framework Tables in Phase 1, including:

- Selection of VECs and indicators;
- Reference sites to establish baseline conditions; and
- Identification of triggers or management limits.

It is important to note that for Phase 1, the VECs, reference sites and triggers would be preliminary and designed for an Interim Monitoring Program.

**TABLE 1: COMPARISON OF PROPOSED STRUCTURES FOR PERMANENT WATERSHED AND BASIN MONITORING vs. PROJECT LEVEL MONITORING**

**STRUCTURE OF WATERSHED AND BASIN PARTS OF PERMANENT MONITORING PROGRAM (As Established in Phase 2)**

| WATERSHED VECS, INDICATORS, TARGETS | | | MONITORING BASELINE CONDITIONS OF THE WATERSHEDS AND BASIN | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **VECs** | **Indicators** | **Targets** | **EXISTING PROGRAMS AND SOURCES** | | | **NEW DATA** | | | **ROLES AND RESPONSIBILITIES** | | |
| | | | **Source** | **Sampling** | | **Source** | **Sampling** | | **Data Collection** | **Data Analysis and Reporting** | **Checking and Improving Program** |
| | | | | Location | Dates & Frequency | | Location | Dates & Frequency | | | |
| Water Quality,<br>Water Quality Flow, etc. | Measureable Indicators for:<br>• Natural conditions in watersheds<br>• Actual conditions in the Basin for effects of climate change on aquatic environment<br>• Change in Basin conditions beyond natural variability due to climate change | Measureable targets for:<br>• natural variability of watersheds indicators<br>• natural variability of CC indicators | | | | | | | 1. For Protocol Design: Indicator, Location, Date, Frequency, etc.<br><br>2. For Implementation | 1. For Protocol Design:<br>• QA/QC of data and variability of results<br>• Reporting format, scale and mode (web-based?)<br><br>2. For Implementation | 1. For Protocol Design to review/improve:<br>• standardization of VECs and indicators<br>• data consistency<br>• links with project monitoring<br>• shift from EE to cumulative effects<br><br>2. For Implementation |

**Routine Monitoring Question – Watershed Scale**: What is the natural condition of a core set of indicators at reference locations for the watersheds?
**Climate Change Monitoring Question – Basin Scale:** What is the actual condition of a key set of climate change indicators that affect water quantity, quality and flow in the Basin?
**Monitoring of Changed Conditions Question – Basin Scale:** What are the changes in natural conditions in the Basin when the baseline is beyond natural variability for key climate change indicators?

**STRUCTURE OF PROJECT LEVEL PART OF PERMANENT MONITORING PROGRAM – TO MONITOR ACTUAL CONDITIONS UPSTREAM AND DOWN STREAM OF DEVELOPMENTS (As Established in Phase 2)**

| Related Watershed VECs, Indicators and Targets | | | RELEVANT DEVELOPMENT DATA | | MONITORING OF ACTUAL CONDITIONS IN DEVELOPMENT AREA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VECs** | **Indicators** | **Targets** | **Development footprint** | **Potential Environmental Effects** | **PROJECT LEVEL VECS, INDICATORS & TARGETS** | | | **MONITORING PROTOCOLS** | | | **ROLES AND RESPONSIBILITIES** | | |
| | | | | | **VECs** | **Indicators** | Targets | **Data Collection**<br>•Location,<br>•Date,<br>•Frequency | **Analysis and Reporting** | **Checking and Improving** | **Data Collection**<br><br>Protocol design<br><br>Implementation | **Analysis and Reporting**<br><br>Protocol design<br><br>Implementation | **Checking and Improving**<br><br>Protocol design<br><br>Implementation |
| Water quality, quantity,<br>flow, fish , caribou, etc.. | Measureable Indicators for<br>•Actual conditions upstream and downstream of developments<br>•Change in actual conditions beyond natural variability | Measureable targets for variability | •area of land/water disturbed<br>• intakes of water by project<br>• discharges to water | •predictions for probable effects to VECs and indicators | | | | | | | | | |

**Routine Monitoring Question – Project Scale:** What is the actual condition of watersheds upstream and downstream of locations with existing and proposed developments?
**Monitoring of Changed Conditions Question – Project Scale:** What are the changes in actual conditions upstream and downstream of locations affected by developments when the baseline is beyond natural variability?

**TABLE 2: PROPOSED STRUCTURE FOR WATERSHED AND BASIN SCALES OF MONITORING**

**PHASE 1: MONITORING TO UNDERSTAND WHAT IS GOING ON IN THE WATERSHEDS AND WITH CLIMATE CHANGE IN THE BASIN (INCLUDING LINKS WITH BASELINE MONITORING FOR DEVELOPMENTS)**

| NGMP VECs | VECs and Indicators | BASELINE INFORMATION (EXISTING AND HISTORICAL) | | | | | | WATERSHED AND BASIN MONITORING PROTOCOLS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Relevant NGMP Indicators | Relevant Baseline Parameters and data | Sampling | | Key Sources | Relevance for Watershed Monitoring | | Measureable Indicator/ Parameter | Data Collection Protocol | Data Analysis and Reporting Protocol | Checking and Improving Program |
| | | | Location | Dates & Frequency | | Scale (territory, region, watershed, local) | Gaps | | •Indicator, Location<br>• Timing, frequency<br>• Roles and responsibilities | • Info needs of users<br>• QA/QC of data and variability of results<br>• Reporting format, scale and mode (web-based?)<br>• Roles and responsibilities | • Standardization of VECs and indicators<br>•Consistency of data<br>• links with monitoring actual conditions at project level<br>• What can be learned about watershed?<br>• How can protocols be improved?<br>• Roles and responsibilities |

**WATERSHED SCALE**

**Interim Baseline Data Collection Question:** What is the natural condition of the water quality, quantity and flow at the watershed scale (based on existing monitoring data)?

**Program Design Questions and Sub-questions:** What core set of indicators, reference locations and data protocols are needed to measure the natural conditions of water quality, quantity and flow in the watershed on an ongoing basis?

- Using existing monitoring data and sampling sites, what indicators for water quality, quantity and flow can be collected and analyzed by government organizations (AANDC, EC, DFO and GN) to provide basic understanding of conditions for Baker Lake watersheds?
- Are there any critical gaps in the existing baseline information on water quality, quantity and flow that need to be filled to understanding what is going on in the watersheds?
- What is the range of natural variability of baseline conditions for water quantity, quality and flow at reference sites?

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NGMP | Water Quality<br>Water Quantity<br>Flow | | | | | | | | | | |

**BASIN SCALE**

**Interim Baseline Data Collection Question:** What is the effect of climate change on water quality, quantity and flow in the Basin (based on existing monitoring)?

**Program Design Questions and Sub-questions:** What set of indicators and reference locations and data protocols are needed to measure the effect of climate change on baseline conditions in the Basin?

- What is the state of knowledge about the VECs and indicators for measuring the effects of climate change on water quality, quantity and flow?
- Do any additional VECs, indicators and locations need to be sampled and analyzed to understand the affects of climate change on conditions in the Basin and/or watersheds?

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NGMP | Permafrost, Precipitation<br>Lake Ice, Hydrology | | | | | | | | | | |

**PROJECT SCALE**

**(included to ensure consistency and linkages between watershed and project level monitoring – see Project Level Monitoring Table for details)**

**Interim Baseline Data Collection Question:** What is the actual condition of the watershed upstream and downstream of locations with existing and proposed developments?

**Program Design Question and Some Sub-questions:** What set of indicators, reference locations and data protocols are needed to measure actual conditions of the watershed upstream and downstream of existing and future developments?

- What existing monitoring data is being collected and by whom for locations near existing and future developments? Which of these relate to the core set of watershed-level indicators and which to project-specific condition?
- Using existing data collection, sampling sites and project monitoring programs of the private sector monitoring (Meadowbank, Kiggavik), what indicators for water quality, quantity and flow data can be collected and analyzed by private sector to understand baseline conditions upstream and downstream of developments? How do these relate to the core set of watershed indicators?

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NGMP | Water Quality<br>Water Quantity<br>Flow, Fish, etc. | | | | | | | | | | |

**TABLE 2: PROPOSED STRUCTURE FOR WATERSHED AND BASIN MONITORING SCALES OF MONITORING (cont'd)**

**PHASE 2: PERMANENT BASELINE MONITORING PROGRAM FOR MEASURING NATURAL CONDITIONS IN WATERSHEDS AND THE EFFECTS OF CLIMATE CHANGE ON THE BASIN**

| Program VECs, Indicators, Targets | | | MEASUREMENT OF BASELINE CONDITIONS | | | | | | WATERSHED AND BASIN MONITORING PROTOCOLS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VECs | Indicators | Target | EXISTING PROGRAMS AND SOURCES | | | NEW DATA | | | | | |
| Water Quality, Water Quality Flow, etc. | Measureable Indicators for:<br>• Natural Conditions in watersheds<br>• Climate Change effects in Basin<br>• Early warning that watershed and climate change indicators are beyond their natural variability<br>• Actual conditions in locations affected by developments | Measureable targets for natural variability of watershed and climate change indicators | Source | Sampling | | Source | Sampling | | Data Collection Protocol | Data Analysis and Reporting Protocol | Checking and Improving Program |
| | | | | Location | Dates & Frequency | | Location | Dates & Frequency | •Indicator<br>•Location<br>• Timing, frequency<br>• Roles and responsibilities | • Info needs of users<br>• QA/QC of data and variability of results<br>• Reporting format, scale and mode (web-based?)<br>• Roles and responsibilities | • standardization of VECs and indicators<br>•consistency of data<br>• links with monitoring stressors at local level<br>• gradual shift from EE to cumulative effects monitoring<br>• Roles, responsibilities |
| **WATERSHED SCALE**<br>**Routine Monitoring Question:** What is the natural condition of water quality, quantity and flow at the watershed scale (as measured by a core set of indicators at chosen reference locations using coordinated data protocols)? | | | | | | | | | | | |
| TBD | TBD - measures for water quality, quantity, flow, etc. | Range of natural variability for watershed indicators | | | | | | | | | |
| **BASIN SCALE**<br>**Routine Monitoring Question:** What is effect of climate change on water quality, quantity and flow in the Basin (as measured by a set of key climate change indicators at reference locations)? | | | | | | | | | | | |
| TBD | TBD - measures for lake ice, permafrost, precipitation, Hydrology, etc. | Range of natural variability for climate change indicators | | | | | | | | | |
| **Monitoring of Change in Conditions Question and Sub-questions:** What are the changes in natural conditions when the baseline is beyond natural variability?<br>• What mechanism and triggers needs to be put in place to provide early warning of changes in natural conditions? (could be IQ, community based monitoring, or science triggers)<br>• What monitoring is needed to measure changes in conditions beyond natural variability? | | | | | | | | | | | |
| TBD | TBD – triggers of change, measures for extent and size of changes | | | | | | | | | | |
| **PROJECT SCALE**<br>**(included to ensure consistency and linkages between watershed and project level monitoring – see Project Level Monitoring Table for details)**<br>**Routine Monitoring Question:** What is the actual condition of the watershed upstream and downstream of locations with existing and proposed developments (as measured by core set of indicators for watershed and indicators for project)? | | | | | | | | | | | |
| TBD | TBD - measures for water quality, quantity, flow, etc. | | | | | | | | | | |

## TABLE 2: PROPOSED STRUCTURE FOR WATERSHED AND BASIN MONITORING SCALES OF MONITORING (cont'd)

**PHASE 3: CONTINUATION OF PERMANENT MONITORING PROGRAM ESTABLISHED IN PHASE 2 AND SPECIAL STUDIES DONE IN LOCATIONS AFFECTED BY DEVELOPMENT ON CAUSES OF CHANGES IN CONDITIONS**

**See Phase 3 of Table 3 for Special Studies. Linkages with Special Studies are given below to ensure they are consistency with the Watershed and basin monitoring program.**

| VECs | Program VECs, Indicators, Targets | | MEASUREMENT OF BASELINE CONDITIONS | | | | | | WATERSHED AND BASIN MONITORING PROTOCOLS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Indicators | Target | EXISTING PROGRAMS AND SOURCES | | | NEW DATA | | | | | |
| | | | Source | Sampling | | Source | Sampling | | **Data Collection Protocol** | **Data Analysis and Reporting Protocol** | **Checking and Improving Program** |
| | | | | Location | Dates & Frequency | | Location | Dates & Frequency | | | |
| Water Quality, Water Quality Flow, etc. | Measureable Indicators for<br>• Natural Conditions in watersheds<br>• Actual conditions upstream and downstream of developments<br>• Measures for contribution of climate change and development stressors to change in actual conditions | • Measureable targets for natural variability of watershed and climate change indicators<br>• Measureable targets for actual variability upstream and downstream of developments | | | | | | | •Indicator<br>•Location<br>• Timing, frequency<br>• Roles and responsibilities | • Info needs of users<br>• QA/QC of data and variability of results<br>• Reporting format, scale and mode (web-based?)<br>• Roles and responsibilities | • standardization of VECs and indicators<br>•consistency of data<br>• links with monitoring stressors at local level<br>• gradual shift from EE to cumulative effects monitoring<br>• Roles and responsibilities |
| **PROJECT SCALE** | | | | | | | | | | | |
| **Cause of Change in Conditions Question:** What are the relative contributions of human developments and climate change to changes in condition in locations affected by developments? | | | | | | | | | | | |
| TBD | TBD – key indicators of sub-questions | | | | | | | | | Consolidation of results from sub-questions | |
| **Sub-Question**: What set of scientific and IQ indicators need to be studied to establish divergence from actual conditions at locations affected by development? (Indicators used for special studies should link to the watershed indicators of the permanent monitoring program) | | | | | | | | | | | |
| TBD | Scientific measures and IQ observations. | | | | | | | | | Comparison of changed conditions with pre-development conditions | |
| **Sub- Question:** What measurements and analyses need to be studies to determine the relative contribution of climate change vs. development stressors to divergence of the baseline from actual conditions at locations affected by development? (Data collected for special studies should link to the watershed and basin data collected by the permanent monitoring program) | | | | | | | | | | | |
| TBD | • Measures for climate change and development contributions | • Predictions for level of effects | | | | | | | | • Assessment of contributions<br>• Comparison of changed conditions with predictions | |

## TABLE 3: PROPOSED STRUCTURE OF PROJECT LEVEL MONITORING THAT LINKS TO WATERSHED LEVEL MONITORING

<table>
<tr><td colspan="14">PHASE 1: MONITORING TO INITIATE BASELINE FOR DEVELOPMENTS LIKELY WITHIN 5 YEARS</td></tr>
<tr><td colspan="3">Related Watershed VECs, Indicators and Targets</td><td colspan="2">RELEVANT DEVELOPMENT DATA</td><td colspan="9">MONITORING OF ACTUAL CONDITIONS IN DEVELOPMENT AREA</td></tr>
<tr><td>VECs</td><td>Indicators</td><td>Targets</td><td>Development footprint</td><td>Potential Environmental Effects</td><td colspan="3">PROJECT LEVEL VECS, INDICATORS & TARGETS</td><td colspan="3">MONITORING PROTOCOLS</td><td colspan="3">ROLES AND RESPONSIBILITIES</td></tr>
<tr><td>Water quality, quantity, flow, fish, caribou, etc..</td><td>Measureable Indicators for<br>•Actual conditions upstream and downstream of existing and proposes developments</td><td>Measureable targets for variability of actual conditions</td><td>•area of land/water disturbed<br>• intakes of water by project<br>• discharges to water</td><td>•predictions for probable effects to VECs and indicators</td><td>VECs</td><td>Indicators</td><td>Targets</td><td>Data Collection<br>•Location,<br>•Date,<br>•Frequency</td><td>Analysis and Reporting</td><td>Checking and Improving</td><td>Data Collection<br><br>Protocol design<br><br>Implementation</td><td>Analysis and Reporting<br><br>Protocol design<br><br>Implementation</td><td>Checking and Improving<br><br>Protocol design<br><br>Implementation</td></tr>
<tr><td colspan="14">Interim Data Collection Question: What is the actual condition of the watershed upstream and downstream of locations with existing and proposed developments? (as measured by a core set of watershed indicators as well as indicators for project specific potential effects)?</td></tr>
<tr><td>TBD – NGMP, EIA, etc.</td><td>Water quality, quantity, flow, fish, etc.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="14">Program Design Question and Sub-questions: What set of indicators, reference locations and data protocols are needed to measure actual conditions of the watershed upstream and downstream of locations with existing and proposed developments?<br>• What existing monitoring data is being collected and by whom for locations near existing and future developments? Which of these relate to the core set of watershed-level indicators and which to project-specific condition?<br>• Using existing data collection, sampling sites and project monitoring programs of the private sector monitoring (Meadowbank, Kiggavik), what indicators for water quality, quantity and flow data can be collected and analyzed by private sector to understand baseline conditions upstream and downstream of developments? How do these relate to the core set of watershed indicators?<br>• What is known about future developments that are likely within 5 years? i.e. location, timeframe, scale, potential aquatic impacts (type of emissions, downstream “footprint” and project- specific VECs, indicators, predicted effects) and monitoring program.<br>• Are there any critical gaps in the monitoring information of future or existing developments (Meadowbank, Baker Lake community) that need to be filled to be able to establish a baseline of actual conditions upstream and downstream of developments?<br>• What is the range of natural variability of baseline conditions for water quantity, quality and flow upstream and downstream of developments?</td></tr>
<tr><td>TBD – NGMP, EIA, etc</td><td>Water quality, quantity, flow, fish, etc</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

**TABLE 3: PROPOSED STRUCTURE OF PROJECT LEVEL MONITORING THAT LINKS TO WATERSHED LEVEL MONITORING (cont'd)**

| PHASE 2: PERMANENT MONITORING PROGRAM AT THE PROJECT SCALE FOR MEASURING ACTUAL BASELINE CONDITIONS AND CHANGES IN CONDITIONS UPSTREAM AND DOWNSTREAM OF DEVELOPMENTS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Related Watershed VECs, Indicators and Targets** | | | **RELEVANT DEVELOPMENT DATA** | | **MONITORING OF ACTUAL CONDITIONS IN DEVELOPMENT AREA** | | | | | | | | |
| **VECs** | **Indicators** | **Targets** | **Development footprint** | **Potential Environmental Effects** | **PROJECT LEVEL VECS, INDICATORS & TARGETS** | | | **MONITORING PROTOCOLS** | | | **ROLES AND RESPONSIBILITIES** | | |
| Water quality, quantity, flow, fish, caribou, etc.. | Measureable Indicators for<br>• Actual conditions upstream and downstream of developments<br>• Changes in actual conditions beyond natural variability | Measureable targets for variability | •area of land/water disturbed<br>• intakes of water by project<br>• discharges to water | •predictions for probable effects to VECs and indicators | **VECs** | **Indicators** | Targets | **Data Collection**<br>•Location,<br>•Date,<br>•Frequency | **Analysis and Reporting** | **Checking and Improving** | **Data Collection**<br><br>Protocol design<br><br>Implementation | **Analysis and Reporting**<br><br>Protocol design<br><br>Implementation | **Checking and Improving**<br><br>Protocol design<br><br>Implementation |
| **Routine Monitoring Question:** What is the actual condition of the watershed upstream and downstream of locations with existing and proposed developments (as measured by core set of watershed indicators and indicators for project – specific potential effects)? | | | | | | | | | | | | | |
| TBD | | | | | | | | | | | | | |
| **Monitoring of Change in Conditions Question and Sub-questions:** What are the changes in actual conditions upstream and downstream of developments when the baseline is beyond natural variability?<br>• What mechanism and triggers needs to be put in place to provide an early warning of changes in actual conditions at locations affected by developments? (could be IQ, community based monitoring, or science triggers)<br>• What monitoring is needed to measure changes in conditions beyond natural variability? | | | | | | | | | | | | | |
| TBD | | | | | | | | | | | | | |

**TABLE 3: PROPOSED STRUCTURE OF PROJECT LEVEL MONITORING THAT LINKS TO WATERSHED LEVEL MONITORING (cont'd)**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PHASE 2: PERMANENT MONITORING PROGRAM FOR MEASUREING ACTUAL CONDITIONS AND CHANGES IN CONDITIONS IN LOCATIONS AFFECTED BY DEVELOPMENTS** | | | | | | | | | | | | | |
| **PHASE 3: SPECIAL STUDIES DONE IN LOCATIONS AFFECTED BY DEVELOPMENT ON CAUSES OF CHANGES IN CONDITIONS AND CONTINUATION OF PERMANENT MONITORING PROGRAM ESTABLISHED IN PHASE 2** <br> **See Phase 2 of Table 3 for Details on Permanent Monitoring Program.** | | | | | | | | | | | | | |
| **Related Watershed VECs, Indicators and Targets** | | | **RELEVANT DEVELOPMENT DATA** | | **MONITORING OF ACTUAL CONDITIONS IN DEVELOPMENT AREA** | | | | | | | | |
| **VECs** | **Indicators** | **Targets** | **Development footprint** | **Potential Environmental Effects** | **PROJECT LEVEL VECS, INDICATORS & TARGETS** | | | **MONITORING PROTOCOLS** | | | **ROLES AND RESPONSIBILITIES** | | |
| Water quality, quantity , flow, fish , caribou, etc.. | Measureable Indicators for:<br>•Actual conditions upstream and downstream of developments<br>• Contributions of climate change and development stressors to changes in actual conditions | Measureable targets for:<br>• Natural variability of watershed and climate change indicators<br>• Predicted level of effects for development | •area of land/water disturbed<br>• intakes of water by project<br>• discharges to water | •predictions for probable effects to VECs and indicators | **VECs** | **Indicators** | Targets | **Data Collection**<br>•Location,<br>•Date,<br>•Frequency | **Analysis and Reporting** | **Checking and Improving** | **Data Collection**<br><br>Protocol design<br><br>Implementation | **Analysis and Reporting**<br><br>Protocol design<br><br>Implementation | **Checking and Improving**<br><br>Protocol design<br><br>Implementation |
| **Cause of Change in Conditions Question:** What are the relative contributions of human developments and climate change to changes in condition in locations affected by developments? | | | | | | | | | | | | | |
| TBD | TBD – key indicators of sub-questions | | | | | | | | Consolidation of results from sub-questions | | | | |
| **Sub-Question**: What set of scientific and IQ indicators need to be studied to establish divergence from actual conditions at locations affected by development? (Indicators used for special studies should link to the watershed indicators of the permanent monitoring program) | | | | | | | | | | | | | |
| TBD | Scientific measures for water quality, quantity, flow, etc. | • Actual variability upstream and downstream of developments | | | | | | | Comparison of levels for changed baseline conditions with pre-development conditions | | | | |
| | IQ observations related to conditions of water, fish, caribou, etc. | | | | | | | | Comparison of levels for changed baseline conditions with pre-development conditions | | | | |
| **Sub- Question:** What measurements and analyses need to be studies to determine the relative contribution of climate change vs. development stressors to divergence of the baseline from actual conditions at locations affected by development? (Data collected for special studies should link to the watershed and basin data collected by the permanent monitoring program) | | | | | | | | | | | | | |
| TBD | • Measures for contribution of climate change<br>• Measures for contribution of development | • Actual conditions and variability for climate change indicators measured in Basin<br>• Predicted level of effects for development | | | | | | | • Assessment of contributions of climate change and development stressors<br>• Comparison of changed baseline levels with predictions | | | | |

# Part 4: Recommended Next Steps

Next steps required for initial implementation of the Monitoring Program and Framework over the next year are:

1. Review the proposed High Level Framework and Program Outline with partner organizations and stakeholders. Partners' and stakeholders' views and agreement are needed in order to finish the Framework. Once the Framework is considered completed, subsequent steps can be undertaken.
2. Design the Interim Baseline Monitoring Program, by populating the Framework for Phase 1, as described in Section 12 above.
3. Develop the governance elements of the Program, which are required to effectively implement the Monitoring Framework and to secure support (and eventually funding) from senior AANDC management and partner organizations. The following aspects of governance need to be established as part of the design and implementation of Phase 1 (these top priority items highlighted in *blue* in Figure 2 below):
    - Coordination arrangements – the roles and responsibilities for coordinating the program, and the multiple parties involved in the program and data collection and analysis needed to be defined;
    - Governance structures – informal roles and responsibilities established during population of the Frameworks need to be formalized. In addition to these basic functions there are a number of other roles and responsibilities involved in the Permanent Monitoring Program that need to be identified – e.g. secretariat and administrative roles, senior management and stakeholder oversight, third party advice and assurance (for science, *IQ* and QA/QC), linkage to Project-level monitoring, analysis and distribution of monitoring data, and review, monitoring and evaluation of progress. A number of different governance models and institutional arrangements have been applied in other jurisdictions; these should be considered when developing the governance arrangements;
    - Stakeholder engagement – identify which stakeholders should participate in design and implementation of the Program and Framework, and when and how they should participate. Stakeholders could include the parties identified in Section 3 that are not already involved, as well as the public and private sector. Not all of the stakeholders will be involved in development of the Framework – the number of stakeholders involved is expected to increase gradually as interest in monitoring grows;

- Integration of *IQ*, science and community and stakeholder views – best practice requires that these be integrated into the Program, and to do so they need to be addressed in the governance arrangements. A range of different approaches have been used for integrating science, *IQ* and stakeholder considerations into governance arrangements, including establishing formal arrangements with universities and academics, retaining consultants and experts, setting up technical advisory groups for *IQ* and community and scientific advice, and involving community stakeholders in everything from management oversight to data collection;

  The integration of *IQ* with science in analysis and interpretation of monitoring data is critical. *IQ* provides useful information on historic and current distribution and abundance of VECs and on the frequency and magnitude of natural disturbances (e.g. climate related events). Expressions of abundance may be relative rather than absolute measures, but this insight is nevertheless informative in assessing relative changes in the environment. As the insights from *IQ* are typically based on careful observations, they can provide valuable information with which to estimate parameters for modelling studies. They can be especially helpful in evaluating changes in the distribution of VECs over time.

4. Finally, consideration should be given to developing the Monitoring Program outlined in Part 2. The purpose of this would be to prepare information needed by senior management needs to justify additional funding. Development of the following two senior management tools is recommended:

   - Logic Model for the Program – this would involve finalization of the preliminary logic model prepared for this assignment (see figure 2 below); and
   - Results-based Management and Accountability Framework (RMAF)[14] – an RMAF is a common part of program design and funding proposals. Development of an RMAF for the Program would mainly involve consolidating the information acquired from populating the Phase 1 Framework and from designing the governance arrangements recommended above. Some additional work also would need to be done to develop the Program performance strategy and complete the governance work for the RMAF – these additional areas are highlighted in yellow in Figure 2.

[14] See http://www.tbs-sct.gc.ca/cee/tools-outils/rmaf-cgrr/guide01-eng.asp

# Figure 2: Priority Steps in Development of Aquatic Cumulative Effects Monitoring Program for Baker Lake Basin

**(DEVELOP GOVERNANCE= 1ST (blue); COMPLETE LOGIC MODEL FOR PROGRAM = 2ND (refine entire figure); DEVELOP INFORMATION FOR RMAF = 3ND (yellow))**

| **Inputs** | | | |
|---|---|---|---|
| • Initially – existing resources and partner capacities<br>• Budget increase in 3-5 years for permanent baseline monitoring program<br>• Secure long-term funding for cumulative effects monitoring program for key watersheds and the Basin ( program consists of baseline monitoring + intense monitoring of changed conditions + special studies on causes of changes) | | | |
| **Activities** | | | |
| **Program Management and Coordination**<br>• Coordination processes, mechanisms, tools<br>• Governance Structure – organizations, roles and responsibilities<br>• Links to project-level monitoring<br>• Stakeholder engagement<br>• Integration of scientific, IQ and community knowledge in program<br>• Ongoing work planning and budgeting | **Monitoring Data Collection**<br>• Design baseline data collection – VECs, indicators, sampling, protocols<br>• Implement baseline monitoring<br>• Community involvement<br>• Track scientific and TK triggers for changes in conditions<br>• Design intense monitoring for changed conditions and special studies on causes of change | **Monitoring Analysis and Reporting**<br>• Analysis approach, protocols, and tools for baseline, changes in conditions and causes of changes<br>• Technical QA/QC<br>• Integration of science and IQ<br>• Format, template, scale and presentation mode<br>• Access and distribution of analysis | **Program Review and Improvement**<br>• Design of Performance Measurement Strategy<br>• Monitoring, evaluation of progress and results<br>• QA/QC of designs and implementation<br>• Standardized of protocols and consistency of data<br>• Shifts from interim to permanent program<br>• Triggers for changes in conditions and special studies |
| **Outputs** | | | |
| Program management and coordination arrangements established | Data collection designed and implemented | Data analysis and reporting designed and implemented | Program review and improvement systems in place |
| **Immediate Outcomes** | | | |
| Program efficient– delivering on time and budget | Data collection efficient | Data analysis efficient | Improvements to program ongoing – data consistency and analysis quality |
| **Intermediate Outcomes** | | | |
| Program effective – partners supportive and collaborative, stakeholders supportive, program delivering desired monitoring data | Data collection effective - high quality & consistent data VECs/indicators suitable | Analysis and reporting effective – timely, meets user needs | Full monitoring program established, i.e.: permanent baseline monitoring, triggers for intense monitoring of changed conditions and special studies on causes<br><br>Program achieving desired quality of monitoring products |
| **Ultimate Outcome** | | | |
| Users have appropriate information to understand the aquatic conditions and trends in watersheds in the Baker Lake Basin and in local areas near development stressors and to determine the relative contribution of climate change versus developments to changed conditions near developments. | | | |

## Appendices

# Appendix 1: State of Knowledge and Best Practices – Technical Considerations

Design and implementation of watershed-based cumulative effects monitoring requires the integration of knowledge from a number of environmental management and technical fields including: environmental impact assessment (EIA), cumulative impact assessment (CEA), land use planning, environmental effects monitoring (EEM), water resource management – at local and watershed scales, compliance monitoring and crisis/spill management. However, the knowledge from these different areas has been only partially integrated for cumulative effects monitoring in watersheds and is largely focused on design and theory. Some practical watershed, basin or cumulative effects initiatives in other jurisdictions have occurred, but these provide only preliminary guidance and lessons. Thus, this appendix summarizes the extensive theoretical knowledge relevant to this assignment and provides advice on how to apply this knowledge (including design principles, identification of VECs, etc.) based on the professional judgement of the two technical experts on the team[15].

The design of environmental monitoring frameworks, regardless of their spatial scale, must be done in the context of specific questions to be addressed. Without this essential focus the results of monitoring programs are likely to fail in providing useful information for environmental management decision-making.

The design of a watershed-based framework for cumulative effects monitoring must thus be nested within and informed by the structure of a watershed-based framework for cumulative effects assessment and management. That is, the monitoring program must generate the information needed to enable cumulative effects analysis and decision making. This means providing information to:

a. confidently determine the realized (accumulated) state of valued ecosystem components (VECs) as affected by human activities (past, present, and proposed) and natural drivers; and

b. provide information to assess the pathways that link human induced stresses with VECs and their relative contribution to the overall cumulative effect reflected in the state of the VEC.

The latter information, used to isolate the contribution of individual stresses, is critical to enabling prediction of the cumulative effect on VECs when proposed new developments are added to the mix of drivers. The implication of these requirements is that monitoring should measure indicators of the state of the various pressures, indicators of the state of the VECs and indicators of selected intermediate environmental components that lie within ecological pathways that connect stressors to VECs.

[15] L.A Greig (CEA expert), and KR Munkittrick (aquatic watershed monitoring expert and head of Canadian Watershed Network).

### a. Cumulative Effects

A cumulative environmental effect is broadly understood to be the change in environmental (VEC) condition that results from the combined impact of multiple stresses (pressures) imposed by different activities or processes. In addition to natural environmental drivers, stresses that affect VECs result from human activities that may, or may not, be subject to requirements for formal EIA[16]. Cumulative effects can also result from a single activity or stress that recurs with sufficient frequency, over space or time, to overwhelm a VEC's ability to recover from prior stress before subsequent additional stresses occur, resulting in a cumulative effect.

Core elements of the understanding of cumulative effects are:

- The condition of a VEC is determined by the combination of all stresses that act on it. Thus VECs are themselves integrators of the various stresses that impact them;
- The cumulative effect experienced by a VEC includes the VEC's response to the stresses imposed;
- The accumulation of multiple small impacts that individually could be considered insignificant can result in a large unacceptable cumulative effect;
- Cumulative effects on VECs are not limited to the accumulation of direct effects, but also result from indirect effects;
- The accumulation of effects from multiple activities can be assessed at a variety of points in the environment, for example: effects on environmental processes that affect a species (VEC), effects on the quality or quantity of its habitat, effects on some physiological process of individuals of the species, or on the species population; and
- Ultimately, a key outcome of CEA is a determination of the condition of selected VECs, and the appropriate spatial frame of reference for CEA is the spatial distribution of the VEC.

### b. Cumulative Effects Assessment

Monitoring of indicators of a VEC's condition reveals its condition in the context of all the stresses that affect it. Consequently, to understand the contribution of specific human activities on VEC condition, it is necessary to isolate the contribution of the activities by comparing measurements of a VEC's condition when affected by the activities plus natural drivers with measurements / estimates of the "natural / undisturbed baseline" (the baseline) condition of the VEC (affected only by natural drivers), with the cumulative effect being the difference between the affected and baseline conditions.

[16] Canadian environmental legislation refers to cumulative effects as arising from the combined effects of multiple developments (projects). However since VECs respond to all stresses that affect them, understanding the contribution of specific projects means that it is also necessary to account for effects of natural drivers and activities that may not be subject to EIA requirements.

The baseline may be established either by estimating a historical undisturbed or relatively undisturbed condition with whatever historical data may be available or by locating reference-sites that currently remain in an ideally undisturbed state.

The literature recognizes two approaches to cumulative effects assessment (CEA):

1. A stressor-based (SB) approach that enables prediction of the potential impact of a proposed developments on the future condition of selected VECs done by isolating and modelling the processes (pathways) that translate individual stresses to changes in VEC condition, and

2. An effects-based (EB) approach (also referred to as environmental effects monitoring – EEM) that measures the realized (accumulated) condition of VECs through environmental monitoring and analysis of this state relative to a baseline condition (effects-based CEA).

The knowledge needed to predict the cumulative effect attributable to proposed future developments must be obtained from experience by monitoring development effects as part of an EIA process together with incisive effects-based CEA supported with a regional/watershed monitoring program.

In either case, the success of the approach is tied in large measure to the appropriate identification of Valued Ecosystem Components (VECs) and indicators of specific attributes of their condition. The high-level aquatic monitoring framework to be developed for the Baker Lake Basin is rooted primarily in the EB approach. At the same time, development of the framework has a secondary objective of supporting efforts to assess the potential cumulative effects of new developments through providing monitoring data that can be employed in analyses to predict the contribution of individual stressors.

### c. Watershed Cumulative Effects Frameworks

***Experience to date:***

While efforts to develop watershed CEAs, to help ensure sustainability of VECs, have been ongoing in Canada since the 1980's, no standardized approach has been accepted for monitoring cumulative effects at the river or watershed level. Currently, monitoring programs focused on how watersheds work are starting to focus on two key objectives:

1. Clarifying river system components and trends; and

2. Attribution of such trends to different stressors.

However approaches to achieve these objectives vary considerably across the various efforts undertaken to date, including the selection/definition of VECs (Ball et al., 2012). There are a number of challenges to consider in developing a standardized approach to monitoring watershed-based cumulative effects, including:

- Determining the issues of scale for watershed cumulative effects and how they can be managed;

- Exploring how reference conditions can be established to effectively account for background trends and natural variability; and
- Understanding which environmental components and indicators should be monitored and assessed for Watershed cumulative effects assessment.

Experience from current efforts to develop watershed CEA frameworks has shown that four key components for such a framework are:

1. Consistent monitoring of a core set of VECs and indicators of VEC condition at regional and local scales;
2. Watershed planning;
3. Assessment of accumulated watershed state (effects-based CEA of selected VECs); and
4. The use of stressor-based predictive models and development scenarios to explore the consequences of alternative development scenarios.

Experience also shows that worldwide, monitoring is the most deficient component (Dubé et al, in press). The Canadian Water Network consortium program has identified the following four steps for gradually moving monitoring from an EEM focused approach to a CEA focused approach, which is by its nature much more complex.

1. Develop consistent monitoring of indicators in the basin (short term)
2. Develop a series of triggers for endpoints that allow the monitoring program to adapt (medium term)
3. Develop a series of relationships that links the drivers to the responses (and provides a series of predictions for endpoints) (Long term)
4. Developing a cumulative effects assessment model (very long term)

Currently CWN is focused on step one: development of consistency in indicators, protocols, and in data collection, analysis and reporting. This is the appropriate starting point for the Baker Lake Basin monitoring framework.

***Design Principles:***

The following principles should guide the pursuit of sustainability generally and CEA monitoring design at watershed scales:

1. Appropriate Scale: Broader regional scales are required for assessment of sustainable development. In this case, the watershed is a highly appropriate unit of analysis;
2. Scientific Rigour: Core results must be peer reviewed by independent scientists on a consistent and ongoing basis;
3. Transparency: Core results must be available and communicated to ensure optimal knowledge translation, exchange, review and comment;

4. Prospective Scenarios: Sustainable watershed development is greatly enhanced using predictive scenario-based impact analysis (Duinker and Greig 2007);

5. Watershed Planning: A plan is critical to identify VECs that matter to stakeholders (and appropriate indicators of their condition), to address potential conflicts associated with multiple resource users and to develop management thresholds where further development will compromise the vision for the watershed (Henocque and Andral 2003). CEA prospective scenarios inform the watershed planning process;

- Science Linkages: Explicit relationships exist between predictive components of watershed management (cumulative development scenarios), integrated regional monitoring, and impact mitigation. For example, predictive modelling requires the empirical knowledge provided by watershed monitoring, and can greatly assist in guiding the effective design of field monitoring programs. As such, watershed management must include all elements in an integrated, consistent and systematic process;

- Sustained Commitment: Sustainability relates to the long-term future condition of social, economic and ecological systems. Thus, support for science directed toward sustainability requires stability and consistency through space and time (Greig and Duinker 2011); and

- Adaptability: Adaptive management represents a powerful paradigm to integrating prospective EIA/CEA and monitoring programs (Jones and Greig 1985).A watershed management framework inclusive of CEA must adapt in design and implementation where necessary to accommodate changes in technology, regional environmental conditions (e.g. climate change), to incorporate new scientific insights, and to improve predictive tools on the basis of comparing predicted impacts to actual changes measured through monitoring.

***<u>Framework Structure Overview:</u>***

At a very broad level, the framework for watershed-based cumulative effects monitoring in the Baker Lake Basin would include:

a statements of the goal and objectives for the framework;

a statement of scope;

a set of principles; and

a description of linked operational components for implementation of the framework.

This broad structure is in keeping with current thinking and with best practice for assessment of watershed-based cumulative effects and for integration of environmental effects monitoring (EEM) with cumulative effects assessment (i.e. Dubé 2003, Squires *et al* 2010, Canadian Water Network [CNW] watershed consortium program).

The monitoring framework should be adaptively tiered with both regional and local monitoring with regional monitoring focused on: 1) assessment of accumulated environmental state; and 2) developing functional relationships between regional system drivers[17] and environmental (VEC) response. Specifically, how much environmental change has already occurred (assessment of accumulated environmental state) and what caused the change (relationships between regional system drivers and VEC responses). Local monitoring programs are similarly focused on: 1) assessment of accumulated state as driven by both regional drivers and local drivers from development activities; and 2) development of functional relationships between local system drivers and VEC responses, accounting for the effect of regional system drivers. As discussed below, triggers are used to invoke intensified local monitoring when there are indications of a pending unacceptable cumulative effect. Figure 1, illustrates the typical relationship of regional and local monitoring components for watershed monitoring frameworks.

[17] Regional system drivers are primarily natural drivers but also include anthropogenic stresses such as climate change, long range transport of contaminants and other human activities that may occur in less developed but not pristine reference contexts.

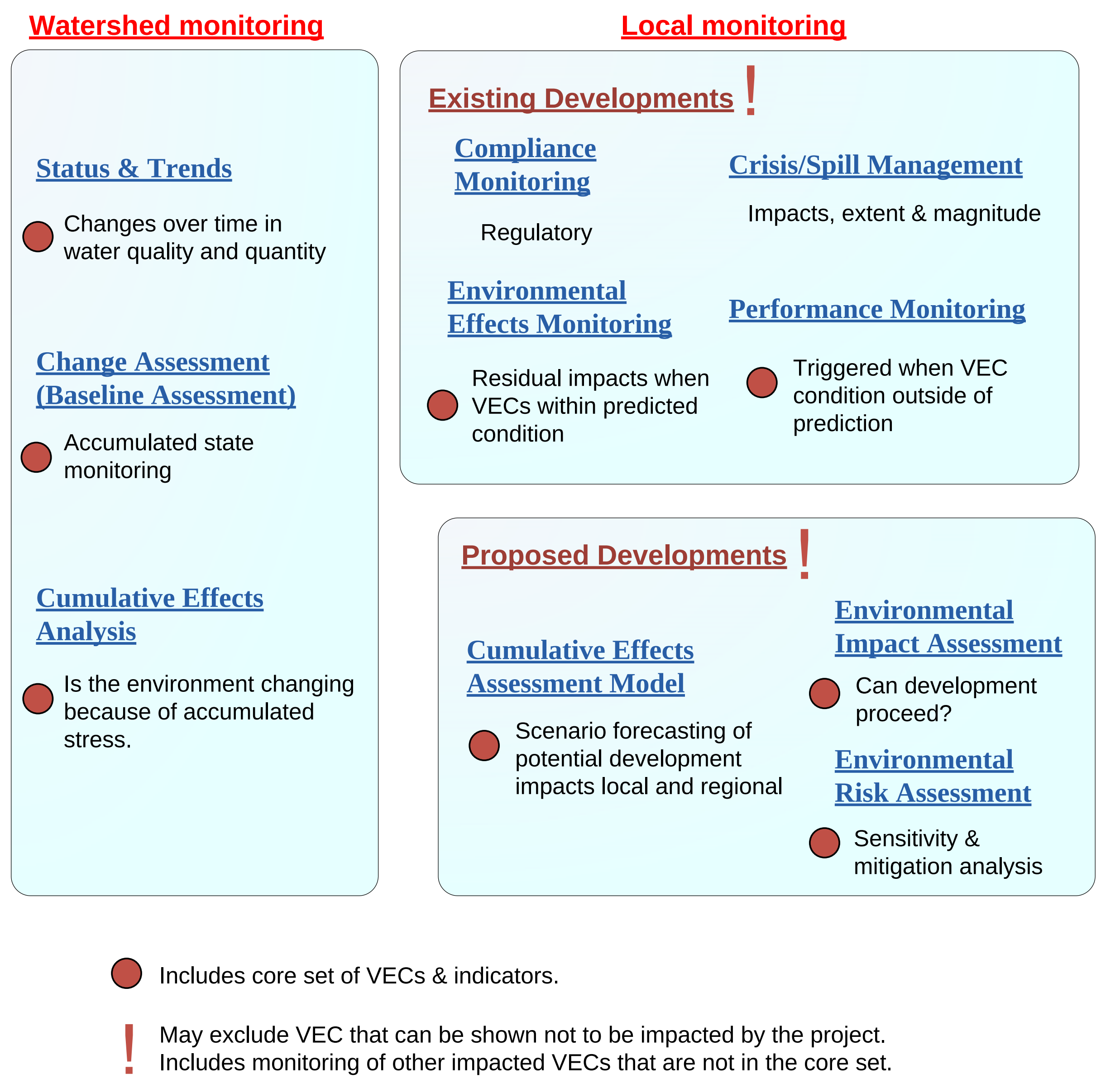



**Figure 1** Recommended relationship of regional and local monitoring components for watershed monitoring frameworks.

Driver/response relationships also form the basis for development of thresholds (i.e., how much change is sustainable and/or acceptable). Seitz et al. (2012) describe types of relational analysis between landscape scale stressors and responses for the Athabasca River generated from regional monitoring data. The work of Salmo Consulting Inc. et al. (2003, 2004) includes more thorough landscape scale driver/response relationships. Enabling the development of such knowledge is a key goal for a watershed-based cumulative effects monitoring framework.

### *d. Selection of VECs and Indicators*

VECs are the things people value in an ecosystem, i.e. what is important to them. VECs can be identified in relation to physical things (e.g. water, a fish population), ecological processes (e.g., carbon sequestration), and even abstract concepts (e.g., ecological integrity). The more abstract VECs are, the harder they are to deal with in a technical framework, so VECs should be defined a concrete entities (e.g. biotic and physical resources, ecosystem processes). Indicators are measurements that can be taken that reflect different aspects of VEC condition (e.g. for the VEC water quality, indicators may include measures of various contaminants, nutrients and physical condition such as temperature). Indicators selected must be ecologically relevant to assessing VEC response to the stresses they are exposed to, i.e. they must be responsive to the stresses. In general VECs are defined by stakeholders and also by technical experts, while indicators are usually defined by technical experts (Beanlands and Duinker, 1983).

Watershed CEA frameworks must establish a core set of VECs established that are a standard requirement for both regional and local monitoring. The selection of a core set of VECs and indicators is essential to provide scientific rigour, consistency and the ability to roll up to the higher level scales in time and space necessary for CEA. Given realistic limits on funding for monitoring it is simply not feasible to measure everything. Initially a long list of VECs may be identified by stakeholders and technical experts. However, such lists must be screened for the ecological relevance of VECs to be included in the core set. Given the requirement for a smaller core set, monitoring of the VECs selected should provide insight to potential cumulative effects on other VECs. For example where several VECs are known to be sensitive to a given driver (stress) inclusion of the most sensitive VEC may be appropriate to provide early warning of impacts (i.e. a canary in the mine strategy). With such an approach, it is feasible that a VEC included in the core set would be less valued by stakeholders than another, because it was more sensitive to stress(es) that impact the more valued VEC. A key criterion is the value of the information obtained by monitoring condition of VECs in the core set. Once VECs are identified, indicator selection is done my technical experts.

Some indicators provide superior measures of local conditions (e.g. fish species with restricted distributions), however results from the monitoring need to be relevant to VECs which may have a broader range and thus be less or more affected depending on the distribution of drivers. Any decisions about key monitoring indicators are a compromise in choices between the ecological relevance of a change, the time lag before you can detect it, the reversibility of the change, and the ability to determine the cause. Changes at the community level are highly relevant, hard to reverse, take a long time to develop, and are hard to link to a cause. At the other extreme, changes in molecular or physiological endpoints occur quickly, maybe relatively easy to reverse and easier to link to a cause, but are not very relevant ecologically. Monitoring at the community level accepts that there are many easier to reverse changes that would have been detectable earlier than you would detect a community change. Monitoring at the physiological level means that there are many changes you can detect that may not translate into effects at higher levels of organization. Artful design of a watershed monitoring framework needs to consider an appropriate balance between community and physiological level indicators.

A recent stake of knowledge review of the state of VECs identified within Nunavut the Nunavut General Monitoring Plan dealt with approximately 50 bio-physical VECs (e.g. water quality and quantity, groundwater; geophysical/geochemical conditions; avian, terrestrial and aquatic biota) that could occur within the watersheds in the Baker Lake Basin. For a watershed monitoring framework selection of VECs should focus on water, the physical substrate / structure of rivers, and selected aquatic biota. Selection of indicators of water condition should pay attention to identification of indicators that have relevance to estimating condition of biotic VECs, including those that may not be part of the core set of VECs. For example, CEA for caribou (whose range will likely extend well beyond watershed boundaries) will require substantial additional information beyond that collected in a watershed context. However, with climate change a significant driver within the Baker Lake Basin, knowing river velocity and depth at caribou river crossings during migration may be important for CEA of caribou.

### *e. Identification of Ecologic Thresholds, Management Limits and Triggers*

Ensuring sustainability of VECs requires maintaining them in a condition that is consistent with their resilience, for example for biotic VECs maintaining a population size that can be sustained through natural reproduction in the context of natural environmental variation without risk of population collapse. In this context an ecologic threshold of species abundance would equate to a population level below which there was a likelihood of population collapse given additional stress from human activities or natural drivers. While there are modelling approaches for estimating thresholds it is often the case that they are not known with confidence.

Management (reference) limits are values that are set in consultation with stakeholders to establish levels of acceptable risk[18], and informed by scientific analysis that provides estimates of safe limits for selected indicators. Management limits are set conservatively relative to estimates of ecologic thresholds, and define indicator values that when reached require a management response to limit further stress on a VEC.

Triggers are analogous to management limits and signify that there is a cumulative effects problem at a particular monitoring site within a local development monitoring area. They are set as predefined deviations from the baseline-reference condition, for example 1, or 2, standard deviations from baseline mean values for a given indicator, and should be set conservatively relative to management limits.

Triggers are used to invoke an adaptive response with more intensive monitoring in a local context to characterize a cumulative effect problem, including when necessary expansion of the local monitoring program design to better characterize the specific stresses that are causing a problem. A tiered/triggered adaptive monitoring design at the local level provides for reduced intensity of monitoring until such time as it is necessary to effectively manage a specific problem. Setting triggers also takes account of the specific character of stresses associated with human activities occurring in a local context.

Ecologic thresholds, management limits and triggers are all functions of the environmental context (e.g. physical ecosystem condition and productivity and characteristics of VECs such as absorptive capacity, or reproductive strategy). They are not in themselves characteristics of development activities. However, when the relationship between a stressor from a particular human activity and the VEC response is known (e.g. dose response to a contaminant) it is convenient and common practice to set stressor-based management limits. From a cumulative

[18] Also referred to as limits of acceptable change.

effects perspective, stressor-based management limits should be in the form of ambient standards or total loadings.

If not already known for the VECs selected for the Baker Lake Basin monitoring framework thresholds and management limits will need to be defined. Some information may be available from other jurisdictions, with analogous ecosystem condition and patterns of development, to assist with defining these values. Triggers are defined for areas where development is occurring and take account of both characteristics of the VECs and characteristics of the specific stresses imposed by the activities. In particular, indicators selected for setting triggers must be responsive to the stresses imposed.

### *f. Identification of Drivers (Stresses)*

In watersheds, and elsewhere, VECs and their associated indicators respond to a range of drivers, some of which are natural (e.g. temperature, rainfall/drought, fire) and many of which are associated with human activities. The point of a stressor-based CEA for proposed new developments is to be able to identify which human activities, if implemented within the watershed, will be compatible with sustaining VECs within acceptable limits, and those that should be avoided due to unacceptable effects. In addition to identifying stresses imposed by human developments this requires identifying all of the natural drivers that affect VEC condition.

### *g. Reference Sites to Establish a Baseline Condition*

Reference sites provide the basis for comparison of VEC condition under different mixes of stress. In general the mix of overlapping stresses from both natural drivers and human activities differs across the landscape. For cumulative effects analysis, reference sites provide the basis for developing a baseline condition (determined by natural drivers only or natural drivers and other human disturbances) for comparison with sites that are also affected by a particular development activity.

The choice of location of reference sites is a function of their purpose. In a watershed context, reference sites are generally used in two ways: 1) to characterize the range of natural conditions and natural variation within a watershed, and 2) as a frame of reference for comparison with sites impacted by human activity. In the first case sites are located to provide insight into the range of conditions (e.g. on different tributaries, different parts of the main stem, up/down stream of natural influences such as areas where melting permafrost may influence water quality).

In the second case, where the comparison between reference sites and an impacted site is done to try to isolate the effect of a particular stressor, sites are identified to be as similar as possible in other respects to site characteristics at the impacted site, such as: hydrology, physical structure (e.g. habitat characteristics such as substrate composition), and biotic VECs/indicators (e.g. fish species, invertebrates). Ideally the impacted and reference sites differ only with regard to the presence of the human activities that influence the impacted site. In reality the sites will not be identical in other respects and it may be necessary to characterize the range of natural variability with multiple reference sites. It is not essential that such sites be located high in the watershed.

Determining where in space and time to measure / estimate the baseline is a substantial challenge as in many contexts there remain few, if any, locations where an undisturbed condition exists. Where there are not sufficient data to establish a historical baseline and no completely undisturbed sites, current practice is to identify sites that are relatively less affected by human activity in order to provide contrast to assess the incremental contribution of human activity to the overall cumulative effect. The process for identification of sites is thus driven by identification of criteria for site selection (driven by the purpose for the sites) and screening of candidate sites in progressively greater detail (Mrazik 1999; Chaves et al., 2006; Stoddard et al. 2006; Nelitz et al., 2007; Perrin et al., 2007).

### *h. Boundaries – Time and Space*

Practical temporal and spatial boundary conditions must be established in any systems analysis, as well as how the analyzed domains of time and space will be resolved into smaller units, suitable for analysis. The outer bounds are termed the extent, and the inner bounds the resolution (Duinker and Baskerville 1986). For CEA the spatial extent should be defined according to the spatial extend of the VEC. For example, for CEA of the impacts on a fish population that resides wholly within a single watershed the spatial extent of the analysis would be the area within the watershed where the population resides. This could be the entire watershed or some portion of it. For example, for migratory birds subject to stresses in areas of their range outside the Baker Lake Watershed, understanding their overall condition (e.g. population abundance) will need to account for impacts (e.g. direct mortality, or habitat loss) that occur elsewhere.

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# Appendix 2: State of Knowledge and Best Practices – Governance and Management Considerations

### a. Lessons Learned

A review of case studies of environmental and cumulative effects monitoring in Alberta (with special attention to the oil sands), of cumulative effects monitoring in the Mackenzie Valley, Northwest Territories (the NWT Cumulative Impacts Monitoring Program), and of community-based environmental monitoring in Yukon, Alaska and the NWT (the Arctic Borderlands Ecological Knowledge Co-op), conducted as part of the current project, identified a number of significant issues related to environmental and cumulative effects monitoring programs. Most of these issues appear to be recognized, at least in principle, by the Nunavut General Monitoring Program (NGMP), most notably in the NGMP's 2010-2015 Strategic Plan. How effectively these key issues are addressed by the NGMP generally, and specifically with regard to the design, development and implementation of a framework for watershed-based cumulative effects monitoring in the Baker Lake basin, will be a key determining factor in the overall success of this initiative.

Environmental and cumulative effects monitoring in Alberta has been largely driven by public concerns that have focused on the failure of cumulative effects management in northeast Alberta and the oil sands. Major reviews of the state of practices and recommendations for best practices (which the Government of Alberta is publicly committed to meeting) were conducted by the Royal Society of Canada (2010), the federal Oil Sands Advisory Panel (2010), the Report of the Alberta Environmental Monitoring Panel (2011), and the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring (2012).

The NWT Cumulative Impacts Monitoring Program (NWT CIMP) was established under the Mackenzie Valley Resource Management Act (1998) and has been the subject of several independent reviews, most recently in the 2011 NWT Environmental Audit and the 2009 report of the Mackenzie Gas Project Joint Review Panel.

The Arctic Borderlands Ecological Knowledge Co-operative was established to record community-based observations of certain ecological conditions in the range of the Porcupine caribou herd. Reviews of the program have been conducted and reported by the Co-op and its partner organizations.

The key issues and recommendations from these programs and reviews, which are applicable in whole or in part to development of a watershed-based monitoring program for Baker Lake basin, are consolidated under two general categories and outlined briefly below.

*Organizational Requirements for Monitoring, Evaluation and Reporting*

All of the programs listed above have been chronically underfunded and under-resourced to meet their objectives and outcomes. Piece-meal funding has contributed to *ad hoc* design and fragmented programming. Long-term sustainable funding is a critical element in designing, developing and implementing a monitoring system and programs within it. Industry has a role in providing long-term funding support to cumulative effects monitoring program, and funding requirements demand participation of industry.

Scientific direction has been weak, lacking in the oversight of monitoring, evaluation and reporting activities, resulting in an inability to:

- identify critical knowledge gaps that prevent meaningful long-term monitoring and effective adaptive management;
- provide sufficient feedback to evaluate and improve monitoring methods;
- establish meaningful environmental baselines and reference conditions, particularly in advance of development and associated impacts.

Rigorous scientific advice and direction should be fully integrated into the design, analysis, evaluation and reporting components of monitoring.  Establishment of a standing scientific advisory body, for example, could adequately address this need.

Traditional aboriginal knowledge, local knowledge and community observations are an important element of monitoring and, like scientific knowledge, should be fully integrated within the broader monitoring program and not limited to a supplementary or satellite component to it.

Many monitoring programs are static and are not responsive and adaptive to environmental change, local and regional needs, evolving scientific knowledge and advances in technology. This greatly diminishes the value of the data they collect.

Inadequate attention to framework and program design, and a narrow and short-term fixation on immediate data needs have contributed to “data dumping” – i.e. collection and inclusion of data that is inadequate for analysis and insufficient or unreliable for adequately informing management decisions.

Data must be relevant to the needs of those who rely on it to inform their decisions and management, and to address public concerns.  This can be challenging as management and regulatory needs and may not be consistent or overlap with areas of local concern and public interest.

Well-defined linkages between institutions and regulators and a monitoring program’s data “products”, reports and deliverables must be well-developed for the latter to have an effect.

The achievement of cumulative effects management outcomes as expressed through regional land use plans and policy instruments, such as regional thresholds with triggers, need to be validated by data and information produced by an integrated environmental monitoring, evaluation and reporting system.  To date there is little evidence that managers, planners and regulators have relied upon or even use regional scale monitoring data and information.

A widespread view exists that environmental monitoring, evaluation and reporting systems must be independent of government, industry and special interests for the public to have confidence in the system and in the information and reports that it produces.  Whatever the system of governance that is established, it is essential that legitimacy, transparency, credibility, accountability and accessibility be the watchwords that inform the principles on which the system is based and for how the system functions.

Ongoing review and evaluation of the monitoring system and program are critical to correcting design flaws and operational shortcomings and failings, and for establishing overall confidence in the reliability and rigour of the system and program.

*Data Acquisition, Management, Evaluation and Reporting*

A propensity for generating long lists of valued components (VCs) and associated indicators for monitoring appears to have established this as an end unto itself and has obscured the need for critical evaluation of the utility of identified VCs and associated indicators relative to “user” needs and program purposes. Indicators are measures of the condition and sustainability of a chosen VC, and define the very character of the VC. However, little attention is paid to establishing and applying clear criteria for the selection of indicators that are scientifically robust, user-friendly and straight-forward to interpret. Criteria for indicator selection could include such considerations as: data availability, data affordability, ease of measurement, robustness, and scalability.

A narrow fixation on data acquisition exists at the expense of analysis, evaluation, reporting and communication, with the consequence that data does not inform decision-making, data acquisition becomes an end unto itself and stakeholder interest and support is undermined. Each of these elements in a monitoring program must be linked and integrated within program design and organization in order for the program to be fully functional.

Transparency as a basic principle of a publicly acceptable monitoring system rests on accessible, comparable and quality-assured data – essential conditions that to date have been largely absent.

The use of traditional knowledge in monitoring programs continues to lag behind the use of science-based information in monitoring. Community-level observations can provide special insight into unusual events and occurrences that may refocus monitoring efforts or provide grounds for special studies.

Standards and methods for the collection of traditional knowledge (TK) and local knowledge (LK) and community observations vary widely, if they exist at all, often making this information of limited value or undermining the confidence that users of the information can place in it. Protocols for the collection, validation and treatment of TK and LK would assist in addressing this shortcoming.

Attention to analysis and evaluation of monitoring data has suffered greatly and has hindered insights into relationships of causality and correlation between stressor effects and environmental conditions. Cause-and-effect relationships are often complex and evaluation activities must take into account uncertainties in order to reveal problems that must be addressed. Evaluation work can also serve to address environmental concerns where there is little or no cause and effect. The evaluation process can be extremely challenging scientifically and requires careful integration of scientific insight, statistical analysis, treatment of uncertainty, and process-based modeling. Monitoring data are needed across a range of spatial scales to support innovative analysis, applied research and/or specialized monitoring to answer specific short-term and long-term priority management questions, and this approach should receive attention in the design of monitoring systems.

The timing and frequency for reporting of monitoring results to the appropriate "users" (planning boards, wildlife management boards, regulators, etc.) should be driven by identified needs of these users.

### b. Institutional Arrangements Under the Nunavut General Monitoring Program (NGMP)

The NGMP's Strategic Plan 2010-2015 (SP) describes the governance model and approach for the development and implementation of the NGMP. The NGMP's Strategic Plan assumes a common regime for the monitoring of all lands and waters within Nunavut (including Inuit Owned Lands), and describes in general terms it describes the various partners with a stake in the program. The core governance structure includes a Steering Committee, Constituency Committees, Partner Advisory Groups, Expert Advisory Groups and the NGMP Secretariat. In addition, other interested parties include a long list of stakeholders and monitoring experts and organizations.

The Strategic Plan identifies a number of general tasks and areas of collaboration, many of which anticipate the need to address some of the challenges identified above in the discussion of *Lessons Learned* from other monitoring programs. However, how this will be accomplished in practical terms is not clarified within the Plan.

Given the large number and broad range of institutional actors participating in the NGMP, the implementation of the NGMP's general program of work faces a major challenge in designing and developing a Nunavut-wide program which depends heavily on "getting it right" at the outset. Moreover, how the core group is deployed will have a critical bearing on the design, development and implementation of a cumulative effects monitoring system for the Baker Lake basin and linkages to Nunavut-wide monitoring.

### c. Significant Management Issues to Be Addressed in the Baker Basin Framework

There are a number of significant management issues which must be addressed in developing a framework for aquatic cumulative effects monitoring in the Baker Lake basin. The specific management issues related to development of a framework for the Baker Lake basin are:

Link with the Nunavut General Monitoring Plan.

Funding of the regional scale Baker Lake framework component by government(s), with contributions from and an ongoing role for industry.

Application of the NGMP Strategic Plan institutional framework to the design, development and implementation of the Baker Lake framework, with special attention to the participation and role of the Steering Committee (notably AANDC and NTI), Constituency Committees, Partner Advisory Groups, NGMP secretariat, Expert Advisory Group, and to the links with NIRB, NWMB and Kivalliq Region organizations.

The initial and ongoing role of science and traditional knowledge-based expertise in program design and development.

Collaboration between proponents and governments, and options for inputs from proponents, in the design of local extensions of the framework and the application of protocols to promote consistency in the use of core monitoring endpoints, the use of regional VECs and indicators, and quality control and quality assurance of data.

Collaboration with research institutions to promote research that supports core monitoring elements and endpoints, and consistency in data quality.

Selection of VECs and monitoring endpoints for new developments. Given the diverse nature of development projects and their environmental effects, each development will affect different VECs. There needs to be reasonable consistency, however, in the definition of VECs and associated indicators across developments of the same type, and possibly across types of developments. Establishing this consistency may generate a need to backfill assessment at regional reference sites.

Development of VEC-specific criteria for identifying preferred indicators (measurements) of VEC conditions.

Clear guidance with respect to who, how and when monitoring data will be analyzed and reported.

The role, use and application of community-level observations within the framework.

Outcome linkages and reporting to NIRB, the Nunavut Planning Commission and regulators and to stakeholders, within the context of the Keewatin Land Use Plan, the draft Nunavut Land Use Plan and NIRB's Cumulative Effects Referral Criteria).

Ongoing testing and evaluation of the effectiveness of the framework and monitoring program(s).

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# Appendix 3: Knowledge of Watershed Conditions and Availability of Existing and Historic Monitoring Data for Baker Lake Basin

The extent of monitoring related to the aquatic environment within the Baker Lake watersheds has been limited, being primarily focussed on mining development and the Hamlet of Baker Lake. In many cases, concentrations of measured substances have been below detection limits. In addition, monitoring has been completed by a range of private, public and academic sector entities, using different analytical laboratories and potentially differing sample collection, handling and analytical methodologies.

Past monitoring studies and research programs relevant to the aquatic environment have included work on:

- Weather
- Freshwater ice regime
- Snow cover;
- Permafrost;
- Hydrological regime;
- Water quality;
- Sediment characteristics and sediment quality;
- Aquatic Biological Monitoring
- Contaminants resulting from long-range transport
- Populations of terrestrial wildlife that have close interactions with the aquatic environment

Monitoring that has been conducted in relation to the aquatic environment is summarized in Table 3-1 below with respect to categories of VECs, indicators, parameters categories and relevance / considerations.

The historical monitoring programs have for the most part indicated that effects from development projects and the Hamlet of Baker Lake tend to be fairly localized, which, considering the size of the area, minimizes the likelihood of overlapping, synergistic effects. Under such circumstances, if monitoring shows that effects do not extend beyond a given source, then the need for broader monitoring of cumulative effects is reduced. The exception to his premise could be radionuclides from uranium mining, particularly if and when more mines are developed.

Important and overriding stressors on the aquatic environment of the Baker Lake watersheds originate with climate change. As a stressor, climate change can affect precipitation, the hydrologic regime, permafrost, ice regime, as well as the life cycles of biological components of the aquatic environment. There is a need to understand theses stresses and the response of the aquatic environment to them, in order to put into context changes that may be detected when monitoring effects from development activities. Enhancing this understanding suggests a need to consider whether the existing hydrometric network within the watersheds is appropriately integrated with other activities to monitor cumulative effects.

A large part of *Inuit Qaujimajatuqangit* collected from residents of the Baker Lake area is from Cumberland Resources and AREVA, in connection with the Meadowbank and Kiggavik projects respectively. These traditional knowledge studies were sound in methodology, but the questions asked of Inuit interviewed were geared mostly towards wildlife rather than to the specifics of the aquatic environment of the Baker Lake watersheds area. Other studies focused on Inuit observations of climate change, do contain some references to changes in freshwater ice and water levels as a result of the impacts of climate change.

Further research will be required to obtain relevant IQ knowledge that could contribute to understanding of baseline data and changes to the aquatic environment of the Baker Lake watersheds area. While the methodology used by past studies to collect IQ is sound, it will be critical in the future to ensure that the right questions are asked in order to acquire the most relevant traditional knowledge available on the aquatic environment. It will also be important to clearly identify the reasons why gathering IQ knowledge on the watershed area is important, and help community members understand that historical information will help provide important baseline data for comparison with future data as resource development progresses in the watershed area.

This summary of historic monitoring activities brings into focus some important considerations for the management of any future initiative to monitor cumulative effects. These considerations include the need to:

- define, to the extent appropriate, common parameters, methodologies, detection limits, QA/QC protocols and metadata requirements;
- integrate the complementary information from IQ and from monitoring based on western science;
- establish the degree of change to be detected and statistical design to detect such change;
- establish a common repository for monitoring data and accessibility to the data; and
- conduct regular and timely reviews of collected data to ensure intercomparability and utility.

These needs emphasize the critical requirement for stakeholder and community involvement in planning, implementing and interpreting monitoring programs, along with the need for open, defensible and clearly rationalized decision-making. Future monitoring of the aquatic environment of the Baker Lake watersheds should be conducted in a coordinated fashion that includes full community and stakeholder engagement, builds capacity at the community level, and gives residents a sense of ownership and responsibility for ensuring the health of the aquatic environment.

**Table 3-1. Monitoring Conducted in Relation to the Aquatic Environment of the Baker Lake Watersheds.**

| VEC Category Monitored | Indicators | Parameter Categories | Relevance / Considerations |
|---|---|---|---|
| **Weather** | Temperature<br>Precipitation<br>Visibility | Temperature trends<br>Rain, freezing rain, snow amounts and relative annual contribution<br>Wind speed and direction<br>Fog, ice fog | Weather parameters provide useful indicators relevant to other aquatic VEC indicators/ parameters including:<br>- ice cover<br>- mixing which affects water quality<br>- water quantity, flows, water levels, hydrograph<br>- erosion and input of sediments and contaminants<br>- permafrost<br>- long range transport of pollutants<br>Weather is monitored at locations where air transportation is required (e.g., Baker Lake, mine development site), and can be applied more broadly. |
| **Freshwater Ice** | Ice cover<br>Ice thickness<br>Freeze-up/Break-up dates<br>Ice colour<br>Ice Condition | Extent of ice cover including:<br>- Freeze-up/Break-up dates<br>- Ice thickness, particularly in relation to travel safety | Ice cover is important :<br>- at watercourse crossing points for wildlife (i.e., caribou)<br>- along routes routinely used by wildlife harvesters<br>- along winter road alignments |
| **Snow Cover** | Amount of snowfall<br>Spatial distribution of snow fall<br>Season distribution of snow fall<br>Frequency of blowing snow<br>Relationship to freezing precipitation events<br>Snow cover duration | Amount of snowfall<br>Spatial distribution of snow fall<br>Season distribution of snow fall<br>Frequency of blowing snow<br>Relationship to freezing precipitation events<br>Snow cover duration | Snowfall data are important for interpreting trends in other VECs, including:<br>- hydrology;<br>- freshwater ice; and<br>- surface water quality. |
| **Permafrost** | Thickness of the active layer<br>Thaw subsidence<br>Presence of thermokarst<br>Development of talik | Relation to surface and groundwater regime<br>Relation to integrity of wastewater containment facilities (sewage lagoons, mine tailings ponds) | Useful in interpreting change in the hydrological regime.<br>Useful in predicting potential stressors (e.g., tailings release due to tailings dam failure, slope failure and sediment pollutant release along a linear development) |

| VEC Category Monitored | Indicators | Parameter Categories | Relevance / Considerations |
|---|---|---|---|
| **Hydrological Regime** | | Water levels<br>Flows<br>Timing in the annual hydrograph | Essential for interpreting observed change in other VECs.<br>Essential in planning and managing developments (e.g., tailings impoundments, hydroelectric developments). |
| **Surface and Groundwater Water Quality** | Statistically significant change in water quality parameters | Temperature<br>Dissolved oxygen<br>Inorganics (alkalinity, colour, conductivity, pH, TSS, TDS, Turbidity)<br>Nutrients<br>Major ions<br>Organics (petroleum hydrocarbons, cyanide)<br>Trace metals<br>Radionuclides<br>Persistent organic pollutants (POPs) subject to long range atmospheric transport | While these categories of parameters are, or have been monitored, detecting meaningful change for some categories of parameters (e.g., organics, trace metals, radionuclides, POPs) can be challenging. Key considerations include:<br>- baseline concentrations can be very low and below the level of detection by routine laboratory analytical methodologies;<br>- such low concentrations mean that sample contamination and variance in methodologies between parties can result in data that are artifacts or potentially meaningless;<br>The above considerations dictate a need for careful parameter selection and rigorous inter-laboratory inter-comparability verification and QA/QC.<br>Given the spatial distribution of developments that give rise to inputs affecting water quality, changes in certain particular contaminants (e.g., petroleum hydrocarbons, cyanide, trace metals, radionuclides) can be quite localized to those inputs. Broad-scale monitoring may not be necessary or appropriate for parameters/locations where there is no detectable change within a localized area. |
| **Sediment Characteristics and Quality** | Particle size distribution<br>Carbon content<br>Presence of pollutants | Moisture<br>pH<br>Total organic carbon<br>Particle size distribution and proportion of fine sediments<br>Hydrocarbons<br>Polycyclic aromatic hydrocarbons (PAHs) | While the challenge may not be as great as for water quality, detecting meaningful change for some categories of parameters in sediments (e.g., organics, trace metals, radionuclides, POPs) can be challenging. Key considerations include:<br>- concentrations can vary depending upon particle size and organic content; |

| VEC Category Monitored | Indicators | Parameter Categories | Relevance / Considerations |
|---|---|---|---|
| | | Trace metals<br>Radionuclides<br>Persistent organic pollutants | - baseline concentrations can be very low and below the level of detection by routine laboratory analytical methodologies;<br>- baseline concentrations are highly affected by the mineralization of the sediment particles, which generally reflects mineralization of the surrounding rock;<br>- such low concentrations mean that sample contamination and variance in methodologies between parties can result in data that are artifacts or potentially meaningless;<br>The above considerations dictate a need for careful parameter selection and rigorous inter-laboratory inter-comparability verification and QA/QC.<br>Given the spatial distribution of inputs, changes in certain particular contaminants (e.g., petroleum hydrocarbons, cyanide, trace metals, radionuclides) can be quite localized to the inputs. Broad-scale monitoring may not be necessary/appropriate in cases where there is no detectable change within a localized area. However, sediment can be a useful integrator of broadscale changes, provided that sample station selection is appropriate and standardized. |
| **Aquatic Biology** | Aquatic vegetation quality | Vegetation quality<br>- concentrations of trace metals and radionuclides in macrophytes<br>- also represented as fish habitat | Aquatic biology monitoring is driven by the potential effects on the aquatic environment likely to be at risk of change and the life-cycle biology of potentially affected species, particularly fish species.<br><br>Monitoring contaminants in tissues is subject to the same considerations regarding sampling, sample contamination, intercomparability and QA/QC, as outlined above with respect to water and sediment. In the case of monitoring contaminants in fish tissues, fish size, age, |
| | Benthic invertebrate abundance and diversity | Benthic invertebrates<br>- abundance, species present and community structure<br>- also represented as fish habitat | |
| | Fish and fish habitat | Fish and fish habitat<br>- species present, spatial distribution, | |

| VEC Category Monitored | Indicators | Parameter Categories | Relevance / Considerations |
|---|---|---|---|
| | | timing of life cycle functions (e.g., spawning, migration) and abundance (Arctic grayling, burbot, cisco, lake trout, lngnose sucker, ninespine stickleback, round whitefish, slimy sculpin, Arctic char)<br>- fishing pressure and harvest data<br>- fish habitat characteristics within the zone of influence of developments, including water quality, sediment quality, hydrology<br>- lethal and sub-lethal toxic effects, including bioaccumulation of contaminants and fish health | condition and fat content (for organic contaminants) are also important parameters to incorporate into the analysis. |
| | Bioaccumulation of contaminants in aquatic biota | Tissue (flesh, bone, liver) concentrations of:<br>- ash and percent moisture<br>- trace metals<br>- radionuclides | |

# Appendix 4: Documented and Anticipated Stressors and Vulnerabilities on the Aquatic Environment of the Baker Lake Watersheds

The Baker Lake watersheds constitutes a very large area with extremely sparse population beyond the vicinity of the Hamlet of Baker Lake. The most apparent stressors on the aquatic environment within the watersheds include those related to mining exploration and development, as well as the Hamlet of Baker Lake itself. For the most part the effects of these stresses are relatively localized.

A summary of stresses in relation to components of the environment is presented below in Table 4-1.

**Table 4-1: Summary of Stresses and Related Environmental Components**

| Components of the Environment | Related Stressors |
|---|---|
| Weather – temperature, precipitation, visibility | Climate change<br>Natural cycles and events |
| Freshwater ice | Climate change<br>Hydroelectric development<br>Natural cycles and events |
| Snow cover | Climate change<br>Natural cycles and events |
| Permafrost | Climate change<br>Natural cycles and events |
| Hydrological regime | Climate change<br>Hydroelectric development<br>Mine development and operation (principally open pit, tailings pond)<br>Natural cycles and events |
| Surface and groundwater quality | Mining exploration<br>- *Inorganics (alkalinity, colour, conductivity, pH, TSS, TDS, Turbidity)*<br>- *Nutrients*<br>- *Major ions*<br>- *Organics (petroleum hydrocarbons, cyanide)*<br>- *Trace metals*<br>- *Radionuclides*<br>Mine development, operation and closure<br>- *Temperature*<br>- *Inorganics (alkalinity, colour, conductivity, pH, TSS, TDS, Turbidity)*<br>- *Nutrients*<br>- *Major ions*<br>- *Organics (petroleum hydrocarbons, cyanide)*<br>- *Trace metals*<br>- *Radionuclides*<br>Hamlet of Baker Lake<br>- *Wastewater management and disposal* |

| Components of the Environment | Related Stressors |
|---|---|
| | - *Solid waste disposal*<br>Government activities<br>- *Organics (petroleum hydrocarbons, cyanide)*<br>Linear developments<br>- *Organics (petroleum hydrocarbons)*<br>Transboundary aquatic stressors<br>Long range transport of air pollutants<br>- *Mercury*<br>- *Persistent organic pollutants (POPs)*<br>Natural cycles and events |
| Sediment characteristics and quality | Mining exploration<br>Mine development, operation and closure<br>Hamlet of Baker Lake<br>- *Wastewater management and disposal*<br>- *Solid waste disposal*<br>Linear developments<br>- *Sediment size*<br>- *Organics (petroleum hydrocarbons)*<br>Government activities<br>- *Organics (petroleum hydrocarbons)*<br>Transboundary aquatic stressors<br>Natural cycles and events |
| Aquatic biology<br>- Aquatic vegetation quality<br>- Benthic invertebrate abundance and diversity<br>- Fish and fish habitat<br>- Bioaccumulation of contaminants in aquatic biota | Mining exploration<br>Mine development, operation and closure Hamlet of Baker Lake<br>- *Wastewater management and disposal*<br>- *Solid waste disposal*<br>Hydroelectric development<br>Government activities<br>- *Organics (petroleum hydrocarbons)*<br>Fish and wildlife harvesting<br>Linear development<br>- *Organics (petroleum hydrocarbons)*<br>- *Suspended solids and sediment deposition*<br>- *Interference with fish passage*<br>Transboundary aquatic stressors<br>Long range transport of air pollutants<br>- *Bioaccumulation of POPs, mercury, etc.*<br>Natural cycles and events |

Stresses related to mining are currently linked with the operating Meadowbank Gold Project, with potential stresses associated with the proposed Kiggavik Uranium Mine and with a proposed Aberdeen-Turqavik Uranium Project. These stresses are situated in the lower reaches of the Baker Lake watersheds, relatively close to Baker Lake itself. Mining exploration is, however, more widely distributed within the watersheds. Stresses related to mining tend to be relatively localized, although there are concerns about more widespread stresses associated with radionuclides from mining and potentially cumulative effects across multiple uranium related projects and activities.

Stresses associated with the Hamlet of Baker Lake relate to potential hydrocarbon spills, sewage treatment and disposal and solid waste disposal. In addition, fish and wildlife harvesting by residents and people operating out of Baker Lake constitute the most meaningful stress on fish as well as wildlife populations that relate to the aquatic environment. Lodges also contribute to these stresses.

As an overriding stressor, climate change has the potential to induce important cumulative changes in the aquatic environment within the Baker Lake watersheds. These potential changes that can have important implications for the hydrological regime in the watersheds, include changes in precipitation; the permafrost regime with resultant changes in soil porosity, ice regime, water flows, and timing within the hydrologic cycle. These stresses can also affect the biological environment and can act cumulatively with stresses from development. These broader climate change stresses are not specifically project-related, but will need to be monitored and understood through broader climate change research initiatives in order to place cumulative effects from development in a proper context.

# Appendix 5: Information Contributions and Capacities of Agencies Involved in Monitoring Activities in Baker Lake Basin

| Data Contributions and Capacities of Agencies Involved in Monitoring in Baker Lake Basin | | |
|---|---|---|
| **Agency** | **Information/Data Contributors** | **Capacity for Analysis and Expert Advice Based on Meadowbank Project Certificate** |
| **Federal Government** | | |
| Aboriginal Affairs and Northern Development Canada (AANDC) | • *Water Resources*<br>o Licence operations and changes<br>o Compliance monitoring data (e.g., mining exploration and operations, communities)<br>• *Land Administration*<br>o Land Use Permits issued and associated environmental effects and monitoring requirements<br>• *Mineral Resources*<br>o Staking activity<br>o Exploration Permits issued and associated environmental effects and monitoring requirements<br>• *Nunavut General Monitoring Plan*<br>o Monitoring of the long-term state and health of the ecosystemic and socio-economic environment in Nunavut Settlement Area<br>o AANDC is the lead federal department responsible for implementing the NGMP, and supports the NGMP Secretariat office and staff. The GN and NTI are key partners. | Monitoring terms and conditions of water license and Surface Land Lease and Quarrying Permits<br><br>Advice on policies and guidelines related to Territorial Water and Land Regulations, review of water quality monitoring results related to water license, including receiving water assimilative capacity water quality assessment<br><br>Advice on policies and regulations for management of terrestrial ecosystem (along with GN and EC).<br><br>NGMP is not referenced in Meadowbank 2006 project certificate because the current organization did not exist until 2010.<br><br>NGMP aims to support, facilitate and coordinate the collection, analysis, management and dissemination of information regarding long term state and health of environment |
| Environment Canada (EC) | • *Meteorological Service of Canada (weather data)*<br>o Temperature<br>o Rainfall<br>o Snowfall<br>o Ice cover including freeze-up and break-up data<br>o Greenhouse gas concentrations<br>• *Water Survey of Canada* | EC – review of records of MMER monitoring kept at mine site, groundwater monitoring data, climate change monitoring and modeling, monitoring of environmental effects in receiving environment, emergency response and spill |

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| | o Hydrological data<br>o Water quality data (limited, location specific)<br>o Sediment characteristics data (limited, location specific)<br>o Benthic data (limited, location specific)<br>• *Environmental Protection*<br>o Water quality data (limited, location specific)<br>o Sediment characteristics and quality data (limited, location specific)<br>o Benthic data (limited, location specific) | contingency plans<br><br>General advisory services: review of the results of monitoring under EC jurisdiction; i.e.: water quality monitoring for Section 36 of Fisheries Act, air quality monitoring, migratory birds monitoring, monitoring of species at risk |
| Fisheries and Oceans Canada (DFO) | • Fish populations, fishing activity levels and fish health<br>• Water quality data (limited, location specific)<br>• Sediment characteristics data (limited, location specific)<br>• Lodge operations<br>• Benthic data (limited, location specific) | Advice on policies for management of fish habitat, freshwater intake, end of pipe fish screen guidelines. Also advice on creel survey methodology and interpretation of results<br><br>DFO consulted on development of blasting program to minimize effects on fish and fish habitat and water quality, and DFO approval required prior to commencing blasting |
| Health Canada | • Contaminants in country food relevant to the aquatic environment (e.g., fish, caribou, etc.) | HC consulted by proponent on development and implementation of program to monitor contamination levels in country food. |
| Natural Resources Canada (NRCan) | • Mining activity and effects<br>• Permafrost regime and changes<br>• Geology (e.g., shoreline erosion, acid drainage, post-glacial rebound, etc.<br>• Inputs of key indicators to water (e.g., radio-nuclides, arsenic, copper, lead, zinc, rare earth minerals) | Nothing relevant to aquatic parameters included in Meadowbank Project Certificate (NRCan involvement focused on regulation of explosives). |
| **Government of Nunavut (GN)** | | |
| Department of Environment | • Terrestrial wildlife population monitoring and harvest management (e.g., caribou)<br>• Climate change information<br>• Waste management<br>• Information on parks and special places | Information on wildlife licenses and permit regulations; no specific guidance for surveying baseline, monitoring impacts of mining developments for wildlife generally, caribou, carnivores or other species or involvement of Inuit, elders or use of TK in monitoring programs |
| Department of Economic Development and Transportation | • *Minerals and Petroleum Resources*<br>o Committed to building a sustainable resource exploration and development sector across Nunavut.<br>o Promotes the development of an effective regulatory regime and develops programs that build capacity | Advice on plan for and review of wellness monitoring data of affected communities<br><br>Participation in Regional Socio-economic monitoring committee.<br><br>Other than Wildlife Act and |

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| | in communities to positively benefit from resource exploration and development.<br>o Works to develop the sector by supporting geoscience and by training and funding community-based prospectors to promote investor confidence in Nunavut.<br>o Coordinates three regional Socio-Economic Monitoring Committees (SEMCs) in Nunavut. These SEMCs were established to assess the health of our communities through a regional monitoring approach in collaboration with the Government of Canada, hamlets, industry, Regional Inuit Associations, and other interested parties.<br>• *Community Operations: Kivalliq Region*<br>o Ensures departmental programs are delivered and administered to meet the specific needs of each region and their communities.<br>o Oversees regional transportation activities and business development services. | Environmental Protection Act, the GN lacks regulatory authority and specific advisory guidelines for many areas of interest included in project certificate – e.g. energy use, early warning monitoring, emergency response plan, closure and abandonment of facilities and infrastructure and management of public use of all weather road |
| Department of Culture, Language, Elders and Youth | • Surveys and reporting on planned or accidental disturbance to archaeological or paleontological sites | Guidelines for Archaeological and Paleontological Permit holders |
| **Institutions of Public Government** | | |
| Nunavut Planning Commissions (NPC) | • Monitoring land use in Inuit Owned Lands in association with Inuit associations that include the KivIA | Could assist in coordination of data collection and tracking data trends in comparable form to facilitate the analysis of cumulative effects. |
| Nunavut Impact Review Board (NIRB) | • Review development initiatives and projects, and makes recommendations on monitoring requirements to be attached to regulatory approvals. | NIRB appoints monitoring officer to monitor Meadowbanks project as per section 12.7.2 of NLCA. NIRB reviews Socio-economic monitoring program that proponent designs in consultation with GN, INAC, KivIA and submits to NIRB within 6 months of project certificate being issued |
| Nunavut Wildlife Management Board (NWMB) | • Main instrument of wildlife management and the main regulator of access to wildlife in the Nunavut Settlement Area (NSA). The NWMB vision is “conserving wildlife through the application of Inuit Qaujimajatuqangit and scientific knowledge."<br>• The NWMB participates in or facilitates wildlife research and conducts a wildlife harvest study | Local HTOs, NWMP and GN-DOE consulted on development of Terrestrial Wildlife Management Plan and review proposed plan and on development of comprehensive hunter harvest survey prior to construction and ongoing |

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| | from time to time.<br>• Plays a primary role in establishing, modifying, or removing levels of total allowable harvest;<br>• Plays a primary role in establishing and/or adjusting the basic needs level;<br>• Approve the establishment, disestablishment, and changes to boundaries of Conservation Areas;<br>• Identify wildlife management zones and areas of high biological productivity and provide recommendations to the Nunavut Planning Commission with respect to planning in those areas;<br>• Approve plans for management and protection of particular wildlife habitats including those within Protected Areas;<br>• Approve plans for:<br>o Management, classification, protection, restocking or propagation, cultivation or husbandry of particular wildlife, including endangered species; and<br>o The regulation of imported non-indigenous species and the management of transplanted wildlife populations;<br>• Provide advice to government departments, NIRB and other agencies regarding mitigation measures and compensation related to impacts arising from commercial and industrial developments on wildlife habitat;<br>Approve designation of rare, threatened and endangered species; | through life of project.<br>Local HTOs and Elders consulted on mapping of caribou migration corridors |
| **Academic and International** | | |
| ArcticNet | ArcticNet is a Network of Centres of Excellence of Canada that brings together scientists and managers in the natural, human health and social sciences with their partners from Inuit organizations, northern communities, federal and provincial agencies and the private sector. The objective of ArcticNet is to study the impacts of climate change and modernization in the coastal Canadian Arctic. Over 145 ArcticNet researchers from 30 Canadian Universities, 8 federal and 11 provincial agencies and departments collaborate with research teams in Denmark, Finland, France, Greenland, Japan, Norway, Poland, Russia, Spain, Sweden, the United Kingdom and the USA. | Proponent to hire independent contractor to undertake assimilative capacity assessment and submit results to accredited lab. |

# Appendix 6: Project Level Monitoring Program Undertaken by Private Sector – Meadowbank Project

| Category in Meadowbank Project Certificate | Relevant Aquatic VECs and Indicators | Monitoring Information/Considerations |
|---|---|---|
| Monitoring Records | All monitoring information for VECs and indicators to include specific information about data collection (who, when, where), analysis (when done, who did analysis, methods used) and results of analysis. | Monitoring defined in Project Certificate to include baseline monitoring where needed, effects monitoring and compliance monitoring |
| Water Quality and Waste Management | Groundwater- salinity, major ion concentration, dissolved metal load<br><br>Tailing pond discharge – parameters of concern in water license and pH<br><br>Discharge from Baker Lake marshalling area – monitoring as per water license<br><br>Mine waste materials – acid generation potential, metal leaching, non- metal constituents<br><br>Weather station at mine site – atmospheric data, air temperature and precipitation<br><br>On -site Lab – capacity to monitor parameters for all site discharge points and other water quality monitoring required by regulatory authorities | Semi- annual ground water sampling with results incorporated into water quality and treatment program<br><br>Mine waste materials sampling and analysis to be done within 2 years of start of operations to compare with predictions<br><br>Tailings management strategy take account of climate change and ongoing monitoring and review of technical developments<br><br>Results of on-site lab analyses used in water quality assessment study of receiving water assimilative capacity |
| Project Alternatives and Planned Changes | Expansion Plan tailings management – include parameters in schedule 2 of Metal Mining Effluent Regulations, especially if plan affects Second Portage Lake | Includes no net loss plan for fish and fish habitat |
| All weather Private Access Road | All water course crossings – effects monitoring program<br><br>Access and Traffic Management plan – monitoring of | Consideration of DFO guidance for stream crossings with fish present<br><br>Undertake adaptive management practices as required to |

| | | |
|---|---|---|
| | environmental and socioeconomic impacts of road | respond to impacts |
| Fish and Fish Habitat | Freshwater intake pipe – monitoring plan for fish and fish habitat impacts<br><br>Water flow from Third Portage Lake – monitoring program for channel erosion, water levels and success of fish habitat enhancements<br><br>Fish-out program for dewatering Second Portage Lake – augment baseline fisheries data to support monitoring programs<br><br>Creel surveys within water bodies affected by the project<br><br>Fish Habitat Monitoring Plan – augment baseline fisheries data prior to operations and measure success of No Net Loss Plan | Fish-out must be done in consultation with DFO, elders and HTO<br><br>Proponent to engage HTOs in creel survey<br><br>Monitoring plan to be developed in consultation with HTOs and DFO |
| Wildlife and Terrestrial | Terrestrial Ecosystem Management Plan includes: updated baseline data; comprehensive hunter harvesting survey; details of methods and analysis for baseline and survey, details of monitoring program (including for caribou); and Wildlife Summary Monitoring Report for baseline year (2007)<br><br>Annual Wildlife Monitoring Results Report – baseline monitoring, effects monitoring, compliance monitoring, covering VECs assessed by proponent in EIS | Wildlife Summary Reports include:<br>• Involvement of Inuit in Monitoring Program (no specific mention of IQ)<br>• Details on methodologies for field surveys, analysis and adaptive management in response to monitoring results |
| Socio-economic | Socio-economic monitoring program - Monitor socio-economic impacts and effectiveness of mitigation strategies – no VSECs or indicators identified | Ongoing consultation with KivIA, affected local governments in monitoring. |
| Human Health | Program to monitor contamination of country foods | HC consulted on development and implementation of program |
| Accidents and Malfunctions | Early Warning Monitoring Program on boundary of mine and road including flows into water bodies – applies to all VECs | Communities of Baker Lake and Chesterfield Inlet to be involved in early warning monitoring |
| Other | Blasting Program – minimize effects on fish and fish habitat, water quality, and wildlife management VECs | Developed in consultation with DFO |