

A Potential Role for CHARS in Leading Development of the Canadian Arctic Monitoring and Prediction Network (CAMPNet)

Summary

The urgent need to develop comprehensive and coordinated monitoring of Arctic communities and ecosystems has been recognized by many, and is the motivation for IASC to convene this Arctic Observing Summit. Canada is like many other northern nations in that monitoring is presently conducted to meet individual mandates by a range of players at various scales using different approaches that make it difficult to develop a coherent picture of community and ecological change. There are also important gaps in the kind of information that is generated by present monitoring efforts, given evolving and accelerating social, industrial, and environmental issues at northern latitudes. The Advisory Panel established for the recently-announced Canadian High Arctic Research Station (CHARS) has identified monitoring as an important priority. With expertise in science-based monitoring, new financial resources, and a cross-jurisdictional mandate, CHARS is in a position to lead development of coordinated Arctic monitoring in the Canadian North. This paper outlines a proposal for the Canadian Arctic Monitoring and Prediction Network (CAMPNet) that would seek to coordinate present monitoring initiatives, and work with partners to identify, create, and implement new monitoring initiatives as required. The CAMPNet goal is to coordinate all parties to develop a useful and comprehensive system of monitoring, analyzing, assessing, predicting and reporting social and ecological change in Canada's North.

This document is a White Paper submitted to the Arctic Observing Summit held at Vancouver, Canada, April 30 to May 2, 2013. It is intended to invoke discussion and input towards the design and implementation of an effective, useful, and sustainable monitoring and prediction network in the Canadian Arctic. Please submit comments and suggestions to Donald McLennan, Head of Monitoring Science, CHARS.

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The Canadian High Arctic Research Station (CHARS)

The Canadian High Arctic Research Station (CHARS) project was first announced in 2007 with the Government of Canada's Speech from the Throne to "...build a world-class Arctic research station that will be on the cutting edge of Arctic issues, including environmental science and resource development". On August 23, 2012, Prime Minister Stephen Harper announced \$142.4 million over six years for the construction, equipment, and fit-up of the CHARS, and an additional \$46.2 million over six years for the CHARS Science and Technology (S&T) Program. The Prime Minister also announced that an additional \$26.5 million per year has been set aside, as of 2018-19, for the on-going program and operations of the station.

The stated mission for CHARS is;

to be a world-class research station in Canada's Arctic that is on the cutting edge of Arctic issues. The Station will anchor a strong research presence in Canada's Arctic that serves Canada and the world. It will advance Canada's knowledge of the Arctic in order to improve economic opportunities, environmental stewardship, and the quality of life of Northerners and all Canadians.

To read more about CHARS, and the objectives and principles that will guide the development of the CHARS S&T program go to <http://www.science.gc.ca/>. The overall direction governing science priorities for the CHARS S&T program is provided by the Northern Strategy that (<http://www.northernstrategy.gc.ca/>) outlines 4 key outcomes for Federal Government in Northern Canada (Table 1).

CHARS will complement the network of Arctic expertise and facilities across Canada's Arctic and the whole of the country. Activities are being designed to not duplicate effort or deliver on the mandate of other governments or organizations. CHARS will focus on the application of S&T to cross-disciplinary, cross-sectoral issues that are challenging for any one organization to

Table 1: CHARS S&T priorities are linked directly to the 4 outcomes for the Northern Strategy.

<i>Resource Development</i>	<ul style="list-style-type: none"> • Resource development that is economically and environmentally sound and promotes social development; • Renewable resources and unconventional energy sources that contribute to greater energy security and sustainability.
<i>Exercising Sovereignty</i>	<ul style="list-style-type: none"> • Efficient and effective monitoring and surveillance of Canada's vast Arctic; • Effective management of Canada's Arctic waters under changing conditions; • Improved response to, and mitigation of, environmental and other disasters.
<i>Environmental Stewardship & Climate Change</i>	<ul style="list-style-type: none"> • Effective environmental stewardship through greater knowledge of natural and human systems and their interconnections; • Strengthened mitigation efforts through greater understanding of changes in the Arctic climate and the links to global systems, and increased capacity to adapt.
<i>Strong & Healthy Communities</i>	<ul style="list-style-type: none"> • Improved infrastructure and diversified economic opportunities; • Improved health outcomes and community wellness and resiliency.

undertake. CHARS will operate where there are gaps in the mandated responsibilities of existing organizations, or where mandates overlap to such an extent that a broker can add value through coordination. The S&T program will aim to complement and build upon existing investments of governments, industry, northern academic institutions and other organizations that are active in the North, in such a way that the overall value of those investments is strengthened. CHARS will also promote and facilitate international linkages where they may further CHARS S&T priorities and outcomes.

As stated in the mandate for the Station, the geographic scope of CHARS is defined as the lands and waters that lie north of the permafrost line. In this paper “Arctic” and “North(ern)” are used interchangeably to describe CHARS’ focus on the three Canadian territories, Hudson Bay and its coast, Nunavik, and Nunatsiavut.

The CHARS S&T Program – in Development

Science staff at the Arctic Science Policy Integration Branch (ASPI) at Aboriginal Affairs and Northern Development Canada (AANDC) are in the process of developing an S&T Blueprint that will outline in detail the priorities and activities for the CHARS S&T Program for the first five years of operation. The direction for the S&T Blueprint was informed by consultations with the CHARS Advisory Panel, made up of representatives from industry, academia, Aboriginal organizations, and northern governments. It is anticipated that the proposed CHARS S&T Program will begin implementation beginning in the 2014-2015 fiscal year.

One priority for CHARS that is emerging from these consultations is that CHARS should work with partners to establish a sustainable and coordinated pan-Arctic monitoring program for northern Canada. This CHARS S&T objective is the subject of this paper.

Monitoring Economic and Social Change in Northern Communities

Research conducted under the International Polar Year (IPY) produced new understanding of well-being in Northern communities, through the collection and analysis of data on Inuit adults and children as a part of the Inuit Health Survey, and other research (Owens et al. 2012). Tracking and understanding socio-economic and health issues in Northern communities has historically been underfunded compared to the natural sciences (Parlee and Furgal 2012), but is an important component of the CHARS S&T mandate. Monitoring socio-economic change is largely unexplored in this document – due mainly to the limitations of CHARS staff at this time. It should be understood that the CHARS monitoring program intends to work with and add value to the excellent work on social condition and change that is occurring by many individual, government agencies, and academic institutions as CHARS social science and economic capacity is engaged.

The Urgent Need for Monitoring and Assessing Social and Ecological Change in a Dynamic Canadian Arctic

It is now well documented that arctic latitudes are warming more rapidly than anywhere on the planet (ACIA 2005; Blunden et al. 2011; IPCC 2007). This warming is creating, and will continue to create opportunities and challenges for northern communities and ecosystems in Canada (Derksen et al. 2012; SWIPA 2011), effects that can be complex and contradictory. Reduced sea ice is creating new opportunities for industrial activities and may open new fishing grounds, but at the same time these accelerating changes will fundamentally alter the marine ecology of arctic marine ecosystems, threatens infrastructure in coastal communities, and may significantly alter global-scale climate processes (Barber et al. 2012; Strove et al. 2011).

Warming is causing earlier breakup and later freeze up that reduces the operational season of the ice roads that service much of the continental Canadian North (Derksen et al. 2012), but also results in reduced heating costs and more clement weather in frigid, northern communities. In response to a warming climate, Arctic tundra, freshwater, and marine ecosystems are beginning to change in complex, poorly-understood ways at a range of spatial and temporal scales that complicate biodiversity conservation objectives (Jessen and Patton 2008; McLennan et al 2012).

Outside of these direct and indirect climate-related effects, northern communities are also changing internally – evolving from those largely dependent on country food and subsistence lifestyles, to those based in self government and wage-based employment, increasingly influenced by national and international media, changing demographics, new health issues, and other social pressures (Parlee and Furgal 2012).

These ongoing and evolving changes in northern communities and ecosystems create high levels of uncertainty that will make it difficult to implement effective adaptation policies, and to make timely management decisions. A recent concern that has been identified for example, is the possibility of being surprised by social or ecological ‘tipping points’ - where a very small change in a driving factor such as temperature results in sudden and unanticipated effects

(Lenton et al. 2009). Uncertainty around the intensity and scale of climate driven social and ecological change also complicates the sustainable development of Canada's considerable northern resource base, resources now being made more accessible and financially feasible because of climate change effects.

A Proposal - The Canadian Arctic Monitoring and Prediction Network (CAMPNet)

All assessments of climate driven change in the Arctic have emphasized the important role that monitoring and prediction must play by providing useful and timely information on how, and how rapidly communities and ecosystems are changing - knowledge that can directly inform governments, industry and communities, and support the implementation of proactive management approaches and more informed, risk-based decision-making (ACIA 2005; IPCC 2007; SWIPA 2011). With cross-jurisdictional scope and specialized expertise, CHARS is positioned to fill an important niche in organizing, developing, and delivering comprehensive and timely monitoring of communities and ecosystems across the Canadian Arctic.

Governments have already invested in a number of social and ecological northern monitoring initiatives, and it is proposed here that CHARS will lead the development of CAMPNet – a pan-Canadian arctic monitoring and prediction program that aims to coordinate and build on the many ongoing northern monitoring initiatives, and implement new monitoring efforts that will engage northern citizen and science communities to work together to measure and communicate important changes in arctic communities and ecosystems, and to predict how they will change over the near and longer term.

The CAMPNet Vision

CAMPNet will be a sustainable, science- and community-based monitoring and prediction system that will strategically measure, assess, and report change in communities and ecosystems, and will produce useful analyses and predictions to support proactive and effective management and adaptation decisions in a rapidly-changing Canadian Arctic.

Coordination and Optimization – Not Replication

The CAMPNet vision is not intended to replace any of the many ongoing monitoring initiatives that are presently occurring on the Canadian North, nor will it encroach on the existing mandates of federal departments and territorial governments. The approach is to coordinate ongoing initiatives in order to optimize the overall national investment in arctic monitoring, science and scientists. The CAMPNet establishment process will include a rigorous assessment of ongoing initiatives and identify key gaps that can be filled to provide a comprehensive measurement and assessment of ecological and social change. Where gaps exist CHARS has some human and financial resources to lead efforts to fill these gaps, but the emphasis will be on leveraging resources with other parties – including Federal and territorial governments, academic-led programs and projects, industry, not-for-profit organizations, northern communities, and relevant international organizations.

CAMPNet Proposed Structure

It is proposed that CAMPNet will be comprised of two main component structures:

1. a world-class monitoring and prediction program in the Cambridge Bay area, and;
2. a network of coordinated and strategically-located monitoring sites across the Canadian North.

This ‘hub and spoke’ design is intended to provide Canada with a comprehensive scientific and adaptive monitoring and prediction system that is centered at CHARS, but has component sites that are coordinated as one integrated system, and represent the ecological and social diversity of the Canadian North. A first task will be to organize the CAMPNet Monitoring Advisory Committee (MAC) to guide program development.

CAMPNet Proposed Objectives

CHARS monitoring staff and the CAMPNet MAC will work with partners across the North to establish a monitoring and prediction system that:

1. identifies, measures and tracks changes in key monitoring indicators that will inform northerners, the northern science community, governments, and all Canadians of important changes and evolving issues in Northern communities and ecosystems;
2. develops and demonstrates an approach to cumulative effects monitoring and assessment, through the establishment of regional baseline monitoring and assessment in areas of high resource potential;
3. identifies and tracks possible 'tipping points' that have the potential to suddenly and significantly impact Northern communities and ecosystems;
4. coordinates and makes available the flow of monitoring data from network sites;
5. engages and employs Northerners in the design and implementation of the system;
6. invites participation by international scientists and research organizations, and;
7. every 5 years, assesses and communicates the current condition of Northern communities and ecosystems, and predicts near and long term change in the state of key indicators.

The Hub - A World-Class Monitoring and Prediction Program near CHARS

At the heart of CAMPNet is the establishment of a world-class monitoring station at CHARS, to be established in and around the community of Cambridge Bay on southern Victoria Island in Nunavut. To provide a program structure that will ensure that monitoring results are most useful for communities and decision-making, it is proposed that the monitoring around the CHARS station will be structured and designed through the development of an integrated, social-ecological conceptual model (<http://www.resalliance.org/>) that will link Cambridge Bay and nearby communities to the terrestrial, freshwater and marine ecosystems that sustain and support community well-being, that will include regional industrial developments relevant to community economic opportunities, and that will include broad scale social, economic, and environmental drivers that impact local communities and ecosystems. CHARS monitoring staff will work with the CAMPNet MAC, local community members, and others as required, to create this model for the communities and ecosystems in and around Cambridge Bay. The conceptual

model will serve as a frame for visualizing interactions among model components, selecting monitoring indicators, and designing a monitoring and prediction system that integrates social, economic and ecological factors at a range of scales in the context of social-ecological resilience (Carpenter et al 2006; Chapin et al 2007; Holling 2001).

Monitoring in and around Cambridge Bay will be designed and implemented at two scales - intensive local monitoring directly in and around Cambridge Bay, and more extensive regional monitoring to include larger areas of Victoria Island, the Kitikmeot communities and ecosystems in and around Kugluktuk, Gjoa Haven and Talyoak, and the industrial developments presently being proposed for Bathurst Inlet and Gray's Bay. The spatial and temporal monitoring intensity of the program will be determined by indicator sampling considerations (replication requirements, ranges of species monitored, seasonal factors), human and financial resources, and the involvement and contributions of partners.

The approach to be employed in terms of program design is to spatially co-locate monitoring measures so that changes in important system components (e.g., country food and commercially-harvested species, other focal species, community wellness measures, community or industrial infrastructure measures) can be associated with abiotic (e.g., climate factors such as temperature, precipitation, cryosphere change), biotic (e.g., herbivory, predation, parasitism, disease), social (e.g., harvesting pressure, food preferences, social values), and economic (government policies, industrial activities, global markets) factors that drive change in the system.

The goal is to measure and understand change, and be able to predict how important ecological and social factors can be expected to change in the near and long term – information critical for making informed and proactive management decisions and effective policy in a rapidly changing Arctic. The challenge is to monitor the right things at the right spatial scale and temporal frequency to balance information needs with program costs. To cite Holling (2001):

1. Be “as simple as possible but no simpler” than is required for understanding and communication.

2. Be dynamic and prescriptive, not static and descriptive. Monitoring of the present and past is static unless it connects to policies and actions and to the evaluation of different futures.
3. Embrace uncertainty and unpredictability. Surprise and structural change are inevitable in systems of people and nature.

The Spokes - A Coordinated Network of Northern Monitoring Sites

Selection of network sites will be the work of the CAMPNet MAC, and sites selected can be expected to vary depending on the component sampled. For example, we will work to select sites for monitoring terrestrial and freshwater ecosystems to represent ecological diversity across the terrestrial Ecozones of the Canadian North (<http://sis.agr.gc.ca/cansis/publications/manuals/1996/>), and to build on suggestions for designs outlined in the CBMP EMGs for Canada (e.g., Culp et al. 2012, TEMG. in prep). The proposed approach is to work with existing research stations, such as those included in the Canadian Network of Northern Research Operators (CNNRO), to provide geographic representation and help sustain existing research capacity across the North. Similarly, for monitoring marine ecosystems the objective would be represent the diversity of Arctic marine ecosystems, in marine protected areas, and to represent those marine areas that may potentially be impacted by increased shipping or other industrial impacts. A proposed approach for locating CAMPNet marine monitoring areas is to take advantage of the largely coastal location of Arctic communities, and the expertise of northerners in travelling on sea and ice, to design and implement a network of land-based marine monitoring stations at or near Arctic communities.

Monitoring indicators, protocols and designs will be standardized across CAMPNet sites to facilitate a coherent synthesis of social and ecological change. To optimize the usefulness of CAMPNet results, to facilitate implementation, and to provide circum-polar linkages, it is proposed that CAMPNet will attempt to implement the monitoring indicators and strategies outlined in monitoring plans developed by the Marine (Gill et al. 2011), Freshwater (Culp et al. 2012), and Terrestrial (TEMG in prep) Expert Monitoring Groups (EMGs) under the Circumpolar Biodiversity Monitoring Program (CBMP), a Canada-led initiative within the Committee of Arctic

Flora and Fauna (CAFF), a working group of the Arctic Council (<http://www.caff.is/monitoring>). The CBMP EMG monitoring plans have been developed by expert teams of international scientists, and include under their umbrellas a large number of other pan-arctic networks and organizations.

Other key Canadian linkages that will inform CAMPNet implementation will include the ITEX Network (Henry 2013), CARMA (caff.is/carma), Canadian Permafrost Monitoring Network (<http://www.gtnp.org/canpfnet/>), the Canadian National Vegetation Classification (<http://cnvc-cnvc.ca/>), the Arctic Monitoring and Assessment Program (<http://www.amap.no/>), and the new ADAPT program (<http://www.cen.ulaval.ca/adapt/>) at CEN sites.

Monitoring designs will also strive to be compatible across North America by linking to the Terrestrial Ecosystem Observing Network (TEON) (<http://arcticlcc.org/>) and Arctic Observing Network (AON) (<http://www.arcus.org/search/aon>) in Alaska, and internationally through the Circumpolar Biodiversity Monitoring Program Expert Monitoring Groups, GEOBON (<http://www.earthobservations.org/geobon.shtml>), the Global Terrestrial Network on Permafrost (GTN-P), and the GAW/GCW-WMO.

The organizations listed above do not include all potential CAMPNet associates, but rather is intended to show that, as far as possible, CAMPNet will strive to connect with and add value to ongoing and relevant monitoring initiatives, both nationally and internationally.

The Big Picture – Developing Remote Sensing Methods and Models

Although successfully implementing a CAMPNet approach as outlined here would provide an excellent tool for tracking and understanding arctic ecological change, it would still represent only a very small sample of Canada's northern terrestrial, freshwater and marine ecosystems. To provide broader areal coverage we propose that CAMPNet will work with the Canadian Space Agency, the Canadian Centre for Remote Sensing, and academic specialists to develop remote sensing tools that can scale up observations from local monitoring sites to the immediate areas around the sites, to the watershed, to the region, and eventually to the

entire area of the Canadian North. These analyses will add a critical spatial component to CAMPNet by using knowledge gained about the driving processes and indicator changes from monitoring sites, to develop modeling and other remote sensing tools that can help understand change and predict future states across broad areas. Such tools would help evaluate the present condition and possible future states of tundra vegetation, habitat for broad ranging species like caribou, carbon budgets and cryosphere change in northern terrestrial, freshwater, and marine ecosystems, rates of coastal erosion, patterns of change in marine productivity and sea ice, broad scale land- and sea-to-atmosphere climate feedbacks, and changes in community and industrial infrastructure, across the vast areas of the Canadian North.

Supporting Sustainable Northern Resource Development

Through the Northern Strategy, the Government of Canada is ‘committed to the development of northern resources in a sustainable way, and (to ensure) that Northerners participate in and benefit from development’ (<http://www.northernstrategy.gc.ca/cns/cns.pdf>). A key need that has been identified by many parties over the last several years, and by industry advisors on the CHARS Panel, is the lack of regional-scale monitoring in resource rich regions to help provide cumulative assessments of potential social and environmental impacts of existing, planned, and future industrial development projects. Typically, one issue is that industrial proponents conduct ecological assessments to meet obligations of their individual projects, but questions being raised through public or regulatory consultations often require information over a much broader spatial and temporal scale, and often span jurisdictional boundaries. As a component of CAMPNet, CHARS monitoring staff will coordinate with territorial monitoring programs, industry, communities, and federal/territorial regulators to develop and implement long-term, regional-scale monitoring and assessment to support ongoing initiatives in important resource areas.

The proposed approach is to work with territorial monitoring programs (CIMP and NGMP) and stakeholders in a given region to develop a suite of social and environmental monitoring indicators that spans a geographic area sufficiently large to account for issues raised through

public or regulatory consultations, or as identified in a land use plan for the area of interest. The success of the process will depend on the participation and cooperation of regulators, proponents and local communities, and is intended to dovetail with ongoing regulatory processes. The value that CAMPNet can bring is to apply its expertise and resources to organize and coordinate stakeholders, collect and summarize social and ecological information for the regional area of interest, incorporate local ecological effects monitoring being conducted by industry for individual projects, develop an ecological inventory as a frame for sampling design, and work with all stakeholders to implement cumulative effects monitoring using a small, effective suite of monitoring measures. The sample design will be implemented so that it will be possible to assess the potential impacts of individual projects, and to separate these project-based effects from effects driven by external drivers such as ecosystem successional processes or climate change. Assessments will be framed in the context of monitoring thresholds that meet the obligations of local land use plans or other regulatory targets. If monitoring is implemented using standardized protocols, and data are centralized and available, monitoring results from these regional cumulative impact assessments can be integrated into broader assessments to inform territorial or pan-Arctic summaries of ecosystem and community condition, another key objective of CAMPNet.

The Important Role of Northerners and Traditional Ecological Knowledge

The Aboriginal Peoples of northern Canada are central to community life, possess important knowledge of northern ecosystems, and have centuries of expertise travelling and hunting on the land – skills that can complement and enrich an integrated northern monitoring program. CAMPNet will work with communities and other partners to build on these capacities by supporting ongoing community-based monitoring initiatives, and by initiating new programs to complement existing efforts. A key joint initiative will be the enhancement of existing community monitoring programs that engage northern residents in observing and recording change in and around their communities.

One example of a nascent program that involves Northerners in marine sampling is the Canadian Rangers Ocean Watch (CROW) program, where community-based Canadian Rangers are being trained to monitor snow and ice thickness, snow-ice interface temperature, water column temperature, salinity, chlorophyll and dissolved oxygen, and to deploy ice temperature buoys. The CROW program takes advantage of their unique skills in winter travel to collect data that has not previously been collected in a systematic way – data that can be used to understand and model the fundamental marine processes that eventually determine the abundance and distribution of the char and marine mammals on which the communities rely for country food.

Many of the White papers submitted for this meeting deal directly with community monitoring issues. The White Paper submitted by Kutz et al. (2013) promotes the need for a Sustainable Arctic Wildlife Health Observation Network given the significant and increasing wildlife health risks associated with the rapid climate and ecosystem change presently ongoing in the North. Another White Paper submitted by Knopp et al (2013) outlines progress with community monitoring of local natural resources important to communities in the Inuvialuit Settlement Region. Also Johnson et al. (2013) identify systemic issues with community monitoring as it now exists, and suggest ways to move forward in a more coordinated fashion. These are just a few examples of the many community monitoring initiatives ongoing across the Canadian North, and there are many examples in Alaska as well (Kruse et al. 2011; Payne et al. 2013).

The CHARS Monitoring program will also work with ongoing initiatives under the northern colleges to provide opportunities for training and employing northerners to carry out the systematic and technical field and laboratory measurements involved in monitoring. These could include maintenance of weather stations, air quality and air chemistry sampling, water monitoring stations, installing and maintaining thermistors and frost tubes, snow measures, small mammal traps, and marine sampling. Other training could involve field identification of arctic birds including waterfowl, fish, shorebirds, raptors and songbirds. Laboratory training could teach techniques for identifying soil and stream arthropods and sampling of fish, as well as chemical techniques for soil and water analysis. Employers would include governments, industry, and academic institutions. The objective would be to build on the inherent

observational skills and experience working on the land of northern residents to provide meaningful employment, and to potentially provide a stepping stone to higher education.

A State of the Canadian Arctic Report (SoCAR)

Policy priorities for the Federal government in northern Canada are clearly stated under the Northern Strategy (Table 1). Another objective for CHARS monitoring is to develop a synoptic assessment of northern communities and ecosystems (State of the Canadian Arctic Report - SoCAR) that will, every five years, report on progress towards achieving the objectives of the Northern Strategy.

There are many ongoing programs presently operating in the North that could contribute to SoCAR. A recent summary collected under the Federal Integrated Network of Science and Technology (FINEST) listed about 160 monitoring or related projects that are presently ongoing, at a range of scales and disciplines. Not all of these projects would contribute to a pan-northern synopsis of Northern Strategy goals but many could. Federal monitoring includes programs that track changes in marine, terrestrial and freshwater biodiversity, atmosphere and climate, weather, water quality and quantity, sea ice, permafrost, coastal erosion, sea level change, changes in snow cover and glaciers, and environmental pollutants. Many of these programs are at a very local scale but others are not. For example, Parks Canada measures and reports the state of ecological integrity of 12 national parks across the North, measuring many aspects of northern biodiversity and ecological process across a representative sample of northern ecosystems. Some other examples of Federal broad-based programs - EC maintains a pan-arctic network of water and climate stations, AANDC delivers the Northern Contaminants Program (NCP), and NRCan supports the Canadian Permafrost Monitoring Network.

Projects tracking aspects of human health and community wellness are also implemented by Federal departments across the North. The Public Health Agency of Canada (PHAC) lists 16 projects that monitor cancer incidence, infectious diseases and incidence of domestic violence.

Health Canada (HC) lists seven projects that include integration with NCP on environmental contaminants, radiation monitoring, and the broader Inuit Health Survey.

More recently, AANDC initiated monitoring in Nunavut and the NWT, in response to land claims obligations – establishing with communities, Aboriginal organizations, and territorial governments the Cumulative Effects Monitoring Program (CIMP) in the NWT, and the Nunavut General Monitoring Program (NGMP) in Nunavut. Both CIMP and the NGMP strongly engage northern communities, and will eventually provide comprehensive monitoring, data management, and condition assessments for NWT and Nunavut. Other monitoring within the territories supports regulatory decisions for sustainable harvesting of important country food species such as barren ground caribou, muskoxen, whales, seals, and walrus, and for maintenance of water quality.

What is clear is that there are abundant data available to support a report on the state of northern communities and ecosystems, in terms of the four pillars of the Northern Strategy. CHARS is in a position to work on this formidable task, and a final objective of the CHARS monitoring program is to develop a structured approach to provide reliable, relevant, and repeated monitoring data across a range of disciplines to produce a clearly-communicated statement of the condition of arctic communities and ecosystems, identification of important emerging issues, and progress in meeting objectives of the Northern Strategy.

CHARS and Monitoring Data Management

A critical component of any operational monitoring system is a reliable information management system that collects, archives and makes widely available the data collected. Based on recommendations of the CHARS Advisory Committee, CHARS will act as a key hub for northern data and information, and will become a global leader in polar information management. With this broader data management goal in mind, a significant contribution of CHARS to CAMPNet will be the ongoing management of arctic monitoring data – both data collected by CAMPNet partners, and other monitoring data that contributes to CAMPNet

objectives (e.g., data assembled to produce the SoCARs). CHARS will work with SAON (SAON 2013) and build on work completed to date by the Canadian Polar Data Catalogue (CPDN) and the CBMP to achieve these goals.

CHARS will also work with subject experts, ongoing initiatives, and data holders to develop creative approaches to managing 'non-scientific' data information, and look for opportunities to merge traditional and local knowledge observations of ecological and social change with scientific approaches. As a part of the CHARS data management effort, a set of user tools will be developed that will make CAMPNet monitoring data simple to access for a broad user community. In this way monitoring data collected through the CAMPNet process will be made widely available to potential data users in northern communities, across Canada, and around the world.

Linking CAMPNet to the Circumpolar World

Canada has for many years been a leader of international initiatives in the Arctic, beginning with being a key player in the establishment of the Arctic Council (AC), which was formed as a result of the Ottawa Declaration in 1996. Canada was the first Chair of the AC (1996-1998) and will sit as Chair again in 2013-2015. In the context of arctic monitoring, and in keeping with this tradition, Canada presently leads the CBMP (although this will change in 2013 with leadership moving to the USA and Denmark). As discussed previously, work already completed by the CBMP's Marine, Freshwater and Tundra EMGs will be an important guide for selecting indicators and designing monitoring within CAMPNet. Such international involvement ensures that Canada and CHARS are connected to monitoring programs around the circumpolar Arctic, and are recognized as making important contributions to these international efforts.

The CBMP is in turn the biodiversity monitoring component of the Sustained Arctic Observing Network (SAON) in which Canada is an active participant. In the 2006 Salekhard Declaration, the AC stressed the urgent need for all countries to cooperate in the long term monitoring of arctic communities and ecosystems. SAON has evolved from this declaration and is establishing

a process to ‘...further multinational engagement in developing sustained and coordinated pan-Arctic observing and data sharing systems that serve societal needs, particularly related to environmental, social, economic and cultural issues.’ As discussed in this paper, CAMPNet will work with these national and international bodies to share data and information, will actively participate in the development and communication of common, international monitoring protocols and the design of monitoring systems, and will work to communicate the results of monitoring through the State of the Canadian Arctic Report.

The Critical Role of Research for CAMPNet

The design and implementation of a cost-effective and useful monitoring and prediction network for the Canadian North depends directly on the depth of our knowledge of how ecological and social systems function, and the elucidation of key linkages between drivers and the ecological services on which our industries and northern communities depend. Even relatively ‘simple’ northern ecosystems are highly complex, so that to be able to design an ‘elegant’ monitoring system, i.e., a system that optimizes the monitoring investment, we will rely heavily on specialists across the spectrum of social and environmental science. It is this knowledge that helps select and develop:

- the monitoring indicators we choose to measure (from a very long list of candidates);
- the most effective and efficient monitoring designs that will demonstrate relationships between environmental drivers and monitoring indicators;
- the assessment criteria for interpreting and communicating the significance of measured changes, and;
- the predictive models that provide realistic future scenarios so that we can anticipate and more successfully adapt to the inevitable changes to be experienced in Northern ecosystems and communities.

Science research has been conducted in the Canadian Arctic for many years, and the recent investment by the Government of Canada in northern research under the International Polar

Year program greatly increased our fundamental understanding of a wide range of arctic issues, both in the natural sciences, and for public health and social science (Kulkami et al 2012). Over this same period northern science infrastructure was improved through the Arctic Research Infrastructure Fund (ARIF) – a lasting investment that will help sustain science activities across the North. IPY efforts also significantly improved our ability to work with communities, and to access the wealth of wisdom that exists within the traditional knowledge of Indigenous Northerners (Parlee and Furgal 2012). The CHARS S&T Program presently being developed will work with the northern science community to carry on the momentum generated by the IPY investment, working closely with CAMPNet to design monitoring systems, understand measured changes, and anticipate probable futures.

The Key to Sustaining CAMPNet – Working Together for Mutual Benefit

Designing, implementing and sustaining CAMPNet is clearly a formidable task, and, although CHARS is prepared to lead, and has some human and financial resources to facilitate some of the desired outcomes outlined in this White Paper, CAMPNet will not be successful without the effective engagement and active participation of a wide range of partners - academics to governments to industry to communities - across the Canadian North. Taken together, there is a considerable intellectual resource in northern academic, government and industry science capacity, as well as a depth of traditional knowledge within northern communities. As stated in the SAON (2013) in the White Paper submitted for this meeting – “As in any collaborative activity, the first step is to agree to work together”.

Realistically, the ongoing engagement and active participation of CAMPNet partners will depend directly on the benefits in meeting their own mandates that they receive from the contributions they make to CAMPNet. So, in addition to providing key information to facilitate informed and effective adaptation, examples of how participation in CAMPNet can directly benefit partners in meeting their mandates include;

- assisting territorial governments and industrial proponents with the development of regional-scale baseline monitoring and cumulative effects assessments;
- providing useful information on ongoing and predicted changes in critical ecological services in northern communities;
- permitting condition assessments and change predictions across jurisdictional boundaries, boundaries often crossed by far-ranging species such as caribou, migratory fish and polar bears;
- collecting and archiving CAMPNet monitoring data, and making it widely accessible;
- sharing science expertise across jurisdictions for common goals to optimize the science investments made by federal and territorial governments, by industry, and by academic institutions;
- tracking change in ecological processes and focal species to develop a much deeper understanding of how, and how rapidly northern ecosystems are evolving as climate changes - understanding that can be used to frame more effective science inquiries, and;
- demonstrating world-leading knowledge of social and ecological change, and by being present and active at many monitoring and research sites, we provide an important component of Canadian sovereignty across Canada's vast arctic territories.

The key to achieving all of the goals set out above is to develop the CAMPNet system following an open and participatory process that involves and considers the needs of all contributing partners. In this way we can ensure the benefits of participation flow to contributing partners, and thus help to ensure the long term sustainability of CAMPNet.

Finally, it is stated in this paper, and in many other reports, that coordinated monitoring and assessment is needed because of uncertainties in developing policy and proactive management decisions in a rapidly changing Canadian Arctic. So probably the most important key to sustaining CAMPNet is to ensure that program outputs are useful and timely to decision-makers in federal and territorial governments, in northern communities, and to Northern industrial proponents and their shareholders.

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