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Polar Knowledge Canada

Draft Science and Technology Plan

Overview of Goals, Activities, and Approaches

2020-2025

Canada

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Executive Summary

Rapid change – social, economic, and environmental – is sweeping across the Canadian Arctic and northern communities are feeling the impact. Northerners, in particular, are looking to understand and adapt to the changes they see around them, and to anticipate and prepare for those which may come in future. Developing a better understanding of current and possible future changes, and preparing optimal responses, demands more knowledge than is currently available. This Science and Technology (S&T) Plan 2020-2025 outlines how Polar Knowledge Canada (POLAR) will respond to this need to improve understanding for all Canadians.

Working Collaboratively to Understand Priority Issues

To better understand what new knowledge is needed in order to meet challenges associated with rapid change, POLAR engaged with Northerners and all Canadians. Priority issues, and opportunities to complement existing efforts that are underway were identified by:

- Reviewed current priority-setting documents and initiatives, including the outcomes of the comprehensive consultation exercise that led to the co-development of Canada's Arctic and Northern Policy Framework;
- Engaged directly with representatives from northern and Indigenous organizations; and
- Sought information and guidance from all Canadians via an online open Call for Input.

Based on information gathered, we developed an S&T Plan that supports knowledge creation that is essential to understanding and adapting to rapid change. The Plan is also consistent with what Canadians want and expect from POLAR, will respectfully include Indigenous knowledge holders, and will complement knowledge creation projects and initiatives already under way in Canada's North.

Setting Science and Technology Goals and Desired Outcomes

Through a statistical analysis of information collected through engagement, we identified three broad areas where more knowledge is needed. The primary Science and Technology goals and associated outcomes proposed for 2020-2025 are:

Goal 1: Improve understanding of dynamic northern ecosystems in the context of rapid change

Outcome: Advanced understanding of current changes taking place in Northern ecosystems by developing baseline information and monitoring systems to track key changes in order to project future changes and facilitate adaptation.

Goal 2: Advance sensible energy, technology and infrastructure solutions for the North

Outcome: Increased availability and use of clean energy, waste and waste water, and housing technologies and techniques that meet the unique environmental, social, and cultural conditions prevalent in remote northern communities.

Goal 3: Increase understanding of the connections between northern community wellness and environmental health

Outcome: Improved knowledge of wildlife health leading to a better understanding of country food quality and supply, and greater clarity on the connection between human activities and the environment.

To support these goals, we identified areas of focus and activities describing key ways of implementation.

Creating and Sharing New Knowledge

Based on the feedback received, we also developed five key approaches to guide the way knowledge will be created and shared:

1. Community involvement,
2. Collaboration,
3. Capacity building,
4. Knowledge mobilization, and
5. Data management.

The overall objectives of the S&T Plan are to provide essential information to understand and adapt to a rapidly changing Arctic, and to return this information into the hands of communities and decision makers at a time of pressing need. This will reduce uncertainty regarding the future and provide information crucial to the development of sound adaptation strategies.

Introduction

Climate warming is bringing rapid and unprecedented change to the circumpolar Arctic – air temperature in the Canadian Arctic is warming at a rate two times the global average (Meltofte, 2013; AMAP, 2017; IPCC, 2018; Bush and Lemmen, 2019). This has local, national and global consequences.

In Canada, residents of Northern and Arctic communities are affected the most by this dramatic warming. Each season now brings signs, some obvious and others more subtle, of a shift in long-familiar patterns of sea ice, winds, weather, and wildlife. This affects access to the local food that northern Indigenous communities depend on and has significant social and economic implications for the entire North.

Indigenous and Scientific Knowledge

Indigenous peoples have thrived for thousands of years in the North because of their skill at adapting to change – using their ancestral knowledge in combination with careful observation and examination of new conditions. The speed and scope of the present changes require the use of this ancestral knowledge as well as new information from diverse sources. Together, scientific knowledge and Indigenous knowledge can provide the evidence and understanding needed to adapt to today's conditions and plan for the future.

Polar Knowledge Canada (POLAR), a federal agency with a mandate to advance knowledge of the Polar Regions and strengthen Canadian leadership in polar science and technology, was established in 2015 to address some of these emerging knowledge needs.

Science and Technology Goals for 2020–2025

In developing this Science and Technology (S&T) Plan, we worked with Canadians – including Northerners, other government departments, and researchers – to identify areas where new knowledge is needed the most. Based on pan-Canadian engagement, we developed three goals and a framework for implementing research activities and mobilizing knowledge that is consistent with what Northerners and all Canadians want and expect from POLAR. These goals will ensure that our activities complement the wide range of knowledge creation projects and initiatives already under way in Canada's North. Developing new knowledge on the issues that matter to Northerners and to all Canadians will support decision makers in understanding and adapting to rapid change.

Goal 1: Improve understanding of dynamic northern ecosystems in the context of rapid change

Goal 2: Advance sensible energy, technology and infrastructure solutions for the North

Goal 3: Increase understanding of the connections between northern community wellness and environmental health

The efforts outlined in this S&T Plan provide an opportunity to shape a renewed and respectful relationship with Indigenous peoples in the northern research context, through meaningful engagement with Inuit, First Nations, and Métis peoples. The involvement of Indigenous peoples, and their knowledge, in all stages of the research process will be key steps in this direction.

Over the next 5 years, through this plan, we will provide essential information to understand and adapt to a rapidly changing Arctic. This information will be retuned into the hands of communities, and to all Canadians to improve decision making at a time of pressing need.

POLAR's Operating Context

Polar Knowledge Canada advances knowledge of the Canadian Arctic in order to improve economic opportunities, environmental stewardship and the quality of life of its residents and all other Canadians. It also strengthens Canada's leadership on Arctic issues and operates the Canadian High Arctic Research Station (CHARS) campus in Cambridge Bay, Nunavut.

CHARS is a state-of-the-art research facility in Canada's Arctic and is uniquely placed to support northern communities' current and emerging knowledge needs. It serves as a space to conduct Arctic research, test technologies, support knowledge creation and sharing, and build capacity. The CHARS campus also supports long-term monitoring and research in a poorly understood region in Canada's central Arctic. By focusing efforts in the area surrounding the CHARS campus, CHARS Environmental Research Area (ERA), we contribute important data to Canada's existing environmental monitoring activities, support the ongoing development of baseline datasets, and contribute to Canadian efforts to better understand pan-Arctic change.

Science and technology activities necessary for the full implementation of this plan, and to meet POLAR's pan-northern mandate, are beyond the capacity of our in-house programs. To support and strengthen POLAR's ability to deliver on this broader mandate, funding is provided to collaborators through the Grants and Contributions Program. Moreover, collaborations with entities that have their own resources and can assist in achieving shared goals will be sought.

Informing the Science & Technology Plan

The process to develop the S&T Plan began in the spring of 2018. The S&T Plan will guide POLAR's programs between 2020 and 2025. This section describes the steps involved to develop the S&T Plan.

Engaging Indigenous, Northern, and Public Collaborators

Representatives of Indigenous and northern organizations and governments, academic institutions, and other Northerners were engaged directly through a series of meetings. Additional input from all Canadians was also sought input via an open, on-line Call for Input.

In total, 75 organizations across 17 northern communities participated in engagement meetings and the Call for Input generated 380 survey responses. Responses were

received from northern and Indigenous organizations, non-government organizations, academic institutions, other government departments, and the general public. Participants answered questions about the most important knowledge gaps in the natural, social, and health sciences, as well as in the field of technology testing and demonstration. They also provided feedback about approaches to be considered when conducting science in a northern context.

Setting Priorities and Defining Our Niche

To identify priority issues, documents published by national Indigenous organizations, territorial governments, northern educational institutions, and non-governmental organizations were reviewed and analyzed.

Input from the comprehensive consultations that the Government of Canada conducted to co-develop an Arctic and Northern Policy Framework was also included in the priority-setting analysis.

An “environmental” scan was conducted to assess monitoring and research currently being done by other organizations. This analysis included a review of the mandates and programs of federal, territorial, and other national organizations, as well as identified knowledge gaps that our in-house research team would be well-positioned to address.

Identifying Goals and Areas of New Knowledge

Responses from the engagement meetings and the open Call for Input determined gaps in knowledge (Appendix A) and identified how new knowledge should be applied. The results also clearly outlined key principles on how research should be conducted.

The results of these engagements were then considered in relation to the dominant themes found during the review of priority-setting documents and the mandates of other northern organizations. Looking at our niche within the broader setting of existing programs provided context and helped to ensure our activities and initiatives complement the work of others.

Combining Community Guidance with Data

Since we began work in the CHARS ERA, community engagement has guided the identification of monitoring needs and key ecosystem components of regional importance (POLAR, 2019). We are also working on an improved multi-stage gap analysis to better understand the state of monitoring and knowledge creation initiatives underway within the CHARS ERA.

Guidance from Canadians combined with the gap analysis highlighted where there were needs for additional knowledge. Through these efforts, we have already identified some emerging gaps and are addressing these areas through the in-house research team. As more priority gaps are identified, through further community engagement and the continuation of literature review, future research will be guided towards addressing these.

Science and Technology Goals

The S&T Plan includes three goals to guide our work from 2020-2025. Each goal is supported by areas of focus and activities that outline what POLAR and its collaborators will work on. This section describes the primary goals, their related outcomes, areas of focus, and activities.

Goal 1: Improve understanding of dynamic northern ecosystems in the context of rapid change

Goal 2: Advance sensible energy, technology and infrastructure solutions for the North

Goal 3: Increase understanding of the connections between northern community wellness and environmental health

Goal 1: Improve understanding of dynamic northern ecosystems in the context of rapid change

OUTCOME:

Advanced understanding of current changes taking place in Northern ecosystems by developing baseline information and monitoring systems to track key changes in order to project future changes and facilitate adaptation.

Building on what has already been accomplished in the CHARS ERA over the last five years, baseline information on terrestrial, freshwater, and marine ecosystems will continue to be collected and expanded upon to incorporate emerging priority variables. A long-term monitoring program will be implemented to track key components of these ecosystems. This will involve ground-based observations and studies and covering a wider area with remote-sensing tools.

The data and observations will inform our understanding of ecosystem components as well as their changes and interactions. Ecological models will further support our understanding of the current and future changes at local, regional, and global scales. In-house efforts will focus mainly on terrestrial ecosystems within the CHARS ERA (Figure 1). We will rely on collaborators to gather information on additional high-priority marine and freshwater ecosystems within and beyond the CHARS ERA.

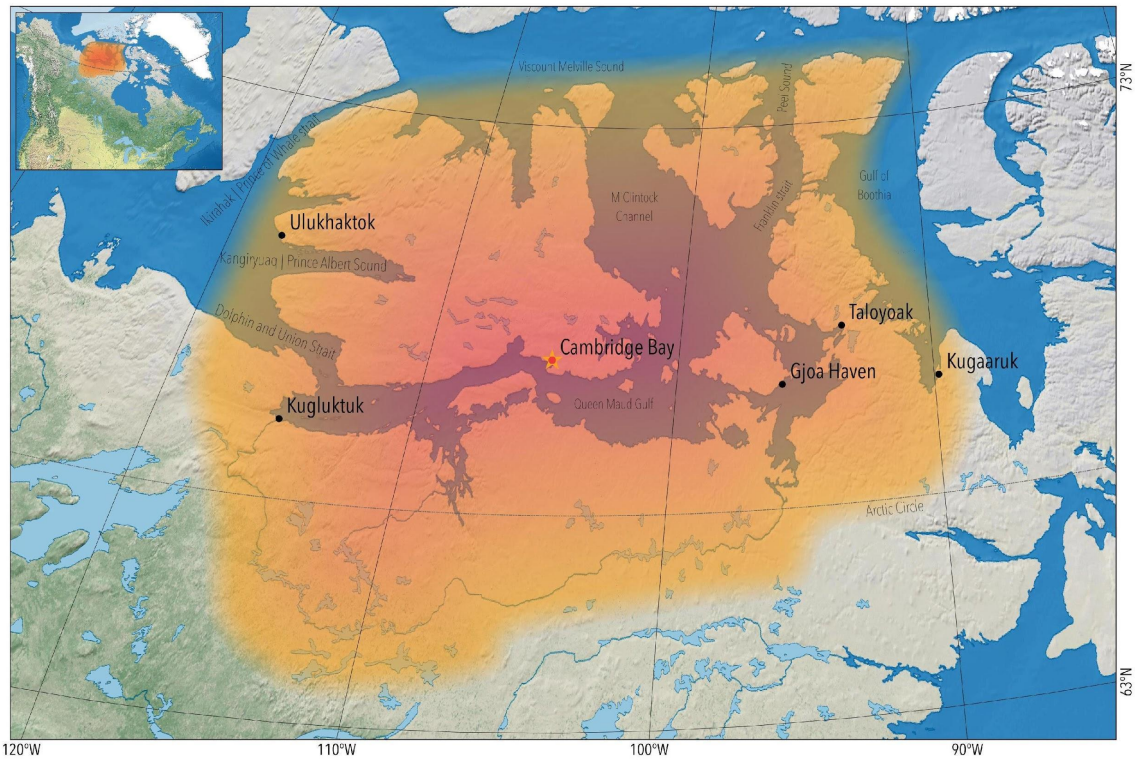


Figure 1 – The CHARS ERA (shaded area) is centered around the CHARS campus in Cambridge Bay, Nunavut. The area includes six communities – Ulukhaktok, Kugluktuk, Cambridge Bay, Gjoa Haven, Taloyoak, and Kugaaruk.

Area of Focus 1.1: Acquire baseline data on terrestrial, freshwater, and marine **ecosystems**.

Activity 1.1.1: Abiotic elements – Understand cryosphere conditions, with a focus on permafrost, snow, and lake and sea ice.

As very little is known about the permafrost conditions of the central Canadian Arctic, additional research is necessary to understand this fundamental ecosystem component (Streletskiy et al., 2017). Our in-house efforts on permafrost will focus on filling key thematic and geographic gaps in the CHARS ERA, based on guidance received from northern communities and experts. Collaboration with local, national, and international groups will be crucial to ensure additional geographic and thematic coverage.

The data and results will be accessible and practical, to allow exchange and use with national and global networks and databases, such as the Nunavut Permafrost Databank

(Government of Nunavut Climate Change Secretariat), the Global Terrestrial Network for Permafrost (GTN-P), and CryoNet. Through our collaborators, research will be conducted on other high-priority components of the cryosphere, such as snow and lake and sea ice.

Activity 1.1.2: Biotic elements – Inventory terrestrial, freshwater, and marine ecosystem components to assess the state of food webs.

Changes in global climate will profoundly affect northern food webs and the human communities they support (NSERC and SSHRC, 2000; Stuckenberger, 2009; Bush and Lemmen, 2019). An accurate inventory of current plant and animal life is urgently required to allow for detection and tracking of changes to biodiversity.

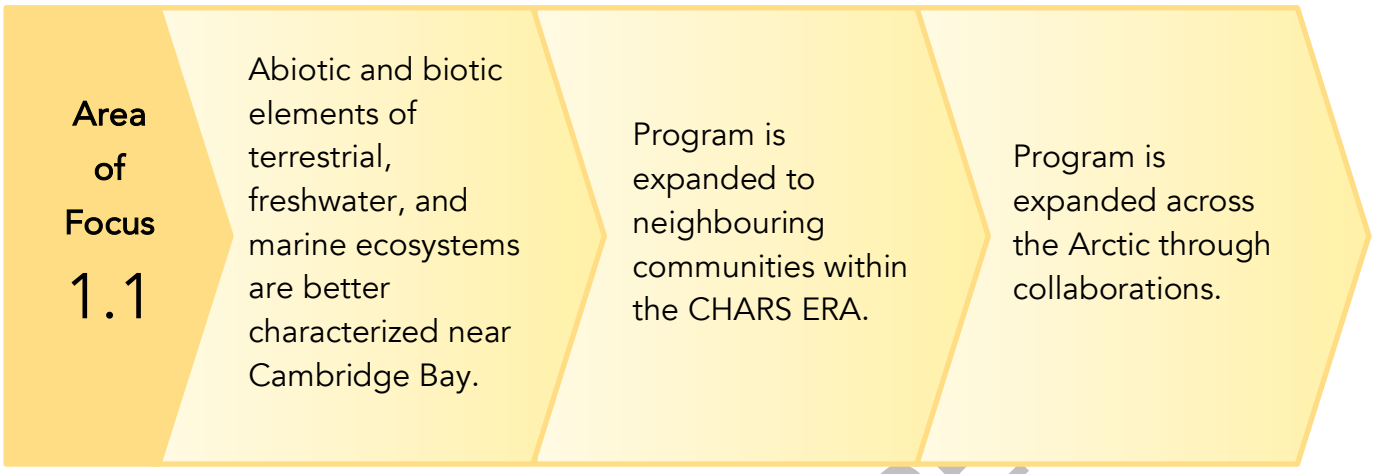
In-house efforts will focus on terrestrial surveys and sampling of biotic elements (plant communities, insects, birds, mammals) within the CHARS ERA to define spatial and temporal variation in species abundance and understand food web dynamics, including identification of invasive species. Standard ground-based surveys will be combined with remote sensing technology (drones, aircraft, satellites) to gather information from local to regional scales. This work will build on existing inventories and fill thematic and geographic gaps.

Characterization of terrestrial ecosystems outside the CHARS ERA and all work in freshwater and marine ecosystems will be done by our collaborators.

DNA “barcoding” will be used as a tool to rapidly identify Arctic life forms. Visiting Canadian and international experts will work with POLAR researchers to catalogue Arctic species and develop a comprehensive baseline inventory of all life forms in the CHARS ERA. This DNA data will be used to quickly and reliably identify species for assessment and monitoring purposes, providing a better understanding of ecological interactions and of food webs. The DNA data will be made publicly accessible via the Barcode of Life Datasystems (BOLD) database.

All data obtained from the research efforts under this activity will be accessible and facilitate exchange and use with international long-term monitoring programs (such as the International Barcode of Life (iBOL) initiative and the Circumpolar Biodiversity Monitoring Program (CBMP)).

Key steps for implementation



Area of Focus 1.2: Monitor and model terrestrial, freshwater, and marine **ecosystems**.

Activity 1.2.1: Develop and implement long-term monitoring programs in key terrestrial, freshwater, and marine ecosystems where baselines have been established.

In-house efforts will be directed toward the development and implementation of a long-term monitoring program for the terrestrial ecosystem in the CHARS ERA. This monitoring program will initially focus on components of terrestrial ecosystems including plant phenology, migratory bird ecology, and carbon flux. Collaborators will conduct additional work on terrestrial ecosystems as well as monitoring of key elements in freshwater and marine ecosystems. They will be encouraged to use standard methods that ensure interoperability of data for comparisons at regional, national and international scales. They will also be asked to mirror the POLAR approach, where baseline information is collected first, a subset of this information is chosen for the monitoring of key ecosystem components, and all information is then used to create models.

The data from our in-house research will be exchanged and used with international networks such as the International Tundra Experiment (ITEX) for the plant phenology component of the program. Similarly, migratory bird monitoring will use standard protocols and will be shared with databases developed by the Arctic Web-interaction working group, the Arctic Shorebird Demographics Network (ASDN), and the Arctic Shorebird Tracking project. All biodiversity data will be shared with the CBMP and the carbon flux data will be shared with the standard FLUXNET system.

This activity complements other initiatives lead by local (e.g., Ekaluktutiak Hunters and Trappers Organization (EHTO), territorial (e.g., Government of Nunavut, Government of Northwest Territories), and federal agencies (e.g., Fisheries and Oceans Canada (DFO), Environment and Climate Change Canada (ECCC)), as well as academic researchers using standard protocols and procedures, like those of the CBMP (Christensen et al., 2013).

Activity 1.2.2: Characterize changes to terrestrial, freshwater, and marine ecosystems through integrated modelling.

Process-driven multi-scale ecosystem models can be used to identify and assess hotspots of greening and expansion of shrubs on the tundra, changes in plant functional traits, and to investigate biodiversity distribution and trophic interactions (Christensen et al., 2013).

In-house efforts will focus on modelling terrestrial ecosystems to understand processes, classify ecotypes, and identify key environmental drivers and environmental changes in the CHARS ERA. The standardized approach to Arctic and Subarctic terrestrial ecosystem classification and mapping will be applied (CAVM Team, 2003; McLennan et al. 2018). Data and models created under this activity will be shared with national and international networks and agencies (e.g. CBMP, Canadian Space Agency (CSA), ECCC, and National Aeronautics and Space Administration (NASA)). Similar modelling work on freshwater and marine ecosystems will be conducted by collaborators to identify important environmental drivers and trends.

Key steps for implementation

Area of Focus 1.2			
	Research activities on vegetation, migratory bird, and vertebrate ecology continue. Terrestrial ecosystems are mapped close to Cambridge Bay.	A ground-based monitoring program is established. Ecosystem maps are developed for terrestrial ecosystems within the CHARS ERA.	Multi-year datasets are available and a terrestrial ecosystems mapping guide is completed. The information is integrated into models.

Goal 2: Advance sensible energy, technology and infrastructure solutions for the North

OUTCOME:
Increased availability and use of clean energy, waste and waste water, and housing technologies and techniques that meet the unique environmental, social, and cultural conditions prevalent in remote northern communities.

Clean energy technologies aimed at reducing diesel dependency and addressing wastewater treatment, as well as the development of waste management technologies and innovative housing technologies and practices for remote communities are critical. Various government, academic, and private sector agencies are conducting northern-focused research related to this goal. In particular, these agencies are focused on moving early stage, innovative technologies through to commercial readiness. However, there are knowledge and experience gaps related to these new technologies and techniques including, testing these new technologies under the unique climate conditions and the ability to demonstrate technologies suitable for the socio-cultural conditions of remote Arctic and Subarctic communities.

The CHARS campus is an ideal location to support Arctic research and assist external collaborators with the testing and demonstration of technologies to ensure they are ready for use in remote northern communities. We are well positioned to advise on community requirements and needs, both social and technical, and to ensure that future technologies work well in a northern environment.

Area of Focus 2.1: Test and demonstrate new and emerging **clean energy technologies** prior to deployment in remote northern communities.

Activity 2.1.1: Further incorporate key clean energy technologies into the CHARS campus infrastructure.

Activity 2.1.2: Support technology demonstrations predominantly in Cambridge Bay including energy storage, biofuels, and advanced renewable energy solutions.

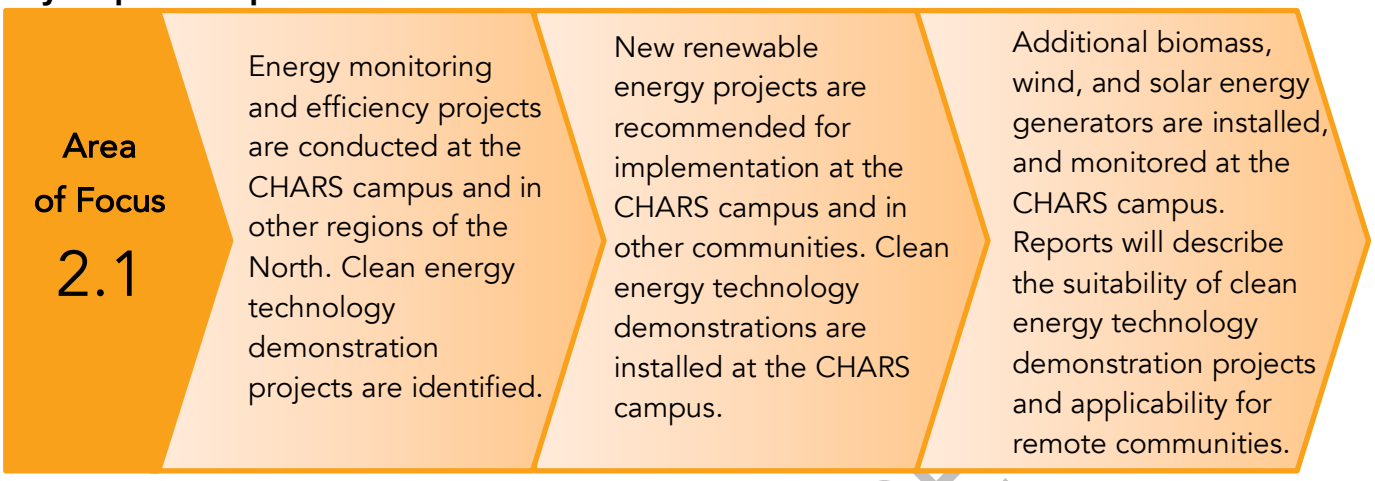
Activity 2.1.3: Facilitate the maintenance and growth of renewable resource monitoring in other regions of the North.

There is significant interest and activity across government, industry, and academia to better understand the requirements for renewable energy generation in remote northern communities (Cherniak et al., 2015). Clean energy design and implementation teams often have limited access and exposure to the environmental, social, and cultural conditions prevalent in the North where these technologies are most useful. This can be a limiting factor in the design and operability of new technologies.

In-house efforts will focus on testing, demonstrating, and monitoring technologies developed and brought forward by collaborators, including hosting technologies at the CHARS campus and in the community of Cambridge Bay. Government, industry, and academic agencies are developing and testing clean energy technologies such as advanced wind turbines, high efficiency solar panels and micro-inverters, community-scale biomass heat and power systems, small nuclear reactors, and a range of short-, medium- and long-term storage capabilities. We will work with collaborators to conduct technology development and demonstrations, as well as resource and gap analyses (e.g., tidal studies; identifying where insufficient resource analysis has been conducted).

Our in-house team will leverage and build upon national programs such as Natural Resources Canada's (NRCan) CanmetENERGY, Renewable Energy Atlas, and Microgrid Field Testing in the Arctic for smart meter and resource monitoring; the Wind Energy Institute of Canada (WEICan) for wind monitoring; and, Build Canada for solar irradiance monitoring.

Key steps for implementation



Area of Focus 2.2: Improve waste and wastewater treatment technologies to reduce health risks from open burning and leaching of contaminants into the environment.

Activity 2.2.1: Incorporate key technologies into the CHARS infrastructure such as waste-to-energy, grey and black water technology, green-housing, and recycling.

Activity 2.2.2: Support technology demonstrations, predominantly in Cambridge Bay, including solutions to test water and wastewater treatment technologies to improve water treatment facilities.

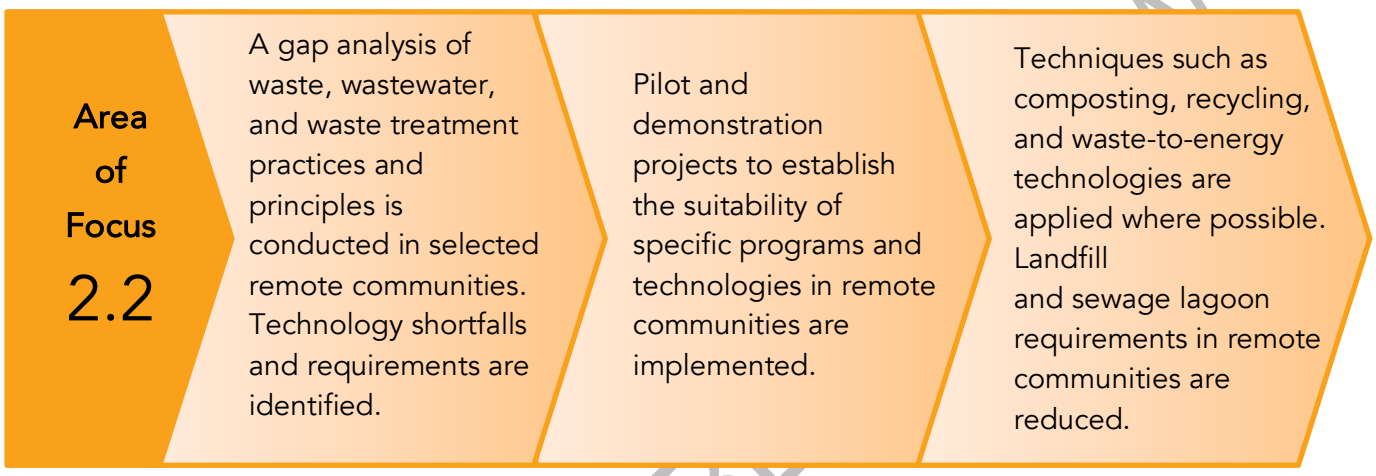
Activity 2.2.3: Support communities in sampling and monitoring waste resources in other regions of the North to decrease pressure on landfills.

Many northern communities face challenges with respect to water, wastewater, and waste treatment. There is a great interest and activity across government, industry, and academic agencies to better understand the requirements for water and waste treatment in remote communities and to address the long-term impacts to health and the environment (Curry, 2016; Wallace, 2018). With our collaborators, in-house efforts will focus on hosting technologies, providing strategic assistance to identify and resolve equipment issues (under guidance from developers), and offering advice and assistance to monitoring waste resources.

We will also advocate between communities and technology developers to ensure that community issues and concerns are fully understood and addressed, and that the technologies being developed are culturally appropriate. Through maintaining our

presence in the North, we will be able to assist with gap analysis and help remote communities identify suitable technologies to meet their unique needs. This activity complements other initiatives lead by programs such as the National Research Council's (NRC) Biotechnology Research Institute for blackwater treatment research and data programming.

Key steps for implementation



Area of Focus 2.3: Facilitate the development of affordable, innovative, and culturally informed **homes** that can be built and maintained within remote northern communities.

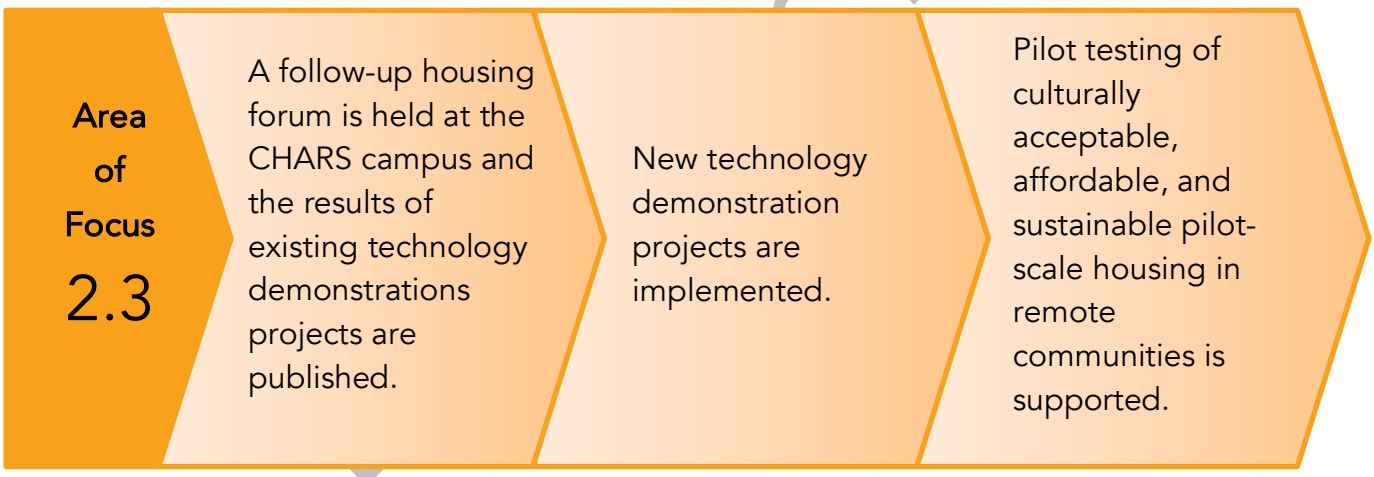
Remote northern communities face a significant number of housing issues ranging from a lack of affordable housing, overcrowding of residential units, and poor design and building practices. These issues can lead to health and social concerns, as well as houses that are unsuitable for the environment. Affordable, sustainable, and culturally acceptable infrastructure and housing in remote northern communities is needed (ITK, 2019; Stratos Inc., 2018). The development of housing technologies and construction practices and techniques is needed to relieve the housing shortfall and improve overall living conditions.

Housing issues are often addressed in isolation, without consideration of constructing and maintaining homes in remote northern communities or the social and cultural requirements of individual communities. We will function as a conduit between remote communities, builders, and technology developers to ensure that construction techniques and materials are producing culturally and environmentally acceptable and affordable housing for remote communities.

With our collaborators, our in-house team will focus on mobilizing knowledge related to northern housing to inform decision-makers and community members. We will also provide facilities and personnel for hosting technology, construction, material, and building demonstration projects, and we will support local communities in the installation of real-time monitoring programs.

This activity will complement existing work by continuing to bring together a diverse range of collaborators including community members, housing corporations, government, and industry agencies to ensure a more holistic approach to improved housing. The results generated from this work will be linked to NRC's Construction Research Centre monitoring projects on dual core Heat Recovery Ventilator (HRV) and the Canadian Mortgage and Housing Corporation (CMHC)'s Energy Recovery Ventilators (ERVs) and HRVs.

Key steps for implementation



Goal 3: Increase understanding of the connections between northern community wellness and environmental health

OUTCOME:
Improved knowledge of wildlife health leading to a better understanding of country food quality and supply, and greater clarity on the connection between human activities and the environment.

Acting on the changes taking place in northern environments requires an understanding of the health of wildlife populations and their habitats, with emphasis on species that are important for local food security (i.e., country foods). We will collaborate with existing monitoring and research efforts focused on where the health of wildlife, ecosystems, and communities intersect, with emphasis on the outcome of environmental change for local food security and community wellness.

Our in-house team will contribute to wildlife health surveillance in the Canadian North, and will coordinate multiple stakeholders and organizations across local, regional, national, and international scales to encourage standardized and shared approaches. We will also support projects and initiatives outside of the CHARS ERA that improve our understanding of wildlife population health and the potential effects of human activities.

Goal 3 has clear links to ecosystem research (Goal 1), and infrastructure and development (Goal 2), with a focus on understanding the effects of wildlife population changes on local communities (e.g., food security and traditional lifestyles among others) and the effects of local pollution on the environment.

Area of Focus 3.1: Enhance understanding of **wildlife population health** through research that addresses the needs and priorities of local communities.

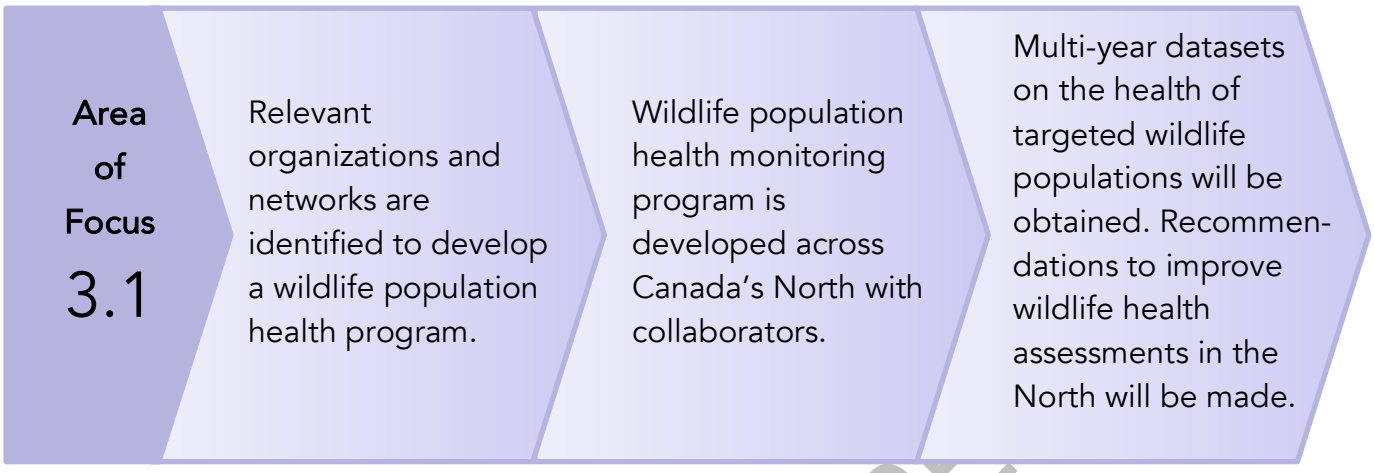
Activity 3.1.1: Strengthen health assessments of wildlife populations.

Harvesting of local wildlife species contributes significantly to northern food security, provides means for revenue, and is deeply ingrained in Indigenous cultures and traditions (Myers et al., 2005). Given the interconnectedness between animal, human, and ecosystem health and the rapid ecological changes occurring in northern ecosystems (IPCC, 2018; Meakin and Kurvits, 2009), there is an urgent need to understand and effectively monitor the health of wildlife populations. This work includes monitoring parameters like population demographics and trends, body conditions, and occurrence and exposure to infectious and non-infectious diseases (e.g., contaminants) (Stephen and Duncan, 2017).

Effective monitoring of northern wildlife populations is undermined by numerous logistical challenges. This leads to knowledge gaps on the status of many wildlife populations of utmost importance for local food security and economies. Filling gaps in the existing long-term monitoring of wildlife population health in the Canadian North is a key objective for POLAR. In-house research will support and complement existing efforts and initiatives at the local, regional, and national levels (e.g., wildlife disease surveillance coordinated by the Canadian Wildlife Health Cooperative (CWHC), Northern Contaminants Program (NCP) coordinated by Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC)).

We will seek opportunities to collaborate with wildlife co-management stakeholders, including territorial and federal governments, land claim organizations (e.g., Hunter and Trappers Organizations (HTOs), Wildlife Management Boards) and other renewable resources boards. We will also seek opportunities to strengthen monitoring networks for wildlife health assessments by connecting with relevant groups, programs, and initiatives (e.g., NCP, CWHC, Conservation of Arctic Fauna and Flora (CAFF)).

Key steps for implementation



Area of Focus 3.2: Assess the effects of human activities on environmental health and community wellness.

Activity 3.2.1: Assess the effects of local pollution and waste on environmental factors, such as air and water quality, in relation to community wellness.

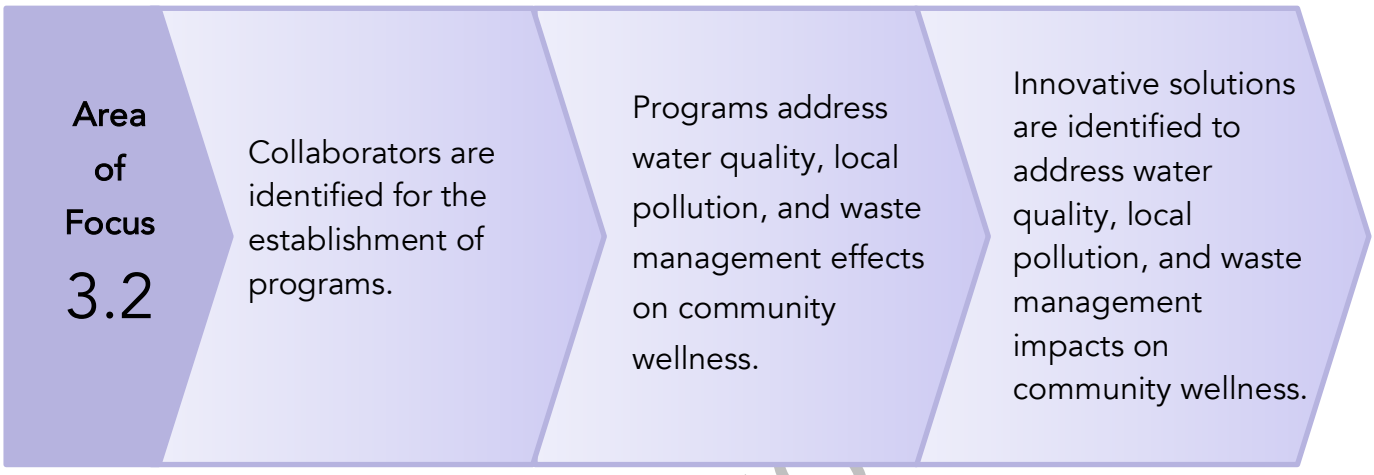
As communities grow, solid and liquid waste streams and point sources of pollution will also increase. This increases the potential for adverse environmental effects from local, human-related activities. While there is a sense that long-range contaminant-related health concerns have been extensively supported through national programs such as the NCP (CACAR Human Health, 2017; CACAR State of Knowledge, 2017), many other community health issues are not yet well addressed. A healthy, unpolluted environment is closely related to community wellness, both from the direct effects of pollution on human health, as well as from a cultural and spiritual perspective.

In-house community-based monitoring program will focus on assessing the potential environmental effects of human activities. Collaborations and external investments will focus on assessing the effects of local pollution and waste management on environmental factors such as air and water quality, in relation to community wellness.

This activity will complement the work of other organizations addressing issues related to northern community wellness in other parts of the Canadian North (e.g., territorial governments, Health Canada, CIRNAC). This activity will also support the work of programs such as Inuit Tapiriit Kanatami's (ITK's) Nuluaq Project (focused on

community well-being), CIRNAC's community-based monitoring programs, and academic networks.

Key steps for implementation



Key Approaches

This section describes the key approaches and general principles that we will use to effectively deliver on our goals:

In our analysis of engagement outputs, five key approaches emerged that indicate how Northerners and all Canadians expect research to be conducted. These will be integrated into all our work. Even more fundamental is the need to build mutual respect through meaningful engagement and collaboration with Indigenous People. As such, we aim to increase the involvement of Indigenous People in all stages of the research process, and to recognize the importance of Indigenous knowledge systems.

Our in-house research team will therefore deliver on our S&T Goals by drawing on different sources of knowledge and by applying five key approaches (Figure 2).

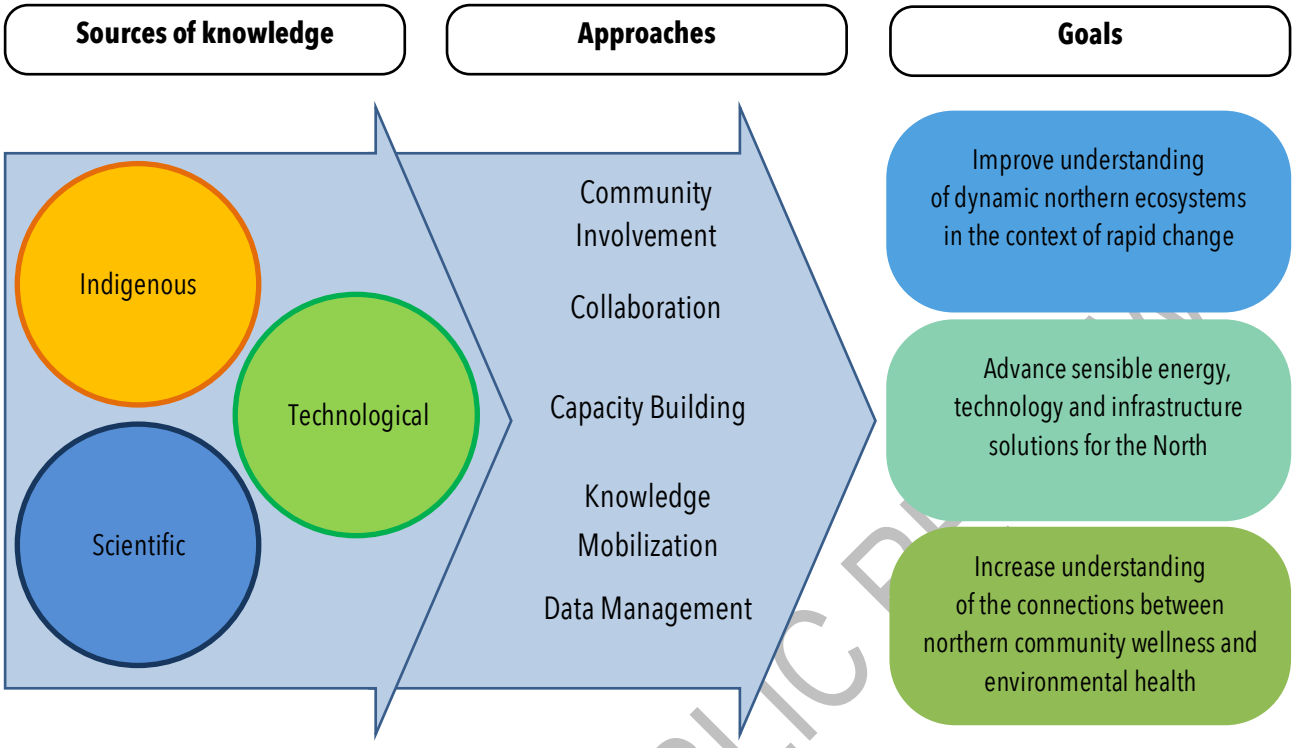


Figure 2 – A schematic illustrating how POLAR will deliver its goals by drawing on many sources of knowledge and employing a variety of approaches.

Community Involvement

Community-led research and community-based monitoring programs empower northern communities to address priority issues that are of local concern. Supporting community leadership in knowledge creation initiatives, training, and knowledge mobilization to overcome existing capacity barriers will be a key aspect of the implementation of this S&T plan.

The CHARS campus will function as a hub for research, monitoring, and knowledge mobilization that will bring together science, technology, and Indigenous knowledge. POLAR will work with collaborators to enable these efforts across the North and strengthen support for community-led initiatives to develop more knowledge. This approach offers a mechanism to both mobilize existing local and Indigenous knowledge and generate new scientific knowledge in a locally-relevant context.

Collaboration

Implementation of this S&T Plan requires collaboration with other government departments, Indigenous and community organizations, research institutions, university and college-based researchers, and the private sector. With the goal of leveraging resources and increasing existing programs and expertise, opportunities to develop

shared initiatives and achieve common goals will be sought. We will participate in regional, national, and international networks to maximize coordination, address gaps, and enhance existing efforts.

Capacity Building

POLAR strives to conduct and support generation activities that have close involvement with northern organizations and communities. At the organizational level, capacity-building efforts will support the development of initiatives that enable community-based monitoring and northern-led research. To build upon the capacity of individuals, we will focus on decreasing barriers and increasing opportunities for Indigenous and local leadership by supporting skills development and facilitating career exposure in monitoring and research. Our team is committed to inspiring, motivating, and aiding youth and early career professionals to continue learning and pursue careers in science, technology, engineering, and math (STEM), with a focus in the North. This will be achieved by supporting local, regional, national, and international initiatives for students and early career professionals in Canada.

Other capacity-building initiatives will include:

- Awards and exchange programs,
- Training, mentorship, and career opportunities,
- Youth education and outreach activities (e.g., science camps), and
- Supporting opportunities for knowledge sharing.

Knowledge Mobilization

Northerners have clearly stated that more action is required to make Indigenous knowledge and scientific findings available to decision-makers. A key focus will be to ensure broad access to research outcomes by tailoring knowledge products for different audiences. Wide distribution of these products will be prioritized to reach all Canadians.

Efforts will also be made to strengthen exchange between knowledge producers and users by providing opportunities for researchers and Indigenous knowledge holders to connect with diverse audiences across Canada. Strategies for knowledge mobilization will include in-person presentations, workshops, community meetings, and the development and distribution of scientific papers, plain-language reports, high-level summaries, and other products for various audiences.

Data Management

Access to data is important to support evidence-based decision making. Decision makers, including all levels of government, Indigenous organizations, planning commissions, and co-management boards, seek improved access to data.

We aim to work with collaborators to facilitate improved data stewardship with a focus on ensuring that metadata and data generated by POLAR-led and POLAR-supported projects are findable, accessible, and ethically open whenever possible. Our team will encourage conversations surrounding data sharing, ownership, and use across other networks and databases, including the ethical use and preservation of Indigenous knowledge. We will work in collaboration with others, such as the Canadian Consortium for Arctic Data Interoperability (CCADI), and the Arctic Data Committee (ADC) to support the development of tools and frameworks for sharing and archiving data.

Conclusion

This S&T Plan outlines the efforts that POLAR will be directly undertaking, and supporting, over the next five years, in response to knowledge needs that Northerners and all Canadians have identified.

Through our Goals for 2020-2025, POLAR will:

- Increase understanding of northern ecosystems and how they are changing to inform appropriate responses,
- Develop solutions to energy, technology, and infrastructure challenges, and
- Create new knowledge that contributes to community wellness.

We will achieve this through efforts by the in-house team, and through a wide diversity of collaborators, including Indigenous organizations and knowledge holders, national and international research bodies, universities, and federal and territorial governments.

Over the next five years, we seek to become known for our innovative approaches, including building long-term, respectful relationships with Indigenous communities and supporting the development of Indigenous researchers. The state-of-the-art CHARS campus, which is integrated into the community of Cambridge Bay, Nunavut, will be used to full advantage.

We are confident that by the end of 2025, work undertaken or supported by our team will have brought significant, new understanding of climate change effects in the North. This new knowledge will also have equipped decision and policy makers, at all levels, with information they need to plan the way forward with clarity in a time of unfamiliar and rapid change.

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Glossary

ADC – Arctic Data Committee – promotes an facilitates international collaboration towards the goal of free, ethically open, sustained and timely access to Arctic data through useful, usable, and interoperable systems

AMAP – Arctic Monitoring and Assessment Programme – one of the six Working Groups of the Arctic Council

ASDN – Arctic Shorebird Demographics Network – conducts shorebird demographic analyses for several target species to determine factors limiting their populations

BOLD – Barcode of Life Datasystems – a cloud-based data storage and analytics platform developed at the Centre for Biodiversity Genomics in Canada

CAFF – Conservation of Arctic Flora and Fauna – one of the six Working Groups of the Arctic Council

CBMP – Circumpolar Biodiversity Monitoring Program – an Arctic Council initiative to integrate and standardize biodiversity monitoring information of polar regions

CCADI – Canadian Consortium for Arctic Data – a group of Canada's foremost Arctic scholars and Arctic data managers

CHARS – Canadian High Arctic Research Station – a research campus located in Cambridge Bay, NU, and the headquarters for POLAR

CHARS ERA – Canadian High Arctic Research Station Environmental Research Area – POLAR's in-house research team will focus much of its work in this region

CIRNAC – Crown-Indigenous Relations and Northern Affairs Canada – a federal department renewing relationship between Canada and First Nations, Inuit, and Métis

CMHC – Canadian Mortgage and Housing Corporation – the federal lead for housing needs and the housing industry

CryoNet – The core component of the Global Cryosphere Watch (GCW) surface observation network. GCW is an international mechanism of the World Meteorological Organization's for supporting all key cryospheric in-situ and remote sensing observations

CSA – Canadian Space Agency – the federal lead for advancing the knowledge of space through science and for using its discoveries for the good of Canadians and all of humanity

CWHC – Canadian Wildlife Health Cooperative – a cross-Canada network of highly qualified people dedicated to wildlife health

DFO – Fisheries and Oceans Canada – the federal lead for safeguarding Canadian waters and managing fisheries, oceans, and freshwater resources

DNA – Deoxyribonucleic Acid – provides the genetic information for all multi-cellular life forms

ECCC – Environment and Climate Change Canada – the federal lead for protecting and conserving our natural heritage, and ensuring a clean, safe, and sustainable environment for present and future generations

ERV/HRV – Energy/Heat Recovery Ventilation – an energy/heat recovery ventilation system that works between two sources of different temperatures whereby recovery of residual heat in exhaust gas can be repurposed to preheat incoming fresh air

EHTO – Ekaluktutiak Hunters and Trappers Organization – the local HTO for the community of Cambridge Bay, NU, under the Nunavut Wildlife Management Board

FLUXNET – a global network of micrometeorological tower sites that use eddy covariance methods to measure the exchanges of carbon dioxide, water vapour, and energy between the biosphere and atmosphere

GTN-P – Global Terrestrial Network for Permafrost – the primary international programme concerned with monitoring permafrost parameters

HTO – Hunters and Trappers Organizations – are local community bodies under the Nunavut Wildlife Management Board tasked with managing the harvesting done by its members

iBOL – International Barcode of Life – an international consortium of researchers and organizations involved in DNA barcoding in order to discover and protect biodiversity

IPCC – Intergovernmental Panel on Climate Change – an intergovernmental body of the United Nations, dedicated to providing the world with an objective, scientific view of climate change, its natural, political and economic impacts and risks, and possible response options

ITEX – International Tundra Experiment – a long-term international collaboration of researchers examining the responses of Arctic and alpine plants and ecosystems to climate change

ITK – Inuit Tapiriit Kanatami – a national representational organization protecting and advancing the rights and interests of Inuit in Canada

NASA – National Aeronautics and Space Administration – is an independent agency of the United States Federal Government responsible for the civilian space program, as well as aeronautics and aerospace research

NCP – Northern Contaminants Program – a federal program working to reduce and eliminate contaminants in traditionally harvested foods

NRC – National Research Council of Canada – the primary Canadian federal research and technology organization in science and technology research and development

NRCan – Natural Resources Canada – the federal ministry responsible for Canadian natural resources, energy, minerals and metals, forests, earth sciences, mapping and remote sensing

NSERC – Natural Sciences and Engineering Research Council – is the largest funder of scientific research in Canada

POLAR – Polar Knowledge Canada – a federal agency leading Canadian polar science and knowledge, headquartered at the CHARS campus, Cambridge Bay, NU

S&T Plan – Science and Technology – this document is referred to as the Science and Technology Plan; a multiyear strategy for POLAR's science and technology activities over the next five-year horizon, 2020–2025

SSHRC – Social Sciences and Humanities Research Council– is the federal funding agency that promotes and supports research and training in the humanities and social sciences

STEM – Science, Technology, Engineering, and Math – a group of academic disciplines

UNESCO – United Nations Educational, Scientific and Cultural Organization – a specialized United Nations agency seeking to build peace through international cooperation in education, the sciences, and culture

WEICan – Wind Energy Institute of Canada – a not-for-profit entity that advances the development of wind energy across Canada through research, testing, innovation, and collaboration

Appendix A: Summary of What We Heard

The engagement meetings focused on the North and the open Call for Input focused at all Canadians included questions to identify what knowledge gaps POLAR should prioritize and how best to address those knowledge gaps to achieve its mandate. The following is a high-level summary of the responses received.

Improve Understanding of Northern Ecosystems

Ecosystem and cryosphere (sea ice, permafrost) research and monitoring is required at local, regional, and global scales to better understand trends and to develop predictive models. As Arctic and northern ecosystem change has global relevance, this work needs to be coordinated with other national and international efforts, as well as data-sharing initiatives. There is a particular interest in species that are utilized as country foods.

Explore Innovative Energy Sources and Building Technologies

POLAR should explore options for alternative and renewable energy, as well as innovations in building technologies. This will reduce the energy costs for families, businesses, and municipalities and improve environmental sustainability. Research and demonstration projects can help justify implementing new or innovative technologies in northern communities. Concerns over water quality and additional options for waste and wastewater management designed for northern conditions were also heard.

Partner with Other Northern and Arctic Organizations

There is interest in exploring opportunities to collaborate with other northern and international Arctic organizations who share similar infrastructure challenges, as opposed to simply importing ‘southern’ technologies. Sensible solutions for the North should consider local capacity for operation and maintenance, as well as access to specialized parts. Changing climate and weather patterns, including permafrost degradation and coastal erosion, are challenging the integrity of housing and infrastructure, with implications for health (e.g., mould, structural problems), business costs (e.g., tourism, shipping), and safety.

Discover Links Between Environmental Health and Northern Communities

There is a need to understand how changes in the environment affect food security, community well-being, and traditional lifestyles. Innovative research approaches are required to include community perspectives and Indigenous knowledge. General concern for environmental health was highlighted, ranging from local drinking water

quality to environmental pollution. Additionally, understanding effects of environmental changes on community health and wellness emerged as another important knowledge need.

Use Research and Monitoring to Support Decisions

Research and monitoring activities are required to support sound, evidence-based decision making and governance by Northerners and all Canadians. These activities are of interest to end-users including:

- Federal, territorial, and municipal governments,
- Resource co-management boards,
- Land-use planning commissions,
- Economic development organizations, and
- Indigenous groups.

Issues raised ranged from increasing marine and terrestrial development to climate adaptation. Northern stakeholders want to see applied research on anticipated development and emerging economic opportunities. Co-management boards and Indigenous organizations stressed the need for further research focusing on species at risk, fisheries, and terrestrial mammals – many of which are important for local subsistence and are considered environmentally sensitive, having scientific, economic, social, or cultural significance.

Conducting Research that is Beneficial to Northern Communities and Canadians

Northerners suggested that research should include community involvement, build collaborations, and assist with building capacity of local people. Northerners and all Canadians emphasized a need for broad knowledge mobilization and good data management to ensure that new knowledge and data would accessible for decision-making at local, regional, national, and international levels.