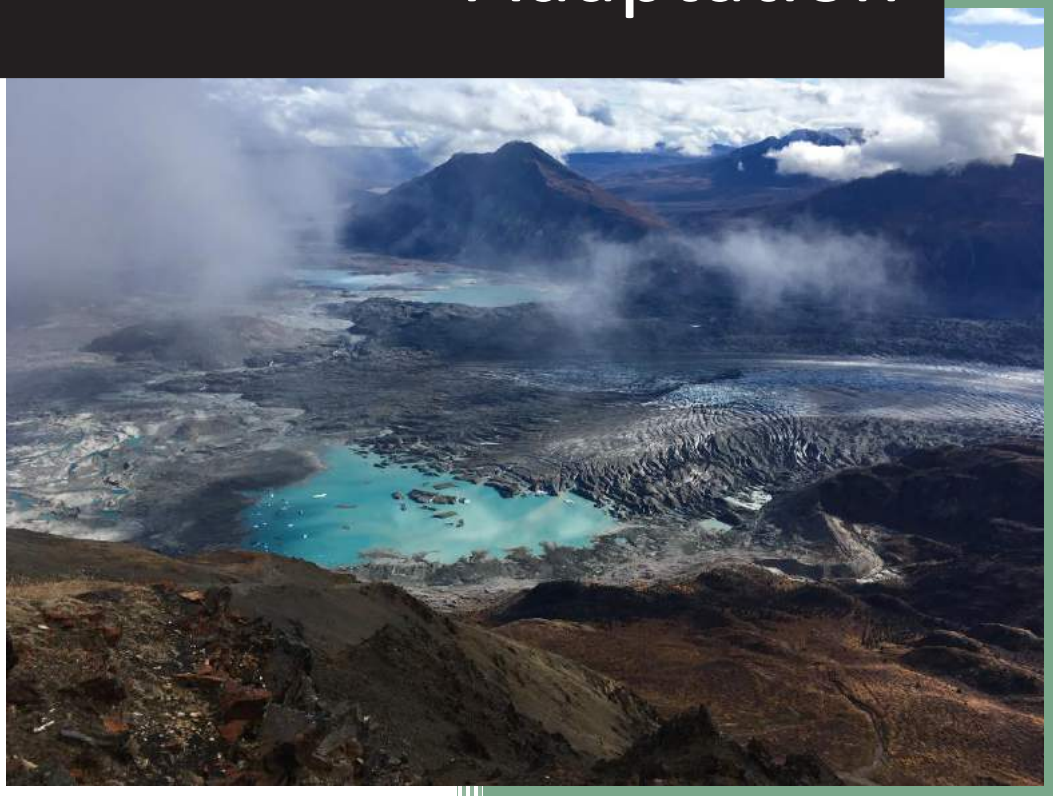
2017

Yukon 'State of Play': Analysis of Climate Change Impacts and Adaptation



Research Northwest & Morrison Hershfield

November 14, 2017

THIS PAGE HAD BEEN INTENTIONALLY LEFT BLANK

Executive Summary

This report was commissioned by Environment Yukon's Climate Change Secretariat to provide the public and other stakeholders with an understanding of how climate change is affecting Yukon, what actions have been taken to date to help us adapt, and the key challenges that we'll need to address to adapt in the future. This work will also explore the economic challenges and opportunities related to adaptation.

This is not a comprehensive analysis of all the issues around climate change and adaptation efforts. It is a synthesis of existing knowledge and provides a focused snapshot of selected key adaptation challenges in the Yukon.

The strongest measure of climate change in Yukon is relative change in annual temperature. The annual average temperature has increased 2°C over the past 50 years, while winter temperatures have increased 4°C.

Annual precipitation (rain and snowfall), another important indicator of climate change, has increased by 6% in the Yukon over the past 50 years, with the greatest increase seen during the summer months.

Temperature is projected to increase by more than 2°C over the next 50 years. Winters are projected to warm faster than any other season. Precipitation is projected to increase by 10% to 20% over the next 50 years in Yukon. Snowfall is projected to arrive later in the fall and become more variable over the winter, with periods of little snow and intense snow-fall events likely becoming more common.

Adaptation to climate change starts when governments, communities, and individuals adjust their expectations about the future and make decisions to better prepare for changing conditions. Yukon has already started to adapt to the effects of climate change and decision makers have an interest in addressing present and future climate change impacts through adaptation.

Growing concern for Yukon's changing climate has led to increased research and adaptation initiatives that contribute to the development of new knowledge and local capacity and expertise. Ensuring that the climate change funding and programming opportunities substantively enhance the adaptive capacity of communities is critical to Yukon's long-term adaptation efforts.

Table of Contents

Cover Photo: Kaskawulsh Glacier (Purdon, Matthias)

List of Figures

List of Photos

1. INTRODUCTION

This report was commissioned by Environment Yukon's Climate Change Secretariat to provide the public and other stakeholders with an understanding of how climate change is affecting Yukon, what actions have been taken to date to help us adapt, and the key challenges that we'll need to address to adapt in the future. This work will also explore the economic challenges and opportunities related to adaptation.

This is not a comprehensive documentation of all the issues around climate change and adaptation efforts. It is a synthesis of existing knowledge and provides a focused snapshot on selected key adaptation challenges in the Yukon.

1.1 CONTEXT

Climate change is already affecting Yukon and consideration of climate is becoming increasingly important in decision making and planning for the future. The Yukon Climate Change Impacts and Adaptation 'State of Play' report was developed to provide Yukoners with the latest information about climate change impacts and adaptation in Yukon. Included in the analysis are the economic impacts of climate change. The report is designed to support public participation in decision making about climate change issues that affect Yukon communities by providing a snapshot of climate change impacts and adaptation efforts to date.

Canada, along with most other countries, has begun taking more aggressive action on climate change. The recently adopted *Pan-Canadian Framework on Clean Growth and Climate Change* (2016) commits to action in the areas of climate change mitigation, adaptation, carbon pricing, and clean economic growth.

The Yukon government has committed to renewing its climate change strategy in a manner that better integrates its approaches to energy, climate change risk and action, and clean growth/economic development. Throughout this process, Yukon government aims to engage with the public to solicit feedback on the renewal of this strategy.

The effects of climate change pull on environmental, social, and economic threads, not all of which are directly related to the changing climate, but are still important to consider when planning for effective adaptation actions. These include environmental changes caused by drivers other than climate change, as well as demography, culture and economic development. Indeed, "climate change has compounded some of the existing vulnerabilities caused by these other factors" (Larsen et al., 2014).

Adaptation to climate change starts when governments, communities, and individuals adjust their expectations about the future and make decisions to better prepare for changing conditions. Yukon has already started to adapt to the effects of climate change and decision makers have taken steps to address present and future climate change impacts through adaptation policies and initiatives. Despite this, efforts to integrate climate change considerations into decisions and implement effective adaptive actions face significant challenges.

Our ability to adapt to climate change will have an important influence on what Yukon's future will look like. If we are proactive in our approach to adaptation many issues can be avoided and some impacts lessened. However, some impacts will be much more difficult to adapt to.

Building momentum for climate change adaptation will take time and concerted effort. Developing expertise and allocating adequate financial resources to adaptation initiatives and planning is critical. This report was developed in part to help support collaborative opportunities for climate change adaptation where connections are not always clear and simple.

What is Climate Change Adaptation?

Climate change adaptation refers to actions that reduce the negative impact of climate change and/or take advantage of new opportunities. It involves making adjustments in our decisions, activities and thinking because of observed or expected changes in climate.

(Lemmen, Warren, Lacroix, and Bush, 2008).

1.2 APPROACH

Our approach to this report has been to:

- Provide a synthesis of the most up to date information available on climate change impacts and adaptation in Yukon (Section 2);
- Select and present concrete examples of some of the Yukon-specific work being done to better understand the effects of local climate change (Section 2.3);
- Provide an overview of our assessment of the Yukon's capacity to adapt to climate change (Section 3) along with a list of known adaptation initiatives undertaken in the territory (**APPENDIX B**); and,
- Examine in more detail four issues that are particularly important as the Yukon continues to adapt to the realities of climate change:
    - Increased risk of extreme weather and wildfire hazards (Section 4);
    - Damage to infrastructure (Section 5);
    - Changing ecological landscapes (Section 6); and,
    - Concerns regarding human health (Section 7).

The four major issues grew from our review of the relevant literature and discussions with key contacts. For each of the four issues listed above, we summarize how climate change and current adaptation efforts intersect with the issue now and how we expect those intersections to change.

We have attempted to identify further opportunities for adaptation, economic costs and possible economic benefits. These opportunities are not intended to be exhaustive or definitive, but to provide a starting point for a renewed conversation about how Yukon can address current and future climate change impacts.

Our focus on further opportunities for adaptation has been guided by four questions:

- Are the risks of not taking further adaptation action significant?
- Are there possible economic benefits from the adaptation action itself?
- Will Yukon regret doing this if the climate threat does not materialize?
- Is this action a win for Yukon communities even if the climate threat turns out to not be a severe as some scenarios projected?

We have also attempted to explicitly highlight where the suggested adaptation opportunities might intersect with other issues and opportunities in Yukon (e.g. Fire Smart and biomass heat). Adaptation opportunities and efforts are rarely stand-alone issues.

Photo 1: Slims River

(Environment Yukon)

2. YUKON'S CHANGING CLIMATE

Climate change is a complex problem that impacts natural, human, and cultural systems in many ways. In Yukon, changes to the climate have already been observed and impact our water, ecosystems, landscapes, and ways of life. How climate change is understood and talked about in Yukon is grounded in scientific evidence, the Traditional Knowledge of Yukon First Nations, and the observations of Yukoners.

Changes are expected to continue and increase in the decades ahead. The amount of change and associated impacts will ultimately depend on the success of global efforts to curb emissions of greenhouse gasses (i.e. mitigate climate change) and our ability to adapt to climate change

Temperature and precipitation are well understood and widely used indicators of climate change that drive a broad range of climate impacts. The Yukon generally has only about 50 years of temperature and precipitation data, not a significant record given that a climate normal is usually defined over a 30-year period. This lack of long-term data makes additional proxy data drawn from historical, local, and indigenous sources of knowledge particularly valuable in improving our understanding how climate change is affecting the Yukon.

Gradual and Sudden

Although temperature and precipitation seem to be changing slowly, the interaction between "gradual" changes and other factors can produce complex and sudden effects. For example, warmer annual temperatures associated with climate change have accelerated the retreat of the Kaskawulsh glacier, which led to a sudden diversion of water from the Slims River to the Alsek River in 2016. This resulted in a substantial drop in water levels in the Slims River and in Kluane Lake, which impacts the communities of Burwash Landing and Destruction Bay.

Variability Within Long-Term Trends

Long-term climate trends are important, but these broader changes are driven in part by short-term weather variability. Extreme swings in temperature and precipitation can have serious impacts on everything from infrastructure to wildlife breeding cycles, but increases in the severity, frequency or duration of extreme events are not easily captured in long-term trends. For example, a one degree increase in average annual temperature can mean 25 days where temperatures are 15 degrees above the seasonal normal if climate remains at normal levels the rest of the year. This example shows how averaging change in temperature throughout the year can hide the extent of extreme temperature variability.

This section summarizes analyses of temperature and precipitation data to show how Yukon's climate has changed and how it is expected to change in the future. Projections for temperature and precipitation change in Old Crow and Whitehorse are also highlighted as local examples of the type of change Yukoners can expect to see in their communities.

As climate change impacts Yukon's regions in different ways, this section also includes discussion of how Yukoners are observing the impacts of climate change in their own communities

and in culturally and ecologically important places. These and other related changes present a wide range of challenges and opportunities for future adaptation efforts in Yukon.

2.1 Historical Changes in Temperature and Precipitation

The strongest measure of climate change in Yukon is relative change in annual temperature. The annual average temperature has increased 2°C over the past 50 years, while winter temperatures have increased 4°C. These temperatures are understood to be increasing at twice the rate of southern Canada and the global average. This rise in temperature means that winters are getting shorter and spring and fall are getting relatively longer. There are significantly fewer very cold days in the winter but no significant change in the number of very hot days (above 30°C) in the summer. (Furgal and Prowse, 2008; Larsen et al., 2015).

Warmer average temperatures are associated with a wide variety of impacts on Yukon communities and landscapes. For example, more rapid permafrost thaw is resulting in an increase in impacts on community infrastructure built on permafrost areas. Warmer temperatures have also resulted in widespread melting of glaciers and the rate of melt continues to increase. Yukon has lost 22% of its glacial cover over the last 50 years (Derksen et al. 2012).

Annual precipitation (rain and snowfall), another important indicator of climate change, has increased by 6% in the Yukon over the past 50 years, with the greatest increase seen during the summer months (Streicker, 2016). Changes in precipitation cause changes in surface and ground water, permafrost, vegetation and wildlife. Yukoners have experienced higher summer precipitation and more extreme rain events, associated flood events, permafrost thaw (more snow cover traps heat in the ground), and river bank erosion. The trend points towards a further increase in annual precipitation and possibly more extreme variability in precipitation as well.

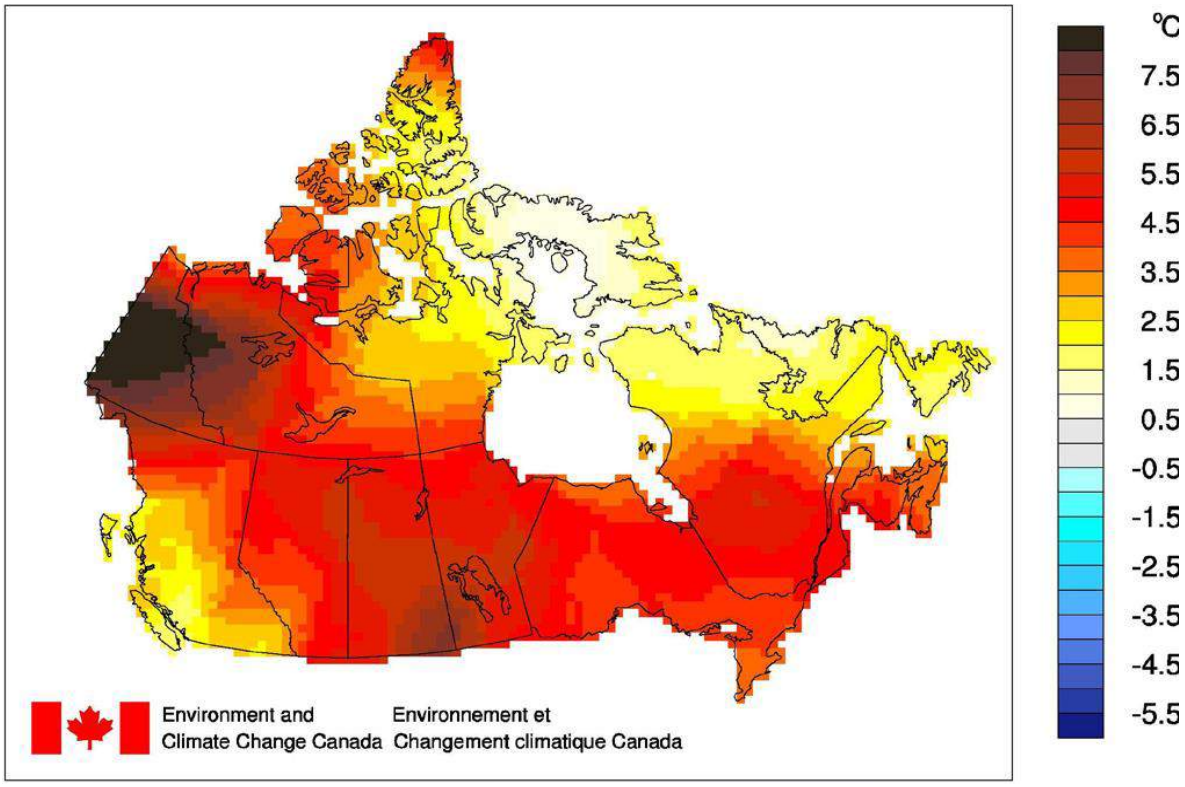
Yukoners have observed an increase in short-term extremes in temperature and precipitation and data suggests that variability is increasing in Yukon. Projected future changes in temperature and precipitation suggest that short-term extremes will happen more often (Streicker, 2016).

El Nino

During "El Nino" years, periodic warming of the Pacific Ocean drives warmer and more extreme weather patterns across North America. In 2015-16 El Nino contributed to Yukon winter temperatures that were almost 7°C above seasonal averages (Environment Canada, 2017). Typically, El Nino years have been observed 5 out of every 100 years, but new research suggests that global climate warming is likely to increase the number of El Nino events to 10 in every 100 years under current emission scenarios (Guojian, et al., 2017).

Figure 1 shows how winter temperatures in 2015/2016 departed from the 1961-1990 average across Canada. The biggest departure from average occurred in the central Yukon.

Figure 1: Temperature Departures from the 1960-91 Average – Winter 2015/2016



(Environment and Climate Change Canada, 2017)

2.2 Expected Future Changes in Temperature and Precipitation

The Intergovernmental Panel on Climate Change has developed three scenarios for future temperature changes for Polar Regions. All scenarios show both an increase in temperature and its variability. Temperature is projected to increase by more than 2°C over the next 50 years in Yukon (Streicker, 2016). Winters are projected to warm faster than any other season (IPCC, 2014).

Precipitation is projected to increase by 10% to 20% over the next 50 years in Yukon. All scenarios project a significant increase in precipitation. In practical terms, this means that precipitation is expected to become more variable and increase in summer months. Snow fall is projected to come later in the fall, become more variable with periods of little snow, and it is likely that intense snow-fall events will be more common (Streicker, 2016).

These expected continuing changes in temperature and precipitation matter to Yukoners as they will need to cope with, and adapt to changes in local environments, impacts on community infrastructure built on permafrost areas, more extreme rain events and associated floods.

For more detail on how Yukon's climate has changed and how it is expected to change in the future see **APPENDIX A** at the end of this report.

2.2.1 Community-Level Climate Change Projections

The Scenarios Network for Alaska and Arctic Planning (SNAP) has developed a climate model that projects temperatures and precipitation patterns for approximately 80 locations in the Yukon. These projections give a sense of how, at a broad level, climate is expected to change at those locations. SNAP releases these projections with the qualifier that there is inherent uncertainty in projecting future climate change, but that the value of developing and using the projections in community adaptation planning "allows for greater flexibility in the face of high uncertainty" (SNAP 2017). One weakness in the SNAP model is that it does not take temperature inversions (i.e. significant temperature differences between lower altitude and higher altitude areas) into account, an important issue in many Yukon communities.

We have selected Whitehorse and Old Crow as examples to illustrate what the SNAP model provides. See **APPENDIX A**. Some selected highlights of the SNAP projections for Old Crow and Whitehorse are:

- Winter temperatures are projected to increase significantly for both Old Crow and Whitehorse;
- Both Old Crow and Whitehorse are projected to have much warmer spring (May and June) temperatures with little extra rainfall in those months;
- Overall precipitation is projected to increase steadily in Old Crow; and
- An overall increase in precipitation for Whitehorse but with more variability than Old Crow.

In general, the same changes are projected for both Whitehorse and Old Crow with notably warmer temperatures and more precipitation expected in the coming decades. At a practical level, these trends likely lead to different kinds of anticipated changes in both communities such as:

- A longer growing season that will allow more local agriculture and therefore more local food supply;
- Increased fire risk early in the fire season which will have the effect of extending the fire season and its associated risks and costs;
- A reduced period during which ice and frozen ground can be used for travel or food storage which may reduce traditional activities; and
- A shift in precipitation from snow to rain, which impacts water storage capacity and surface water availability.

2.3 Community-Level Observations of Climate Change

Yukoners have observed and experienced the impacts of climate change in their communities. Indigenous elders speak to changes on the land, communities, and traditional practices originating from changes in climate.

Sections 2.3.1 through 2.3.3 highlight three examples from of local climate change impacts that have been observed at the community-level. These examples help to illustrate how our changing climate is affecting people in different areas of Yukon, and helps us better understand potential

impacts that we may see in the future. They are also strong reminders of the need for improving local climate monitoring and data collection, and partnerships that will sustain these efforts, to better understand and adapt to climate change impacts that affect Yukon communities.

2.3.1 Yukon First Nation Elders see Climate Change Impacts to Water, Wildlife and Traditional Foods

Yukon First Nations elders and other community members have concerns about the changes that are taking place on their lands that affect their way of life. Elders have documented many changes on the land and in their communities and are concerned about the future.

Indigenous Knowledge

Indigenous knowledge and observations are important to understanding climate change in Yukon. This knowledge indicates that important changes have already occurred. "In the Yukon community members are reporting changes including: unpredictable weather, glaciers and permafrost are melting, wildlife migration patterns, new species, insect populations, increasing forest fires and different water levels." (Champagne and Aishihik First Nations and Alsek Renewable Resources Council, 2009).

At another Yukon workshop elders described similar experiences with the weather becoming unpredictable, expressing growing concern about impacts of climate change on wildlife, land, and water (Dickson, in Henderson and Fox 2005 p. 77).

Elders highlighted the following changes in forums held in 2003-2004 in Yukon First Nation Communities (Huntington, Fox, and Dickson, 2005):

- In northern Yukon, freezing rains in the early winter have created a layer of ice that limit the ability of some animals to access food sources.
- The bush and the forest are changing and shrubs are getting larger, and more abundant in areas where they were not typically seen before.
- Birds that usually migrate south in August and September are now being seen in October and November.
- In some areas, thawing permafrost has caused the ground to drop or has made the area smell foul.
- In more southerly communities, rings around the moon are no longer seen, although they are still visible in the northernmost community. Similar changes to the visual character of the atmosphere have been observed by Inuit Elders who observed changes in the location of the sunset on the horizon (Kunuk and Mauro, 2015). These observations indicate higher levels of moisture in the air linked to increases in temperatures.
- There are more frequent sightings of cougars, and mule deer, and new types of insects.
- People used to be able to predict when it would get colder by looking at tree leaves. It has become more difficult to do that now.

- Lakes and streams are drying up or becoming choked with weeds, making the water undrinkable.
- Many animals are changing where they go and their behavior. Bears used to go into their dens in October and November, but are now out until December.
- There is a growing dependence on market foods and people eat fewer traditional foods.

These are just a few examples of the type of climate change impacts that are causing alarm for many Yukon First Nation elders. Importantly, elders emphasize the need for each community to have the ability to prepare for change and to be a part of designing the strategies that are being developed to respond to climate change impacts.

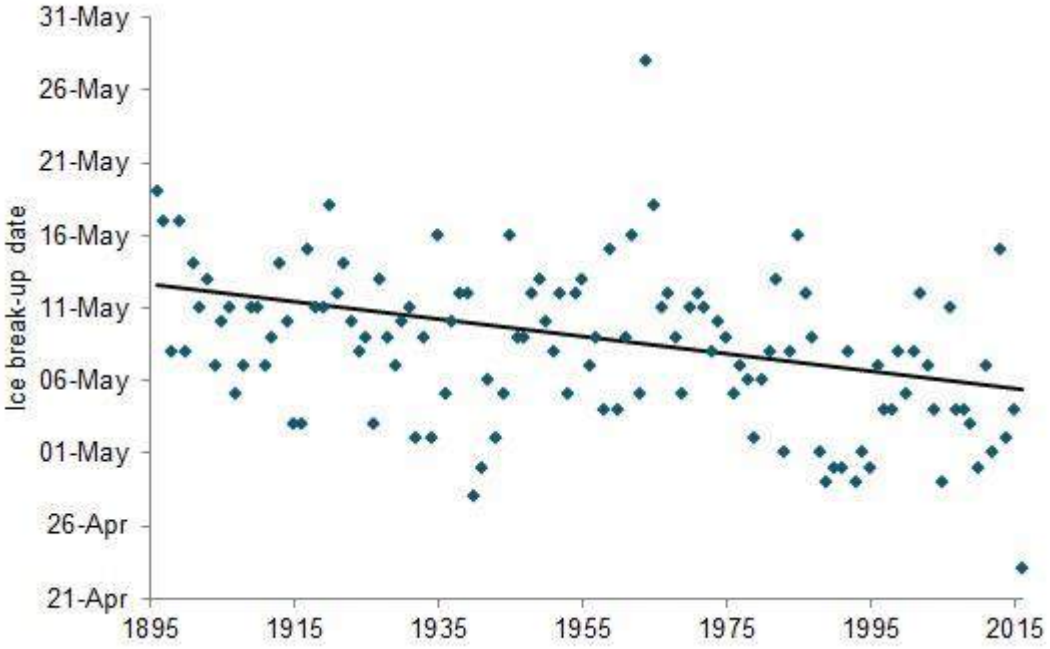
Initiatives like the ongoing adaptation planning efforts of the Champagne Aishihik First Nation (CAFN) and the Selkirk First Nation (SFN) are examples of this work in action. These initiatives have sought to engage directly with community members to understand environmental changes that First Nations citizens are seeing on their traditional territories, and develop new ideas and approaches to preserving traditional practices in the face of climate change.

2.3.2 Ice Breakup on Yukon River in Dawson City

Long-term community level impact information like the breakup data discussed here is valuable for measuring change, understanding the rate of change over time, and can help inform planning for the future. The trend from the past 120 years of breakup data is strong evidence that that fast ice cover on the Yukon River – the ice that extends into water from shore – will continue to diminish in Dawson. Although still an uncommon occurrence, in the winter of 2016-2017 an official ice road was not possible because of poor ice conditions. Long-term data on the ice break up is an indicator that can help inform adaptation measures like extending the ferry season, and planning for shorter ice road seasons.

The exact timing of the ice breakup on the Yukon River in Dawson has been recorded every year since 1886. The practice that originated from a lively betting tradition now provides a long-term indication of how changes in climate are impacting the breakup. **Figure 2** shows the timing of the ice breakup over the past 120 years. The trend line shows the spring breakup occurring on average 6 days earlier per century.

Figure 2: Timing of the Ice Breakup on the Yukon River in Dawson City



(Environment Yukon, 2017)

Earlier breakup means that the ice road across the Yukon River that connects the town of Dawson with West Dawson will experience shorter seasons, limiting access to food, medical care, and work and recreation opportunities for West Dawson residents. All West Dawson residents plan for the shoulder season when there is no access to town, however, when the season extends longer than anticipated residents may be faced with shortages in food or other essential goods that occasionally require expensive helicopter re-supplies. Furthermore, not captured in the ice break-up data is that warmer and more variable temperatures increase the risk of mid-winter and spring flooding. In 2009, ice jamming and unusual patterns of river ice break-up triggered significant damage to infrastructure in Dawson City.

2.3.3 Changes in Vegetation and New Bird Species on Qikiqtaruk-Hershel Island

Documented changes in vegetation and the observation of new bird species on Qikiqtaruk-Herschel Island serve as an example of how climate change is affecting Yukon's most northern region.

A seventeen-year study of the vegetation communities on Qikiqtaruk-Herschel Island documented rapid changes to the island's vegetation ecology (Myers-Smith et al. 2017). Shrubs and grasses are growing higher and expanding into areas that were typically bare or had minimal vegetation. The changes were linked to warming air temperatures along with longer growing seasons and increasing permafrost thaw.

Recent bird surveys conducted on Qikiqtaruk found several migratory bird species that are normally only found in areas a thousand kilometers further south. The most striking example of this was the discovery of a Calliope Hummingbird in the summer of 2017 (see Photo 2).

These observations indicate how changes in climate are changing local ecology and landscapes across Yukon. This has far reaching consequences for wildlife and vegetation that are still not fully understood. While we know that some birds and shrub are changing in response to shifting temperatures, plant or animal species that cannot adapt or move to more favourable areas fast enough may experience stress and other negative impacts.

Photo 2: Calliope Hummingbird, Quiqtaruk-Hershel Island

(Eckert, Cameron, June 2017)

3. YUKON'S CAPACITY TO ADAPT

Yukon's climate change adaptation landscape involves a diverse group of governments and non-governmental organizations with a wide range of jurisdictional responsibilities, resources, and areas of interest and expertise. While the variety of actors involved makes it difficult to assemble a comprehensive picture of Yukon's adaptation capacity, analyzing some of the adaptation projects or initiatives that have been undertaken by these groups provides us with a snapshot.

3.1 YUKON ADAPTATION EFFORTS TO DATE

Over $13 million has been invested since 2008 in the 80 adaptation projects identified in this analysis, most of which (85%) was provided through federal government agencies and programs. More than two-thirds of these projects were partnerships between two or more organizations, with most implemented by First Nations or territorial government agencies – often in partnership with other non-profit, indigenous, or academic organizations – and funded by the federal government.

Two notable federal adaptation programs that have served as drivers of territorial efforts to date to address climate change impacts are:

- Indigenous and Northern Affairs Canada's *Climate Change Preparedness in the North* program (formerly *Climate Change Adaptation Program*) supports identification and assessment of climate-related risks, adaptation research and planning, and efforts to address major climate change issues such as related to infrastructure, extreme weather events, and permafrost degradation. This analysis has identified 35 projects financed through the two funding streams of the program (for First Nations communities and territorial government departments, respectively).

- Health Canada's *Climate Change Health Adaptation Program* has emphasized a community-focused approach; projects address climate change-related needs identified by the community, strengthen a community's adaptive capacity, and involve community members in the project's results. This analysis identified 23 Yukon projects funded through this program, many of which focused on food security and Traditional Knowledge transfer between elders and youth.

The focus of most of these projects has been determined by the capacity and specific interests of proponents, and the criteria set out by funding agencies. These criteria, designed to be enabling rather than proscriptive, have provided significant flexibility for proponents to address climate change impacts of interest to their organizations or communities. While this flexible, project-based approach has helped to realize adaptation actions that might not otherwise occur, it is also more piece-meal than strategic, and does not easily lend itself to a more coherent effort to develop capacity or expertise in areas where they are most needed, or where they can have the biggest impact.

A summary of adaptation projects identified for this analysis can be found in APPENDIX B.

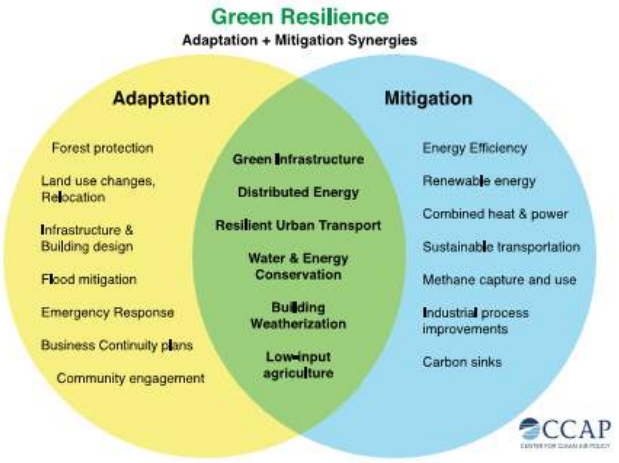
3.2 Key Challenges to Advancing Yukon's Adaptive Capacity

Building partnerships, developing Yukon-specific climate information, fostering innovation, and initiating dialogue with communities about climate change impacts have been the focus of much of the adaptation work that has been undertaken to date in the territory. Building on this work, and re-focusing efforts towards the targeted development of capacity and resources will be an important component of building resilience to climate change across sectors and communities. There are, however, certain challenges that will need to be addressed along the way.

Most of these challenges relate to the multi-faceted nature of climate change (i.e., its complexity and uncertainty) and difficulties related to governance (i.e., difficulty of implementing adaptation due to limited annual budgets and competing priorities). The sense of urgency to address challenges that limit Yukon's capacity to adapt is growing as impacts of climate change, and related issues of community development and sustainability, increase. Other specific issues that limit Yukon's ability to adapt to climate change include:

- Climate change is complex and cannot be fully understood or dealt with by one organization or government – especially in Yukon, which has eleven self-governing First Nations in addition to federal, territorial and municipal agencies with overlapping jurisdictions and interests.
- Government departments and policy-makers sometimes struggle to prioritize long-term planning objectives related to climate change adaptation when faced with immediate needs and financial constraints. Furthermore, it is often difficult for many decision-makers to see tangible connections between the issues they are mandated to address and the interaction of these issues with climate change.
- A challenge in the Yukon, as in the rest of Canada, is that there has been little effort to actively support climate change adaptation through changes to existing legislation or regulations. In part, this appears to stem from a general reluctance to open legislation for changes and from a lack of clarity or consensus on what changes should be made.
- Difficulties in integrating adaptation into long-term planning are compounded by limited local-level information or projections about climate change impacts, which serves to increase uncertainty about what actions should be taken to address climate change impacts at a local scale.
- Financial management and administration systems are sometimes designed in ways that do not adequately consider the long-term financial costs of climate change in present-day spending and procurement decisions (e.g., new buildings are not required to take into consideration possible impacts of climate change).
- Slow progress on mitigating climate change (i.e., reducing GHG emissions) in Yukon risks slowing adaption as well. Successful climate change mitigation measures, particularly in the areas of infrastructure and buildings, will help adaptation and vis-versa (see **Figure** 3).

Figure 3: Green Resilience: Adaptation and Mitigation Synergies



(Centre for Clean Air Policy, 2016)

As impacts of climate change become more apparent, the adaptive capacity of many communities may be challenged or exceeded but the severity of these impacts, reducing their ability to adapt. "Extreme impacts can exceed human and financial resources to address them, and can cause physical, financial and psychological stress. Stress on local governments and service providers, and other responders to disasters, can reduce adaptive capacity to address climate change impacts in both the short and long terms" (Manuel et al., 2012 in Lemmen, D.S., et. al. 2016 p. 118). Building partnerships and relationships with communities so that they can address key vulnerabilities over the long-term will help address this challenge.

No Regrets

The broader benefits of acting to adapt to climate risks is the low/no regrets model where decisions or actions related to climate change make sense in development terms regardless if a specific climate threat materializes in the future. This is achieved by building resilience to changing economic, social and environmental conditions (Adapted from Siegel, 2011). This approach is useful when considering how to plan and prioritize adaptation measures. One can ask: will we regret doing this if the climate threat does not materialize? Is this action good for Yukon communities even if the climate threat turns out to not be as severe as some scenarios project?

Although progress has been made in this area, climate change adaptation still is not systematically considered in most government policy decisions. This makes Yukon more vulnerable to climate change impacts, as present-day solutions are developed without adequate understanding of how the problems being addressed may be affected by climate change over the long term.

Photo 3: Yukon Landslide

(Environment Yukon, 2006)

4. Extreme Weather Events and Wildfire

4.1 Extreme Weather Events

The variability of our climate is expected to increase. This will mean more extreme weather events and greater fluctuations in precipitation, which are associated with increases in landslides and flooding. Flooding can negatively affect communities in a range of ways, including population displacement, impacts on critical infrastructure, interruptions to business activities, decreased production due to worker displacement, impacts on physical health, and impacts on mental health, including depression, anxiety, and post-traumatic stress disorder (Henstra, D. and Thistlethwaite, J., 2017).

Some of the direct and indirect costs that result from extreme rainfall events are exemplified by the flash floods that simultaneously washed out the Alaska Highway at Rancheria and at the south end of Kluane Lake in 2012.

Alaska Highway Closed

"The Alaska Highway reopened Monday evening near Rancheria following the completion of a road detour around the substantial washout at Canyon Creek. Northbound commercial trucks stranded at the highway lodge since the washout occurred last Thursday night were the first to be taken over the single-lane detour… Once Rancheria was cleared, some 200 commercial trucks waiting in Watson Lake to come north were released… Larger industrial vehicles followed. Then private vehicles and RVs were released in groups behind a pilot car. Southbound traffic backed up in Teslin was released at about the same time as vehicles waiting in Watson Lake to come north."

(Whitehorse Star, June 12, 2012).

The highway was closed for a total of four days at Rancheria and two days at Kluane Lake. During this period, the costs that resulted from these closures included:

- Both the emergency road repairs and the permanent repairs;
- The business costs to trucking companies as hundreds of trucks sat idle for days and trucking schedules were disrupted;
- The time costs to travellers, both locals and tourists, whose plans were disrupted and delayed;
- The costs to businesses who ran out of goods (particularly at grocery stores, where shelves sat empty), and to others whose workers were unavailable due to the travel disruption;
- The costs of delays in mail and parcel delivery services; and
- The knock-on losses to tourism businesses as people changed their plans in response.

4.1.1 Adaptation to Flood Hazards

In Canada, flooding has surpassed theft and burglary as the largest single source of property insurance claims (Henstra, D. and Thistlethwaite, J., 2017). Mitigating flood hazard risk requires that we improve knowledge and awareness of what values (e.g. personal or commercial property, public infrastructure, industrial infrastructure, sites for traditional activities, etc.) are exposed to these risks, and what arrangements are currently in place to reduce vulnerability to flooding. In 2016, Yukon government collected digital elevation data in 13 communities to identify what areas might be exposed to flooding at different water levels. This data is currently available online and is being used to create flood risk maps for use by residents, decision-makers and land-use planners.

Photo 4: Flooding at Army Beach

(Environment Yukon, 2007)

Other adaptations to climate change-driven increases in flood hazards in Yukon, both flash flooding and other higher water levels, are currently being advanced through ongoing efforts to reduce flood risks and damage, including:

- Better land planning and zoning to account for flood risks;
- Flood control infrastructure in already developed areas subject to floods;
- Re-assessment of eligibility of property owners for compensation in areas subject to repeated flooding;
- Improved road infrastructure standards, including elevation and culvert size requirements; and
- Updated storm sewer standards.

4.2 WILDFIRE

Wildfire in Yukon forests is an existing hazard to Yukon communities and infrastructure that can have environmental and economic consequences. Most Yukoners live in the boreal forest, where fire is an integral part of the ecology: "fires are frequent and their ecological influence at all levels—species, stand and landscape—drives boreal forest vegetation dynamics" (NRCan, 2017). In addition, many areas near communities, residences, and other infrastructure have accumulated deadfall and forest debris. The Yukon has seen many large wildfires (e.g., in 1958) and will see them again.

Whitehorse Saved by Rain

"Rain saved Whitehorse last week. If it hadn't come, forestry officials say there would have been little hope for the town with a 30-mile front of fire advancing. In some places 20 miles away, the fire came up within five miles of the White Pass tank farm and was seen plainly from city streets Friday evening… Nobody outside was more worried than local inhabitants who were told by Mayor Gordon Cameron to prepare for emergency evacuation. It was decided… that in event of the fire getting too close, local residents would be sent to Carcross either in their own cars or by special White Pass trains."

(Whitehorse Star, July 24, 1958).

There are many factors – forest age, past fire suppression, lack of fuel management, insect infestations, drought, and trees blown down by storms – influencing the likelihood of wildfires. "Quantifying the multiple effects of climate change will be challenging, particularly because there are great uncertainties attached to possible interactions among them, as well as with other land-use pressures" (Price et.al., 2013). However, it appears that climate change is likely increasing both the likelihood and potential severity of wildfire hazards in Yukon:

- Analysis of historical wildfire data examining annual area burned does not reveal a statistically significant increase in fire risks in Yukon, but a trend is apparent when looking more broadly at regional data from Alaska and the Northwest Territories that indicates an increased wildfire risk is expected (Streicker, 2016);

- Natural Resources Canada states that climate change during the 21st century is expected to result in more frequent large fires in many boreal forests: "Large wildfires, which can cause serious economic losses, are expected to become more frequent, but increases in mean annual area burned will be relatively gradual." (Price et. al., 2013);
- Climate change impacts that could add damaged or dead wood to the forest fuel load (for example, from insect outbreaks, ice storms or high winds) may increase the risk of fire; and
- Recent major wildfires in Fort McMurray (2016) and Interior British Columbia (2017) are important reminders of our limited ability to supress intense wildfires and avoid major losses of homes, businesses, and community infrastructure.

The mechanism by which climate change can be expected to result in increased wildfire risk includes greater risk of dry winters and dry summers (through increased precipitation variability despite average precipitation increasing) and through increased heat and desiccation of existing fuel sources. There may also be trends in convective storms leading to more lightning strikes.

4.3 Adaptation to Wildfire Hazards

In practical terms, the primary means of adapting to the increased likelihood and potential severity of wildfires in Yukon largely overlap with existing efforts to reduce risks, including:

- More robust emergency preparedness and public infrastructure (including communication systems along with road access to vulnerable areas) will limit a broad range of risks and improve overall public safety;
- Evacuation and emergency response plans, both at the household and community level. The Yukon Emergency Measures Organization is responsible for coordinating community-level plans, but it is up to individuals to both be aware of these plans and to create their own household plans;
- Land use planning that accounts for increased wildfire risks when planning new developments. One suggestion in the Whitehorse Community Adaptation Plan is to strategically place agricultural land developments as fire-breaks to reduce wildfire risk;
- Encourage the increased use of fire-resistant building materials, including metal cladding, metal roofs and metal soffits, along with closing in areas under decks and porches, to provide better protection from wind-driven embers. Yukon Community Services already provides this advice to Yukoners, however, a more concerted public education campaign and incentive program, or possibly changes to building code requirements for rural-residential lots, could further reduce risks;
- Encourage fuel reduction (deadfall removal, tree thinning, replacement of conifer trees such as spruce with more fire-resistant birch or aspen) on private property. Yukon Community Services already provides this advice to Yukoners; however, a more concerted public education campaign and incentive program could reduce risks; and
- Systematic identification and prioritization of fuel rich areas for targeted fuel reduction on public land near communities.

Photo 5: Yukon Wildfire

(Yukon Government Protective Services)

4.3.1 Adaption Opportunity: FireSmart Plus

Most Yukoners are familiar with the FireSmart program. FireSmart has an annual budget of $850,000, and has spent approximately $15 million since 1999 on efforts to thin trees and reduce fuel loads around most Yukon communities. The program's primary aim is to reduce fire risks, but it is also a local economic development tool that provides seasonal employment.

There are several issues, however, currently limiting the capacity of the FireSmart program to effectively reduce wildfire risk to communities:

- The program's relatively modest funding is spread throughout the Yukon and is not systematically focused on priority areas where wildfire risk is most significant;

- Wooded areas are thinned but very little area is cleared. (Note that clearing at least small areas of spruce further reduces fuel load. The cleared areas then begin the natural process of succession with far lower risk of fire); and
- FireSmart projects can and do provoke public objections that block them from undertaking fuel reduction activities in certain areas.

The risks of wildfire are expected to increase with climate change and the likely impacts of an extreme fire for Yukon communities (and especially for Whitehorse) become larger and costlier every year as fuel loads increase and the community grows. A more aggressive and targeted fuel reduction effort could significantly reduce this risk. This may be accomplished by exploring a mix of tested and innovative approaches, including:

- Improved community awareness and communications to enhance understanding of wildfire risks and the importance of fuel reduction and management in reducing those risks;
- Selectively cutting and clearing small patches and, where appropriate, replacing significant amounts of spruce with naturally re-growing aspen, willow and poplar that is less prone to wildfire; and
- Actively maintaining a mix of increased aspen, willow or poplar trees to stop succession back to spruce.

Building on the above actions, fuel reduction activities also present a further economic development opportunity by supplying firewood and wood chips for bio-fuel heating. The Dawson City wastewater treatment plant currently has been using local wood chips for heat for several years and the Whitehorse Correctional Centre uses a wood pellet fired heating system. There is considerable opportunity to expand the use of wood heat in Yukon, which presents a unique synergy between efforts to reduce reliance on fossil-fuels for heating, while increasing resilience to the impacts of climate change.

The very recent Teslin Tlingit Council (TTC) project to convert ten buildings in Teslin from either propane or electric heat to a district biomass heating system is an example of the opportunities to combine adaptation to climate change with local economic development. Some highlights of the Teslin project include:

- Community support for the project was built up over many years, beginning in 1998 in the TTC forest management plan and being revisited in community plans in 2009 and 2015;
- The project identified a sustainable and economical supply of wood chips processed from locally-sourced waste wood – either from fire smarting activities, development-related, or from the Teslin Tlingit Council-owned sawmill (Hogan, 2017);
- The ongoing operations of the project are anticipated to provide one full-time position plus an unknown employment benefit from local wood supply contracts.

There is a significant risk attached to not taking more action on fuel reduction as an adaptation measure. The forest continues to age and wildfire fuel builds up year by year. There are obvious economic benefits to going forward with a FireSmart Plus approach linked to biomass heating as is clearly illustrated by the TTC's efforts in Teslin. Even if greater risks of wildfire do not emerge

from climate change to the degree anticipated, a FireSmart Plus approach will still reduce the existing risks while providing benefits.

Photo 6: Fighting Yukon Wildfire

(Environment Yukon, 2006)

5. INFRASTRUCTURE

Infrastructure in the Yukon is already being impacted by climate change and the warmer temperatures, higher precipitation levels, and greater weather variability that is projected will further increase environmental stressors to buildings, roads, power and communications systems, water and sewer systems, and mine sites. Specific climate change challenges for Yukon infrastructure include:

Art and Margaret Fry Recreation Centre

In August 2017, engineers deemed large portions of the Art and Margaret Fry Recreation Centre structurally unsound due to permafrost thaw, forcing the City of Dawson to close most of the building for over a month until the decision was made to re-open in September 2017. In 2009, Yukon government allocated $4 million in funding to improve the centre, but a 2014 study estimated that $12.5 million in improvement costs would be required (Yukon News, November 21, 2014). In addition to repair costs, there are other financial and social costs — including loss of recreational and social opportunities and the staff time needed to manage the issue itself — that are difficult to quantify.

- Most existing infrastructure was designed and built based on historical climate data that may not be appropriate for future conditions. Even small increases in snow load, storm severity and frequency, and thawing permafrost may directly affect structural integrity;
- Buildings sited on permafrost are highly vulnerable as rising temperatures increase the rate of thaw. The cost of repairs required to keep affected buildings open and functioning is significant, but there are additional financial and social implications including periods of closure that negatively affect users (e.g. Dawson City's recreation centre in 2017);
- Thawing permafrost, landslides, erosion and other climate-driven damage to infrastructure is having a major impact on roads and highways in Yukon. Highways and Public Works reports higher operating and maintenance costs for many roads and bridges related to these climate impacts. Risks to highway infrastructure are of concern because there are limited transportation corridors through which consumer goods and critical supplies can enter the territory;

Dempster Highway

Climate-related operations and maintenance costs for the Dempster highway have increased significantly in the past two decades. On average, an additional $200,000 dollars per year has been needed to maintain the Dempster highway since 2005 (Burns, 2015). This trend is expected to continue and financial challenges to fund major road repairs are anticipated.

- Thawing permafrost and increased precipitation has led to problems with mine infrastructure both for operating mines and at abandoned sites. Changes in the hydrological cycle – especially extreme precipitation events and melt patterns – are creating higher-than-planned-for water flows that can exceed the capacity of water management structures; and

- Thawing permafrost and other climate hazards present a growing risk for electricity generation and distribution infrastructure, including generation facilities and powerlines.

Ross River School

Thawing permafrost beneath the Ross River School has led to structural damage requiring significant repairs. It was built in 2001 with a thermosiphon system – a method for passive heat exchange – designed to insulate and maintain the permafrost below the building. The system has not been successful. The building has required repairs in 2004, 2006, 2013, 2015 and is still in need of further repairs. In 2015, the school was closed for 5 months, a major disruption in a small community where the school is the center of many activities. Approximately $3 million was spent on the repairs in 2013 and 2015 and cost estimates for further repairs are approximately $1.7 million. (CBC North News reports, May 10, 2017, May 29, 2017 and August 4, 2017). In addition to the well-documented repair costs, there are other financial and social costs — including the disruption of the school year, increased child care costs, loss of recreational and social opportunities and the staff time needed to manage the issue itself — that are difficult to quantify.

5.1 Adaptation to Infrastructure Impacts

Increasing the resilience of Yukon's infrastructure to climate change will require a shift in the way we think about design requirements of our built environment and the way that we evaluate the financial costs of construction, maintenance, and repair. Long-term infrastructure planning that takes future climate change into account will be an important aspect of this work. Other factors that will influence the resilience of Yukon's infrastructure to climate change include:

- Developing critical infrastructure partnerships with federal government agencies, First Nations, municipalities and the private sector to access funding and implement infrastructure adaptation projects (see National Strategy for Critical Infrastructure, 2009; National Action Plan for Critical Infrastructure, 2014);
- Developing and applying new infrastructure standards and best practices. For example, the Northern Infrastructure Standardization Initiative developed many national standards that are directly relevant to land-based infrastructure in northern communities such as technical guidance on factoring in future climate changes when building on permafrost. New infrastructure design and maintenance standards that recognize climate resilience as a key objective are currently under development and are expected to be completed by 2020;
- Improving mechanisms for monitoring and data collection regarding buildings, roads and other infrastructure impacts by climate change, and making this information more accessible and transparent to a wide variety of user groups, may help to stimulate new insights into climate-resilient design;
- Providing opportunity for more innovative building design that leverages lessons learned and best practices from other jurisdictions. More importantly, this approach may also create

space to grow and export local expertise and experience with sub-arctic and arctic infrastructure construction and repair, particularly for permafrost affected areas;

- Engaging communities on a range of infrastructure challenges to discuss the sustainability of community infrastructure, gather key (climate related and other) information, and incorporate the results into infrastructure and other relevant planning processes; and
- Integrating climate change considerations into mining infrastructure development, maintenance and reclamation – a process which can last for over 100 years – to ensure that mines are built with future climate in mind.

5.1.1 Adaptation Opportunity: Improved Accounting for Long-Term Infrastructure Costs

Improving the accounting for long-term infrastructure costs related to climate change will provide benefits, but not doing so does not create significant risks. There are possible economic benefits in the long-term but also some economic costs. However, a better accounting approach to infrastructure will not likely result in regrettable outcomes even if the threats to infrastructure posed by climate change turn out to be less than anticipated.

Photo 7: Thawing Permafrost and Roads

(Environment Yukon)

The Yukon government commonly uses life cycle costing (LCC) to help decide among options for some infrastructure projects. LCC measures the total cost of infrastructure throughout its life including planning, design, construction, operations and maintenance, and any other related costs. LCC is an excellent tool that lays out the financial case for a decision such as whether to completely renovate an old building for a new use or construct a new building, or to compare the total costs of trade offs between capital and operating costs (e.g., investing more up front in energy efficiency to save on operating costs throughout the life of the building).

There is the opportunity for the LCC approach currently used by YG to be expanded to explicitly encompass climate-related infrastructure risks. Examples might include an LCC analysis of culvert size selection when building or rebuilding highways. Installing a larger culvert costs more than a smaller one, but the larger culvert may also prevent road washouts during future flash flood events. Developing a metric to estimate the (increased) likelihood of such floods and including the average of repair and disruption costs saved in the LCC may present an opportunity to improve this decision-making process. Another example may be to develop a metric to estimate the indirect costs incurred (e.g., loss of recreational and social opportunities) when buildings are closed for repairs and include it in the LCC analysis from the onset.

The application of full life-cycle cost accounting to the mining industry presents a more complex challenge. Mining companies build privately-owned infrastructure on public land and generally have an interest in minimizing their up-front costs. Unless the mining company is large and has ready access to capital, it may not be able to finance significantly higher capital costs associated with a full LCC analysis even if those result in net financial benefits in the long-term.

Regulators are already requiring mines to account for climate change in mine design and closure plans, particularly with respect to water management. Governments and the public have an interest in ensuring the long-term stability of mine sites, but the industry continues to have a strong incentive to minimize capital costs and trust that future cash flow and profits will cover any future climate-driven cost-increases. These conflicting incentives make the application of full life-cycle cost accounting to the mining industry challenging.

Minto Mine

The Minto copper gold mine in the central Yukon is an example of a successful operating mine that has struggled to overcome mine design and water management shortcomings since it began production in 2007. Some of these issues are a result of the site's discontinuous permafrost while others stem from higher than expected water levels on site that exceeded the design requirements it was built for. In 2009, the mine had two emergency discharges of untreated water into the Yukon River as its water containment systems were overflowing.

Capstone Mining, owner of the Minto mine, has stated that "…future extreme weather in Yukon could again result in excess run-off at the mine site, which could have an adverse effect on the results of operations at the Minto Mine and on our business, financial condition, results of operation and prospects..." (Capstone Mining Corporation, 2015)

Photo 8: Minto Mine

(Environment Yukon)

6. CHANGING CLIMATE, CHANGING LAND

There is clear evidence that vegetation zones are shifting, forests are more vulnerable to insect infestations and animal species' habitat, ranges, and diversity are changing. Changes to seasonal weather patterns and climate variability also have direct impacts on the way that some species of wildlife feed and breed.

Climate is the most important factor that influences the development of terrestrial ecosystems. Within areas of similar climate, ecosystems vary because of differences in topography and soil. Shifting climates within these bioclimate zones may mean that some of the flora and fauna that have adapted to the historical climate of that area may face increasing ecological pressure under different present and future climatic conditions. These shifts drive changes in the type of vegetation that is present or pervasive in certain areas, and also to the seasonal events (e.g. flowering) in the lifecycle of native plants. Furthermore, climate change may also make areas more hospitable to invasive species, as it enables some plants, insects and animals to survive and thrive in parts of the territory that were previously less hospitable.

Photo 9: Caribou

(Environment Yukon, 2009)

Wildlife species ranges are projected to shift northward on both land and sea, bringing new species into the north while limiting the range of other species already present on those landscapes. Seasonal changes are also affecting reproductive cycles and species productivity for some animals. In southern Yukon, for example, seasonal temperature increases have been

shown to advance the breeding cycle of rock and white-tailed ptarmigan and reduce the average number of eggs produced (Wilson and Marten, 2010). Other documented ecological impacts include more difficult winter and spring feeding for some animals due to deeper snowpack and changes to freeze-thaw cycles that lead to thicker layers of ice on and in the snow. Spring and summer have also seen greater levels of insect harassment of caribou (Furgal and Prowse, 2008; Streicker, 2016), which interrupts summer feeding, reducing overall animal health and leading to reduced reproduction.

Aquatic species are also affected by changes in water temperature and other climate change impacts to Yukon's hydrological regimes. Climate change-related impacts on ocean and fresh-water habitats for wild salmon exacerbate existing environmental and human-caused stressors, jeopardising migration and reducing reproductive success. According to the federal department of Fisheries and Oceans, the annual Yukon River Chinook salmon migration has historically reached up to 150,000 fish; by 2016 this number declined to less than 75,000, and salmon productivity has been consistently low since 2008. In response, several Yukon First Nations have imposed restrictions on salmon fishing for their citizens, cancelling or limiting the amount of fish available for seasonal fish camps.

The cumulative impacts of these ecological, biological and hydrological impacts are less well understood. How these changes will impact the health of keystone species like caribou and salmon, which serve as indicators of overall ecosystem health, is of significant concern for Yukoners – especially Yukon First Nations whose traditional culture, diet and livelihoods are intimately connected with Yukon's landscapes and wildlife.

6.1 Adaptation to the Changing Land

Yukon First Nations have a long history of adaptation to changing landscapes and wildlife.

30,000 Years

"People have lived in what is now called the Yukon for perhaps 30,000 years. During that long period both the climate and the landscape have changed. The weather was sometimes much colder than it is now, sometimes warmer. For at least half of the last 30,000 years, instead of being covered by forests, most of the land was mossy or grassy tundra…The lakes too have changed in number, location, and shape. Rivers once flowed in places where there are none today, and salmon once spawned where they do no longer. Many of the animals that the early peoples hunted were unlike those they hunt today…" (McClelland. 1987. P.17)

Several Yukon First Nations have undertaken community-based research and adaptation planning to evaluate and respond to the effects of climate change on their land, water, and wildlife. For example, Selkirk First Nation partnered with the Arctic Institute of Community Based Research to develop a community based climate change adaptation plan (VanBibber and Pratt 2016). This plan emphasized, among other aspects, the resiliency of the community and ability to adapt as well as the importance of initiatives to connect youth with the land and work to improve the mental wellness of young people in the community.

Southern Tutchone Resilience

"There are many examples of Southern Tutchone people being extremely resilient and adaptable to change in the past, including the dynamic land, the Gold Rush, the construction of the Alaska Highway, residential school, the dam construction at Aishihik Lake, the pipeline coming through, etc. Change has always been happening... The conclusion of this study is that Southern Tutchone people are used to change and making it work for them." (Champagne and Aishihik First Nations and Alsek Renewable Resources Council, 2009)

Shifting species distributions may also provide future opportunities for hunting/trapping (e.g. deer) and warmer temperatures may contribute to higher survival rates for certain species. However, the cumulative negative effects may outweigh these benefits. Currently, very little is known about the full extent of ecological impacts on complex natural systems that will result from climate change and how those impacts will interact with the landscapes and the animals that are valued for food and other human uses. There is a lot of concern, but also a high level of uncertainty.

Anticipating how regional ecological systems will be affected by climate change is very important in determining the potential effects on traditional lifestyles and ecosystem services. Ensuring that planning processes (land-use planning, development planning, park planning, forestry, etc.) explicitly incorporate mechanisms for anticipating and accommodating future climate change will influence the durability and effectiveness of land and resource planning initiatives.

6.1.1 Adaptation Opportunity: Agriculture

Yukon's agricultural sector is limited not only by soil, but by temperature and precipitation. As noted in Section 2, climate change has already resulted in 2^0C higher annual average temperatures and a 6% increase in average annual precipitation. Further change is expected to bring even higher average temperatures and generally higher levels of precipitation.

Higher average temperatures bring longer growing seasons by increasing the average number of frost-free days. In the Canadian prairies, Agriculture Canada is anticipating significant increases in the length of the growing season over wide areas based on a predicted 1^0C to 2^0C increase in average temperatures over the 2009 to 2032 period. For example, while 33.6% of the area had a growing season longer than 130 days in the 1971-2000 period, that is expected to increase to 56.6% of the area by 2032.

Willingness to Buy Local Food

"The consumers in the Yukon show a strong desire to buy locally. This can be seen in the support for community markets, and in strong farm gate sales. This has also translated into high premiums for a limited amount of Yukon production. This local premium may be as high as two to four- fold over imported production." (Serecon, 2007 P. A15)

Although a similar level of analysis has not been done for the Yukon, a similar lengthening of the growing season can likely be expected. And the increased summer precipitation from climate change will also increase agricultural potential and decrease irrigation needs and costs. Some general trends that emerge from the 2016 Census of agriculture, which largely combines the Yukon with the NWT, include:

- The number of farms was largely unchanged from 2011 to 2016;
- The area of cropland remained stable from 2011 to 2016 but there was a shift away from hay to the production of field crops, particularly field pea production;
- The total area dedicated to fruit and berry production more than doubled between 2011 and 2016 while greenhouse production has fallen;
- Overall the agriculture sector in Yukon and NWT reported gross receipts of $10.0 million for 2015, significantly higher than the $4.1 million in 2005; and
- Poultry and egg farms accounted for 44% of reported gross receipts in 2015.

Increasing Yukon agriculture is a low-risk climate change adaptation opportunity. It is an opportunity that may yield significant economic benefits and if properly managed does not have significant downsides if the climate threat turns out to not be as severe as some scenarios projected.

Factors other than climate change that may help to further increase Yukon agricultural production include:

- General trends toward higher demand for more local food. In the Yukon, the popularity of farmer's markets has been rising: Dawson City, Haines Junction, Mayo and Whitehorse have all established local farmers markets (Yukon News, April 21, 2017).
- The increased attention and interest in food security and the role of local food production in enhancing food security in the territory, particularly among rural First Nations communities. Since 2005, food security-related adaptation projects have been pursued by the Teslin Tlingit Council, White River First Nation, Little Salmon Carmacks First Nation, Liard First Nation, Vuntut G'witchin, and the Kluane First Nation. Little Salmon Carmacks First Nation

began a community greenhouse and garden program in 2000 and other communities and First Nations have made similar efforts, including the Tr'ondëk Hwëch'in Teaching and Working Farm, which began in 2015.

- The price premium that many are willing to pay for local food. "There are studies that show that consumers are willing to pay a premium for local products (Brown 2003; Schneider and Francis 2005; Novotorova and Mazzocco 2008; Darby, Batte, Ernst and Roe 2008). But this willingness to pay a premium is apparently contingent on local products being readily available and easy to identify" (Equiterre, 2011).
- The very small amount of local food in proportion to the total market for food in the Yukon. The total gross receipts of farms (both Yukon and NWT) was $10.0 million in 2015 as noted above. The Yukon Bureau of Statistics reports that food and beverage stores in the Yukon had $203.4 million in sales in 2015. The farm receipts include sales (e.g., hay for horses) that do not directly compare to grocery sales and there are significant grocery sales that cannot be displaced by local production (e.g., soft drinks) but the numbers do indicate that local food has a lot of room to grow its market share in the Yukon.

Tr'ondëk Hwëch'in Teaching and Working Farm

In 2015 the Tr'ondëk Hwëch'in First Nation stated the Tr'ondëk Hwëch'in Teaching and Working Farm in the Klondike Valley near Dawson City. In the summer of 2017, the farm had 22 students of varying ages, most of them post-secondary. "Students spend three hours a day in classes, which are taught in a large, open-air frame tent. The other four and a half hours of the day are spent in practicum, doing things like tending the sprawling garden beds, planting seedlings, operating and maintaining farm machinery and taking care of the pigs. Most students live on-site in small frame tents." (Yukon News, July 4, 2017)

7. HUMAN HEALTH AND WELLBEING

Human health and wellbeing can be impacted by climate change in a variety of ways, from exposure to new disease and vectors to physical and psychological health effects of anxiety and stress from extreme weather events or wildfire damaging homes or livelihoods.

Over the long-term, climate change is projected to make the Yukon more hospitable to invasive species that are likely to bring with them both vector-borne and zoonotic diseases. Vectors are organisms (usually insects) that transmit pathogens or parasites from one person (or animal or plant) to another. Zoonotic diseases are diseases that normally infect animals but can make the jump to human populations. Both can cause human illness and can negatively impact plants or animals that contribute to the food security and livelihoods of Yukoners. Climate change may also increase existing health-risks connected to climate-driven hazards or relationships between humans and natural ecosystems.

Ticks in the North

In the summer of 2017, a black-legged tick was discovered in Yellowknife, one of the most northern locations in Canada that this insect has been documented. The black-legged tick, also known as the "deer tick" can be a carrier of Lyme disease. According to Canadian Lyme Disease Foundation president Jim Wilson, deer ticks are becoming increasingly resilient to colder climates, and it is expected that more of these insects will arrive in the north over the coming years.

(CBC North News. June 13, 2017).

According to the 2012 Yukon Health Status Report (Government of Yukon, 2012), many Whitehorse households and most rural households obtain at least some food from hunting (33% and 58%) or fishing (44% and 62%). These traditional food sources, and our ability to access these animals over land and water, are affected by shifting weather patterns and seasonal changes occurring here in Yukon. This may generate changes in diet that lead to physical health impacts, but also has implications for the mental health and psychological wellbeing of Yukon's First Nations people whose ability to participate in traditional cultural activities that are intimately connected with traditional foods may become more limited.

Mental Health

"Many northern communities consider traditional practices as a pathway to mental health and wellness for First Nation youth" *Adapting to Climate Change and Keeping Our Traditions: Selkirk First Nation Adaptation Plan*. (VanBibber and Pratt 2016)

The Vuntut Gwitchin First Nation is one of several Yukon First Nations who have taken steps to better understand the impact of climate change on human health and wellbeing. Between 2007 and 2011, the First Nation undertook a multi-phased project to solicit community feedback on local climate change impacts in the Vuntut Gwitchin traditional territory, understand historical adaptations to address food-related concerns, and develop new actions to improve community food security (Arctic Institute for Community-Based Research, 2017).

Photo 10: Drying Fish

(Environment Yukon)

Extreme weather events and wildfire also have direct and indirect implications for human health and wellbeing. Flooding events affect the safety of individuals, the health of those whose drinking water quality is impacted or whose access to medical supplies or treatment is affected by flooding events, and the mental wellness of people whose property and living conditions are negatively impacted. Similarly, wildfires that lead to community evacuations or property damage can have significant impacts on the people in those areas. Furthermore, anticipated increases in wildfire activity presents the potential for increased respiratory health impacts related to wildfire smoke. In 2017, Yukon government's Department of Health and Social Services initiated a project to improve monitoring of wildfire impacts on human health and improve emergency planning for extreme weather events and wildfires.

The threats posed by climate change to human health and wellbeing are a function of many factors, including exposure to climate hazards, sensitivity of exposed populations to environmental changes (especially the elderly and persons with pre-existing health conditions), and the capacity of the individuals or populations to proactively plan for change and/or to respond to disaster (Seguin, 2008; Seguin and Berry, 2008; Costello et al., 2009).

7.1 Health and Wellbeing Adaptation

Understanding the implications of climate change for public health and wellbeing depends largely on our understanding of the breadth and depth of the relationship between climate and health, and extent to which forward-looking public health programming incorporates climate change considerations.

Specific opportunities to improve Yukon's capacity to understand and respond to direct and indirect climate change impacts on the health and wellbeing of its residents include:

- Enhancing data collection and investing in research on the role of country foods in Yukoners' diets, and the impact of climate change on availability and access to traditional foods;
- Identifying populations most at risk to climate change-related health risks and developing strategies and actions to increase awareness of these risks among these groups;
- Enhancing mental health services in communities and supporting programs and initiatives that enable First Nations to reconnect with traditional land-use activities; and
- Investing in capacity to address health-related vulnerabilities that are increased by climate change, such as food and housing security, poverty and marginalization.

Examples (see **9.APPENDIX B**) of work on communities beginning to adapt to the health and wellbeing issues of climate change include:

- "Pilot Study on the Health Effects on the Selkirk First Nation due to Climate Change" in 2009;
- "Climate Change and Health – Linking our Past and Future through our Traditions and Culture: An Ethno-Botanical Resource Study to determine the Effects of Climate Change on Traditional Ecosystems" in 2010; and
- "Keeping our traditions for the mental wellbeing of Selkirk First Nations Youth: What do we do at the fish camp when there is no fish?" in 2016.

7.1.1 Adaptation Opportunity: Community-Based Climate Monitoring

Community-based climate change monitoring initiatives may provide new opportunities to gather valuable data on impacts of climate change, while simultaneously enabling community members to re-connect with traditional and land-based knowledge.

Not taking the action of further community-based monitoring does pose some risks as lack of local and community-specific data limits the effectiveness of adaptation efforts. It is important that initiatives to establish community-based monitoring programs consider how monitoring might help address local needs and vulnerabilities such as concern about the condition and populations of local game species.

While the impacts of climate change on wildlife, and especially traditional sources of food, is of great concern for Yukoners, there is limited scientific research on what these impacts will mean in practical terms both for wildlife and for the population who rely on them for food. A community-based climate monitoring program that provides resources and training for community residents to monitor and collect data on key ecological indicators of climate change could help to address this information gap while also providing modest economic benefit to Yukon communities.

Integrating the data collected through this program with existing research and information available through other public agencies (e.g. statistics on traditional food consumption, wildlife population health data, forest health information, etc.) may help to provide improved insights into the long-term implications of climate change for human health. The data can also be used to inform and guide natural resource planning and development to ensure that regional ecosystems and their capacity to support important traditional plant and animal species are sustainably managed.

Beyond the information-gathering component of these initiatives, community-based climate monitoring provides a valuable opportunity to integrate traditional knowledge and scientific research on climate change and create new opportunities to re-connect with the land for individuals who may be feeling alienated from traditional land-use activities. Historical insight into local climate indicators related to, for example, the timing of seasonally significant events such as the first snowfall, sightings of migratory birds, and the budding of flowers in spring provide a deeper understanding of long-term climate trends in specific geographic regions. This type of traditional and local knowledge could feed into such initiatives by soliciting the participation of First Nations elders and contribute to cultural revitalization by providing a framework to promote and preserve land-based skills and knowledge for younger community members. (Lemmen et. al. 2016).

Community-based climate monitoring programs are low-risk regardless of how severe the effects of climate change turn out to be. There is an opportunity for communities to benefit in different ways from the programs and their costs tend to be relatively low.

8. BIBLIOGRAPHY

Arctic Institute for Community-Based Research, 2017. "Vuntut Gwitchin Climate Change and Health Research in Northern Yukon (2007-2011)". Retrieved from: https://www.aicbr.ca/vuntut-gwitchin-old-crow

Beckert, Bronwyn, Roy, Louis Phillipe, Kennedy Kristen., and Calmels, Fabrice. "Climate Change Hazard Mapping Project Completed in Yukon." Yukon College: Climate Change Hazard Mapping Project Completed in Yukon, Yukon government, 12 Sept. 2016. Retrieved from: www.yukoncollege.yk.ca/research/post/climate_change_hazard_mapping_project_completed_in_yukon.

Bonnaventure P.P., and Lewkowicz A.G., 2013. Impacts of mean annual air temperature change on a regional permafrost probability model for southern Yukon and northern British Columbia, Canada. The Cryosphere 7: 935-946. DOI:10.5194\tc-7-935-2013

Burns, C., 2015. Climate Change Costs, Yukon Section, Dempster Highway. Presentation to Yukon Government- Highways and Public Works.

Calmels, F., L.-P. Roy, C. Laurent, M. Pelleter, L. Kinnear, B. Benkert, B. Horton and J. Pumple. 2015. *Vulnerability of the North Alaska Highway to Permafrost Thaw: A Field Guide and Data Synthesis.* Whitehorse, Yukon: Northern Climate ExChange, Yukon Research Centre.

Capstone Mining Corporation. 2015 and 2016. Consolidated Financial Statements. pp.44-45. Retrieved from: http://capstonemining.com/home/default.aspx

CBC North News. Various dates. Retrieved from: http://www.cbc.ca/news/canada/north

Centre for Clean Air Policy, 2016. What Does Climate Resilience Look Like? Retrieved from: http://ccap.org/what-does-climate-resilience-look-like/

Derksen, C., et.al. 2012. Variability and change in the Canadian cryosphere. Climate Change, 115, 59–88, doi:10.1007/s10584-012-0470-0.

Environment Canada. 2016. Weather Climate and Hazards. *Pan-Canadian Framework on Clean Growth and Climate Change*.

Environment Yukon, 2017. Date of ice break-up on the Yukon River at Dawson City, 1896-2016. Retrieved from: http://www.env.gov.yk.ca/publications-maps/report-water-river-break-up.php

Equiterre, 2011. Eating at Home: Canadian households and the motivations and obstacles related to buying locally grown food – a pan-Canadian study. p.7 Retrieved from: http://www.equiterre.org/sites/fichiers/analyse_manger_chez_soi_-final_en.pdf

Furgal, C., and T.D. Prowse, 2008. Northern Canada. From: Perspectives on Impacts and Adaptation; Government of Canada, Ottawa, ON, 286p.

Government of Yukon, Department of Health and Social Services: Yukon 2012 Health Status Report: Focus on Children and Youth. Retrieved from: http://www.hss.gov.yk.ca/pdf/health_status_report_2012.pdf

Hennessey, R., Love, N., Kinnear, L. and Duerden, F., 2011. Atlin Climate Change Adaptaton Plan. Northern Climate ExChange, Yukon Research Centre, Yukon College, Whitehorse, YT, 55 p.

Hennessey, R., Stuart, S. and Duerden, F., 2012. Mayo Region Climate Change Adaptaton Plan. Northern Climate ExChange, Yukon Research Centre, Yukon College, Whitehorse, YT, 103 p.

Hennessey, R. and Streicker, J., 2010. Future Histories of Whitehorse: Scenarios of Change. Northern Climate ExChange, Yukon Research Centre, Yukon College, Whitehorse, YT, 39 p.

Hennessey, R., Stuart, S. and Duerden, F., 2012. Mayo Region Climate Change Adaptaton Plan. Northern Climate ExChange, Yukon Research Centre, Yukon College, Whitehorse, YT, 103 p.

Hennessey, R. and Streicker, J., 2011. Whitehorse Climate Change Adaptaton Plan. Northern Climate ExChange, Yukon Research Centre, Yukon College, Whitehorse, YT, p. 84

Henstra, D. and Thistlethwaite, J., 2017. Climate Change, Floods, and Municipal Risk Sharing in Canada." IMFG Papers on Municipal Finance and Governance No. 30. Toronto: Institute on Municipal Finance and Governance. Retrieved from: http://munkschool.utoronto.ca/imfg/uploads/373/1917_imfg_no_30_online_final.pdf.

Hogan, Blair. March 2017. Teslin Biomass District Heating V.3 (presentation). Retrieved from: https://www.uaf.edu/files/ces/nrcd/awec/2017/Blair-Hogan.pdf

Huntington HP, Fox S, Berkes F, Krupnik I (2005) The changing Arctic: indigenous perspectives. In: ACIA (ed) Arctic climate impact assessment. Cambridge University Press, Cambridge, pp 61–98

IPCC, 2014: Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 117-130.

Jones, Sebastian and Hennessey, Ryan, 2011. Dawson Climate Change Adaptation Plan. Climate Change Impacts and Adaptation Division, Natural Resources Canada, Whitehorse, YT

Kunuk, Zacharias and Mauro, Ian, 2015. *Inuit Knowledge and Climate Change* [Documentary Film]. Canada.

Larsen, J.N., et. al. 2014. Polar regions. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability, Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., et. al. (eds.)]. Cambridge University Press. pp. 1567-1612.

Larsen, C., E. Burgess, A. Arendt, S. O'Neel, A. Johnson, and C. Kienholz, 2015. Surface melt dominates Alaska glacier mass balance. Geophysical Research Letters, vol. 42, pp. 5902–5908

Lemmen, D. S., Warren, F. J., Lacroix, J. and Bush, E. (Eds.), 2008. From Impacts to Adaptation: Canada in a Changing Climate 2007. Ottawa, Ont.: Government of Canada. Retrieved from http://adaptation.nrcan.gc.ca/assess/2007/index_e.php.

Lemmen, D.S., Warren, F.J., James, T.S. and Mercer Clarke, C.S.L. editors (2016): Canada's Marine Coasts in a Changing Climate; Government of Canada, Ottawa, ON, 274p.

Lipovsky, P.S. and Yoshikawa, K., 2009. Initial results from the first year of the Permafrost Outreach Program, Yukon, Canada. In: Yukon Exploration and Geology 2008, L.H. Weston, L.R. Blackburn and L.L. Lewis (eds.), Yukon Geological Survey, pp. 161-172.

McClelland, Catherine, 1987. Part of the Land, Part of the Water: A History of the Yukon Indians. Douglas & McIntyre.

Myers-Smith, Isla H., Meagan M. Grabowski, Haydn J.D. Thomas, Sandra Angers-Blondin, Gergana N. Daskalova, Anne D. Bjorkman, Andrew M. Cunliffe, Jakob J. Assmann, Joe Boyle, Edward McLeod, Sam McLeod, Ricky Joe, Paden Lennie, Deon Arey, Richard Gordon, Cameron Eckert, 2017. Seventeen years of ecological monitoring reveals multiple lines of evidence for tundra vegetation change. *Draft manuscript.*

Natural Resources Canada, 2016. *Working Group on Adaptation and Climate Resilience.* Ottawa, ON: Canadian Government Publishing.

Natural Resources Canada, 2017. Retrieved from: http://www.nrcan.gc.ca/forests/boreal/13071

Palko, K. and Lemmen, D.S. (Eds.)., 2017. Climate risks and adaptation practices for the Canadian transportation sector 2016. Ottawa, ON: Government of Canada.

Price, D.T. et al, 2013. Anticipating the consequences of climate change for Canada's boreal forest ecosystems. Environ. Rev., 21 (2013), pp. 322-365

Public Safety Canada, 2014. *National Action Plan for Critical Infrastructure,* Ottawa, ON: Canadian Government Publishing.

Public Safety Canada, 2009. *National Strategy for Critical Infrastructure,* Ottawa, ON: Canadian Government Publishing.

Richardson, G.R.A. and Otero, J. (2012). Land use planning tools for local adaptation to climate change. Ottawa, Ont.: Government of Canada, 38 p.

Scenarios Network for Alaska and Arctic Planning, 2017. Community Charts for Whitehorse and Old Crow. Retrieved from: https://www.snap.uaf.edu/sites/all/modules/snap_community_charts/charts.php

Seguin, J., 2008. Conclusion. In: Seguin J. et al. (Eds.) Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity. Health Canada. Health Canada.

Serecon Management Consultants. 2007. Yukon Agriculture Multi-Year Development Plan. Retrieved from: http://www.emr.gov.yk.ca/agriculture/pdf/yukon_multi_year_development_plan.pdf

Siegel, P., 2011. "No Regrets" Approach to Decision Making in a Changing Climate: Toward Adaptive Social Protection and Spatially Enabled Governance. World Resources Institute. Retrieved from: http://www.wri.org/our-work/project/world-resources-report/no-regrets-approach-decision-making-changing-climate-toward

Streicker, J., 2016. Yukon Climate Change Indicators and Key Findings 2015. Northern Climate ExChange, Yukon Research Centre, Yukon College, p. 84

VanBibber, M., Kassi, N., Pratt, M., March 2016. Adapting to Climate Change and Keeping Our Traditions. Selkirk First Nation.

Warren, F.J. and Lemmen, D.S., editors (2014): Canada in a Changing Climate: Sector

Werner, A.T., H.K. Jaswal and T.Q. Murdock, 2009: Climate Change in Dawson City, YT: Summary of Past Trends and Future Projections. Pacific Climate Impacts Consortium, University of Victoria, Victoria BC, 40 pp.

Wang, Guojian; Cai, Wenju; Gan, Bolan; Wu, Lixin; Santoso, Agus; Lin, Xiaopei; Chen, Zhaohui & McPhaden, Michael J., 2017. Continued increase of extreme El Niño frequency long after 1.5 °C warming stabilization. *Nature Climate Change* 7, 568–572

Whitehorse Star. Various dates. Retrieved from: http://www.whitehorsestar.com/

Yukon News. Various dates. Retrieved from: http://www.yukon-news.com/

9. KEY CONTACTS

Brian Horton, *Research Project Coordinator, Northern Climate ExChange,* Northern Climate ExChange

Alison Perrin, *Climate Change Education and Project Coordinator,* Northern Climate ExChange

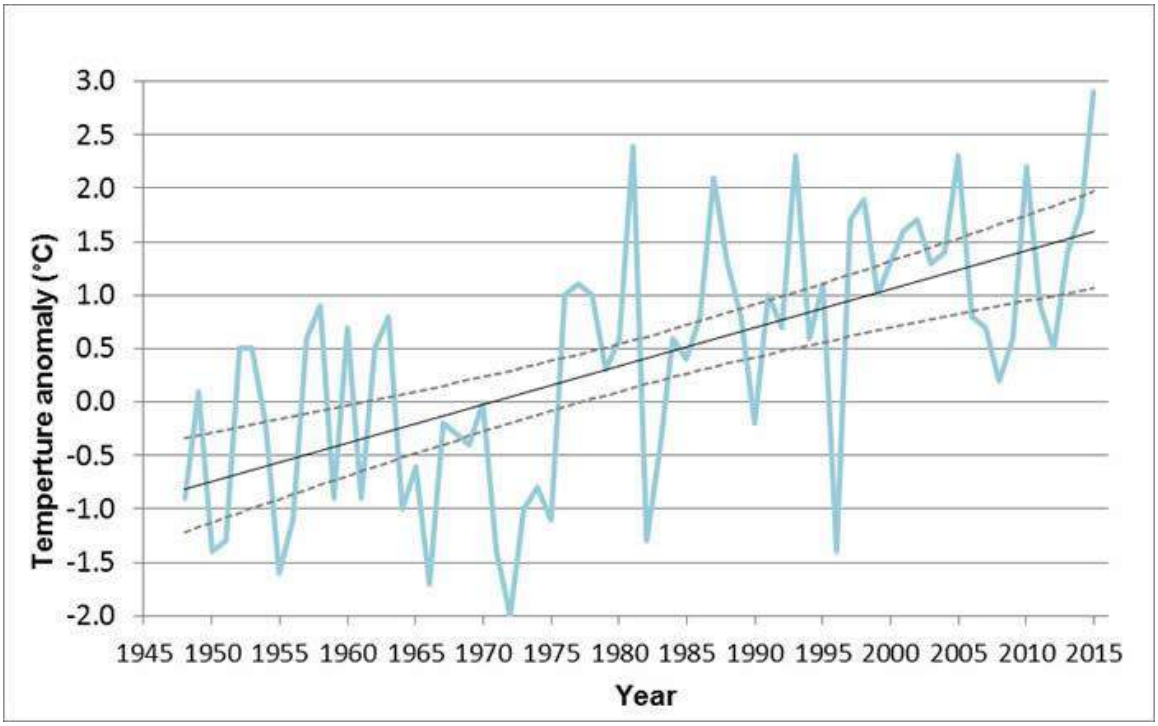
Panya Lipovsky, Surficial Geologist, Yukon Geological Survey

APPENDIX A Yukon's Climate

Currently, projections about future change in Yukon's climate are made by combining historical data for each indicator with different emissions scenarios developed by the Intergovernmental Panel on Climate Change (IPCC). These scenarios suggest possible future conditions based on different "Representative Concentration Pathways" or predicted amount of GHGs in our atmosphere based on more successful or less successful "paths" to stabilize or reduce emissions.

Figure 4 shows the relative change in average Yukon temperature from one year to the next from 1950 through 2016.

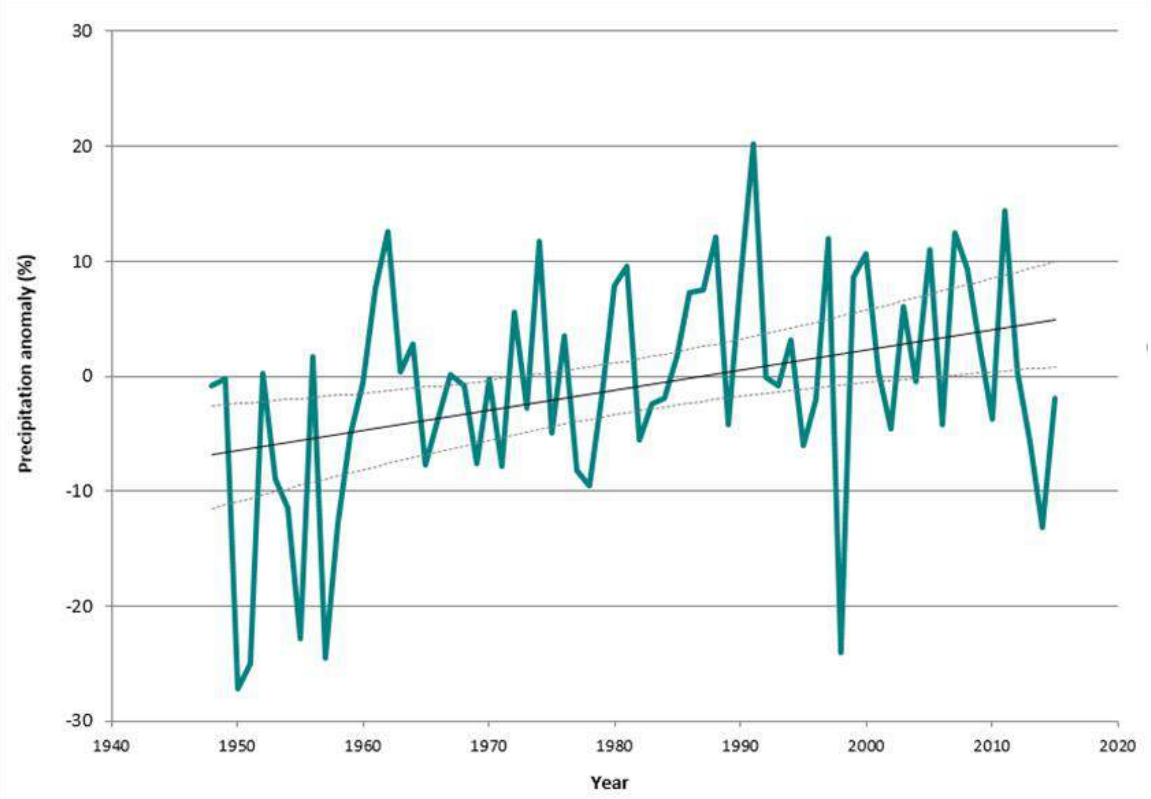
Figure 4: Yukon annual temperature variation, 1950-2016



(Streicker, 2016)

Figure 5 shows the percent difference from the 30-year average (1961-1990) precipitation.

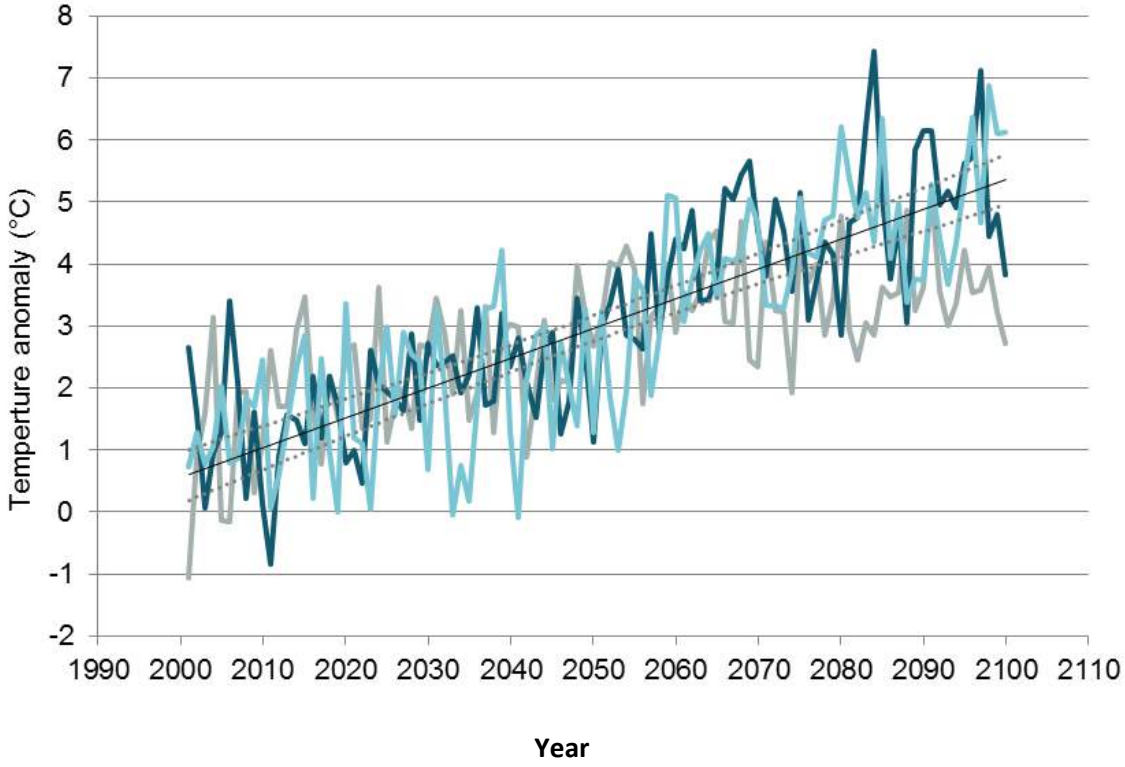
Figure 5: Yukon annual precipitation variability, 1950-2016



(Streicker, 2016)

Figure 6 shows the relative change in average annual Yukon temperature projected over the next century.

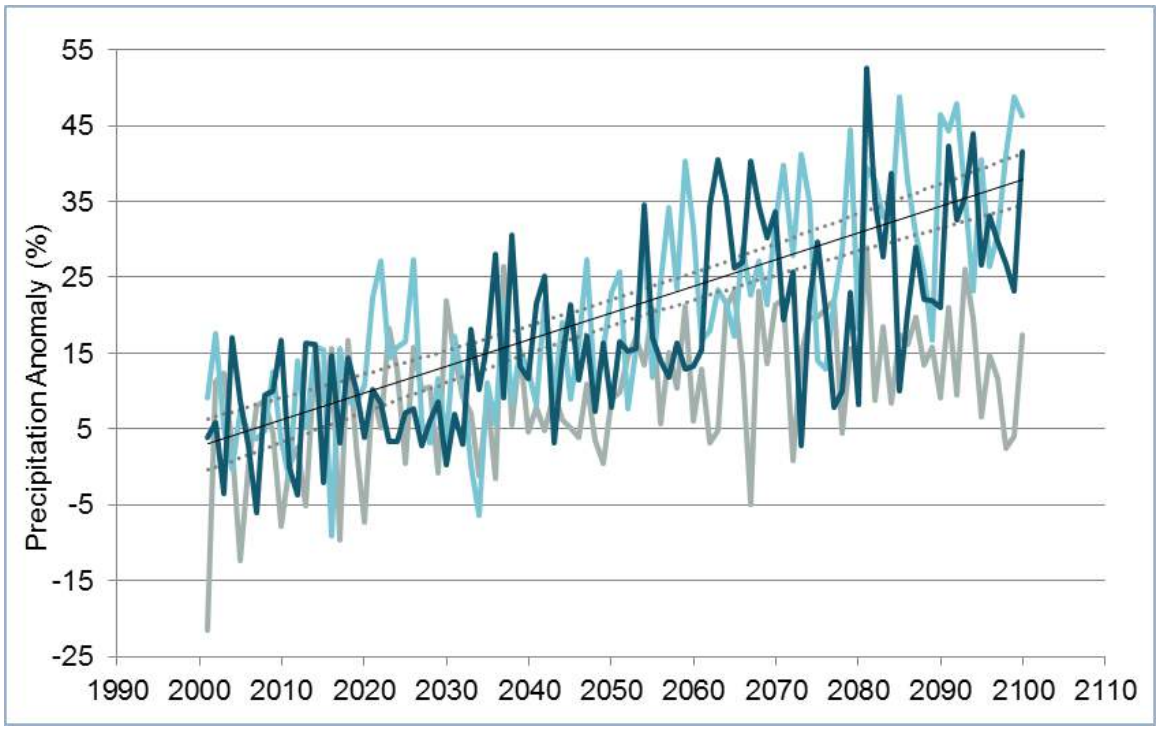
Figure 6: Yukon projected annual temperature anomalies (A2, A1B, B1)



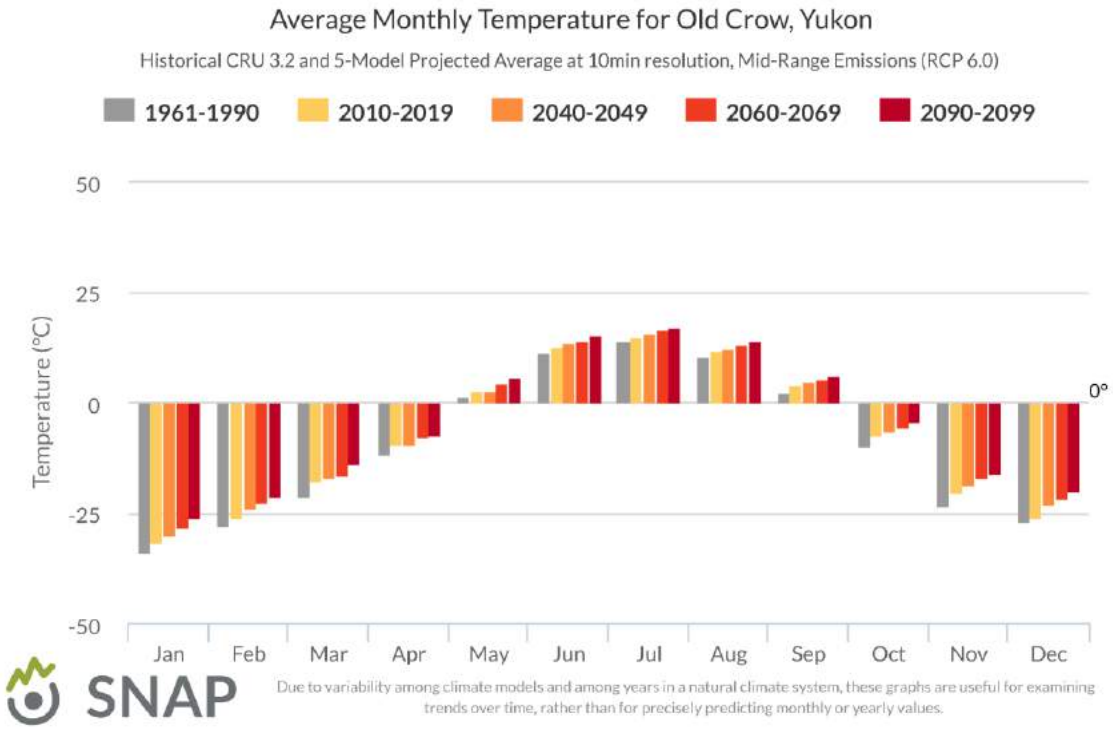
(Streicker, 2016)

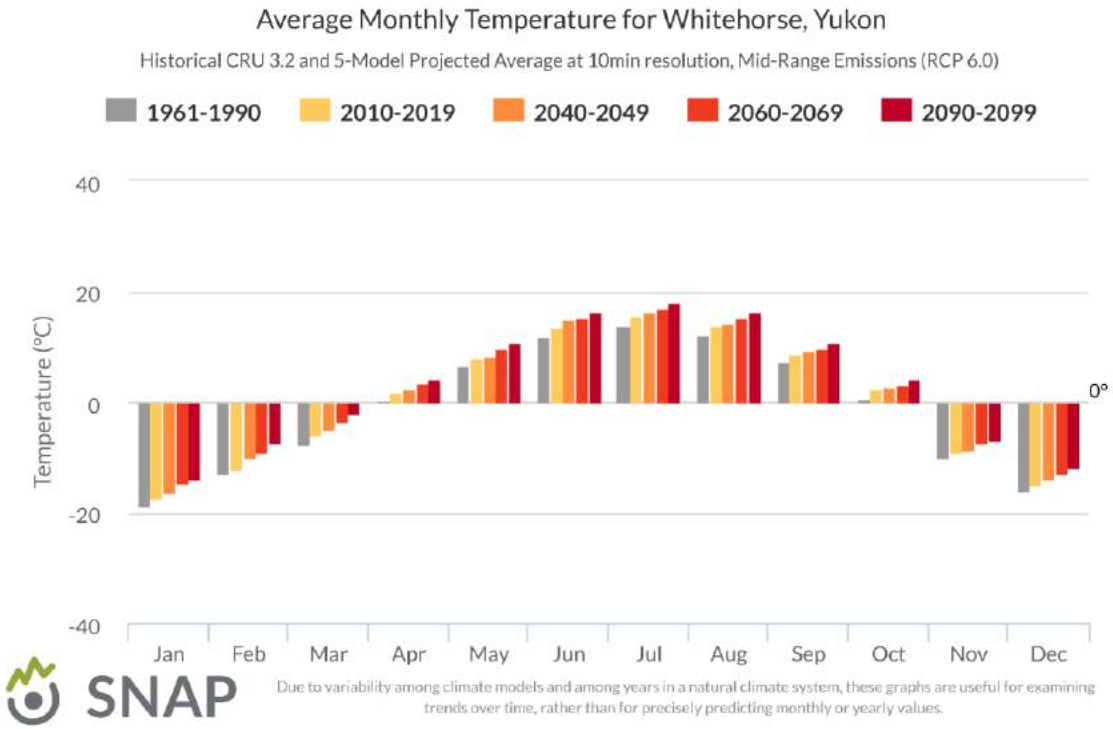
Figure 7 shows the relative change in total annual precipitation in Yukon projected over the next century.

Figure 7: Yukon projected annual precipitation anomalies (A2, A1B, B1).

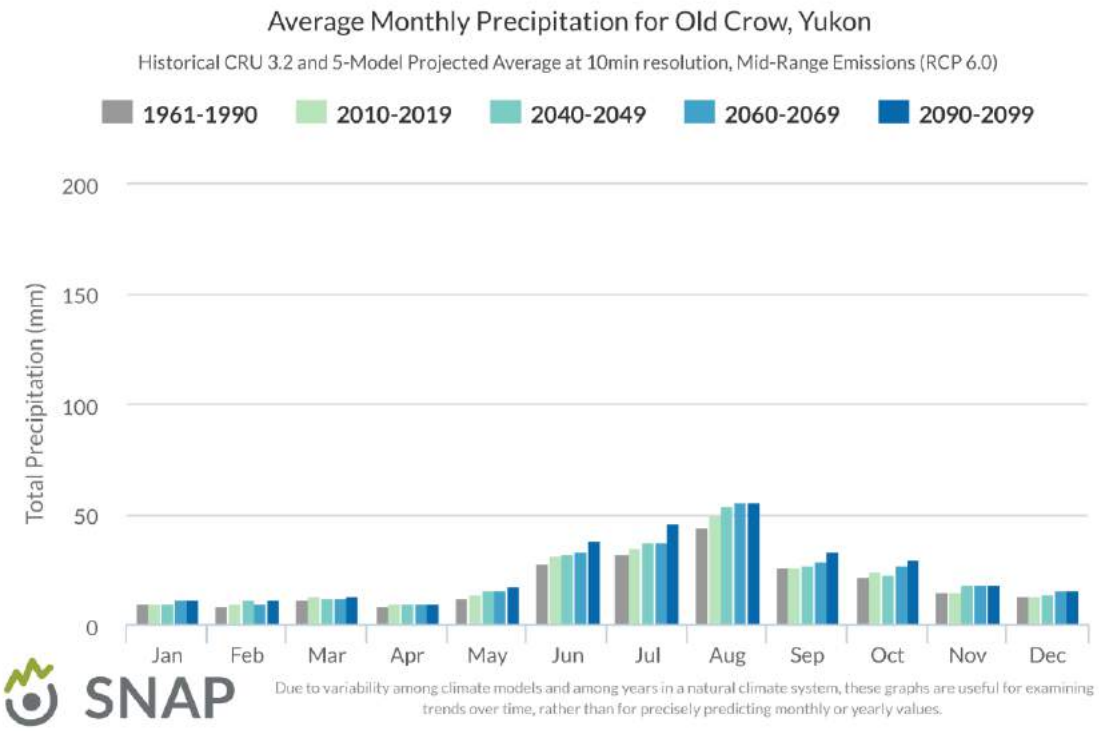


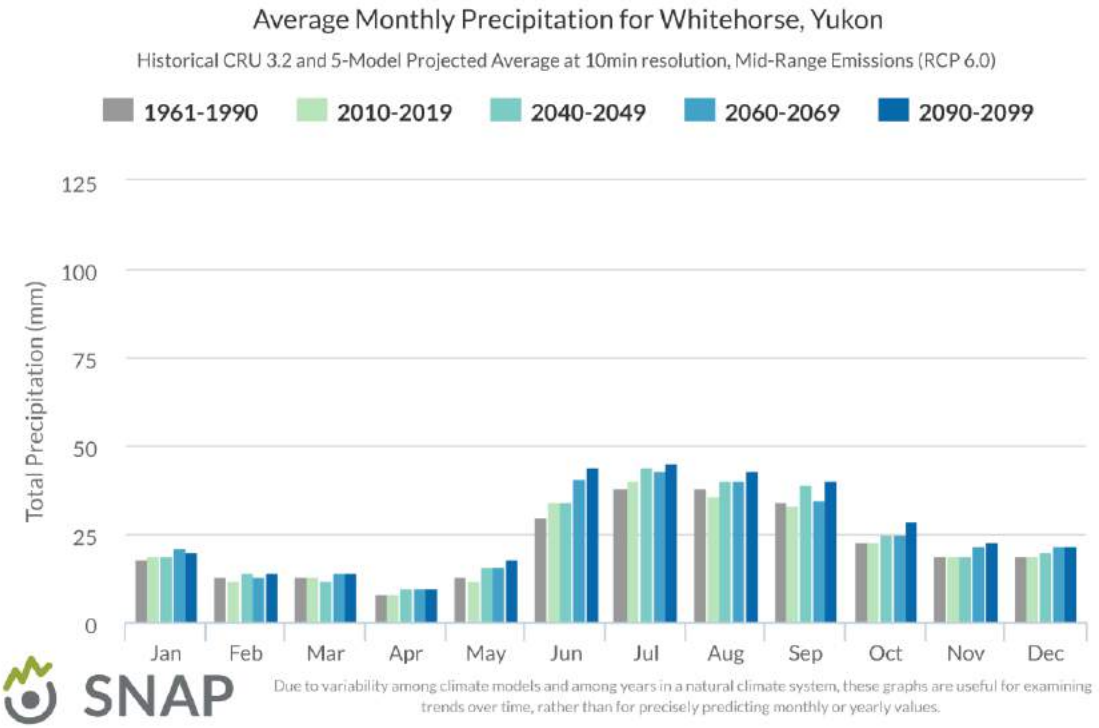
SNAP Community Temperature Projections for Old Crow and Whitehorse are shown below.





SNAP Community Precipitation Projections for Old Crow and Whitehorse are shown below





APPENDIX B List of Yukon Climate Change Adaptation Projects: 2008 through 2017

This appendix presents a summary of available information regarding climate change adaptation projects that have been undertaken in Yukon between 2008 and 2017. Given the wide range of organizations involved in adaptation activities, this summary should be viewed as a snapshot of adaptation actions rather than a comprehensive picture. Readers who have questions or who may be able to provide additional information regarding the projects listed below or other projects not listed in this appendix are encouraged to contact Yukon government's Climate Change Secretariat at ClimateChange@gov.yk.ca.

List of Yukon government acronyms

- CS-EMO – Department of Community Services, Emergency Management Office
- CS-WFM – Department of Community Services, Wildfire Management
- ENV-AHU – Department of Environment, Animal Health Unit
- ENV-CCS – Department of Environment, Climate Change Secretariat
- ENV-FW – Department of Environment, Fish and Wildlife
- ENV-WR – Department of Environment, Water Resources
- EMR-AG – Department of Energy, Mines and Resources, Agriculture
- EMR-ESC – Department of Energy, Mines and Resources, Energy Solutions Centre
- EMR-FMB – Department of Energy, Mines and Resources, Forest Management branch
- EMR-YGS – Department of Energy, Mines and Resources, Yukon Geological Survey
- HPW-PMD – Department of Highways and Public Works, Property Management Division
- HPW-TEB – Department of Highways and Public Works, Transportation Engineering Branch
- HSS-CPRM – Department of Health and Social Services, Corporate Planning and Risk Management
- TC-CS – Department of Tourism and Culture, Cultural Services

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Pan-Territorial Adaptation Outreach	Yukon government (ENV-CCS), Government of the Northwest Territories, Government of Nunavut	Indigenous and Northern Affairs Canada	2012	2013	Project work included a pan-territorial permafrost workshop held in Yellowknife in 2013 that facilitated permafrost information and knowledge-sharing across the three territories to enable an improved response to the impacts of permafrost thaw. Work also included the development of communications products to increase awareness of Yukon government adaptation actions.
Characterizing hydrological processes in the headwater region of the Yukon River: impacts on discharge and implications for hydroelectric security	Yukon Energy Corporation, Yukon College (Yukon Research Centre - Northern Climate ExChange), Yukon government (EMR-YGS; ENV-WR), University of Alberta, University of Saskatchewan	Research Org-Natural Science and Engineering Research Council of Canada (NSERC)	2012	2015	Project identified priority areas of concern and examined climate change impacts on the hydrology of the Yukon River headwaters and implications for downstream energy generation.
Sensitivity of Dempster Highway Hydrological Response	Yukon government (HPW-TEB; ENV-WR)	Transport Canada	2013	2016	Project explored climate change impacts on water regimes along the Dempster Highway.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Arctic Adaptation Exchange	Yukon government (ENV-CCS), Government of Canada (NRCAN), US State Department, University of Alaska-Fairbanks, Aleut International Association, Gwich'in Council International	Natural Resources Canada	2013	2016	Developed a web-based information portal to improve access to information about climate change adaptation research and action across the circumpolar north.
Yukon Flood Plain Risk Mapping	Yukon government (CS-EMO)	Indigenous and Northern Affairs Canada	2012	2015	This flood hazard mapping project collected elevation data for 13 Yukon communities to better understand where flood hazards might be affected by climate change.
Effects of Thawing Permafrost on Agricultural Capacity	Yukon government (EMR-AG)	Indigenous and Northern Affairs Canada	2012	2016	Identified challenges and barriers to agriculture, adaptive measures and best management practices. Modelled areas prone to change in Dawson, Central Yukon, Haines Junction, and Whitehorse/Southern Lakes agricultural regions
Development of Bioclimate Envelopes	Yukon government (ENV-FW)	Indigenous and Northern Affairs Canada	2012	2016	Development of ecosystem classification and modeling to inform research and resource and land use planning.
Communicating Climate Change Adaptation	Yukon government (TC-CS)	Indigenous and Northern Affairs Canada	2012	2015	This project presents a climate change adaptation film and speaker series to share knowledge related to INAC-funded Yukon government climate change adaptation initiatives.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Examining forest vulnerabilities to climate change and developing resilience enhancement strategies through long-term community partnerships in Yukon	Yukon government (EMR-FMB),	Indigenous and Northern Affairs Canada	2012	2016	This project with the Teslin Tlingit Council and broader community integrated science, policy and community participation to assist decision-makers and community members in using long-term climate change considerations for forest management.
The Mountain Pine Beetle in Novel Habitats: Predicting Impacts to Northern Forests in a Yukon's Warming Environment	Yukon government (EMR-FMB), University of British Columbia	Indigenous and Northern Affairs Canada	2012	2016	This project aims to understand the potential for mountain pine beetle outbreaks in Yukon and to establish management steps to decrease the impacts and spread of the beetle.
Vulnerability of the North Alaska Highway to Permafrost Thaw	Yukon government (HPW-TEB), Yukon College (Yukon Research Centre-Northern Climate ExChange)	Indigenous and Northern Affairs Canada	2012	2016	Project focused on determining the vulnerability of the North Alaska Highway to climate change through an examination of permafrost occurrence and type to evaluate potential future effects that could impact Destruction Bay, Burwash Landing, and Beaver Creek.
Sensitivity of Yukon Hydrological Response to Climate Warming	Yukon government (ENV-WR)	Indigenous and Northern Affairs Canada	2012	2014	Project examined impact of climate change on water cycle processes to inform the development of adaptation strategies for Yukon communities.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Climate Change and Public Health	Yukon Climate Change Consortium: Council of Yukon First Nations, Yukon College (Yukon Research Centre - Northern Climate ExChange), Yukon government (ENV-CCS), Arctic Athabaskan Council	Public Health Agency of Canada	2013	2014	This project aimed to improve understanding of general health implications of climate change for Yukon.
Examining Geophysical Data along Transportation Infrastructure in Permafrost Regions	Yukon government (HPW-TEB)	Transport Canada	2012	2013	Processing and interpretation of geophysical data along transportation infrastructure in permafrost regions.
Landscape Hazards in Yukon Communities: Geoscience Mapping for Climate Change Adaptation Planning	Yukon College (Yukon Research Centre - Northern Climate ExChange), Yukon government (EMR-YGS), University of Montreal, University of Ottawa, Yukon First Nations (scoping and community liaison)	Indigenous and Northern Affairs Canada	2010	2016	This project investigated contemporary landscape hazards related to permafrost degradation in Yukon communities. It also considers potential future landscape evolution in response to changes in climate.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Community Information & Needs Assessment (2008-2010)	Yukon government (ENV-CCS); Council of Yukon First Nations	Indigenous and Northern Affairs Canada	2008	2011	Project identified priority areas of community concern related to climate change in 13 Yukon communities and increased awareness of important areas for future climate change programming.
Water Adaptation Project: Adaptive Management for Water Users Responding to Climate Change	Yukon government (ENV-WR)	Indigenous and Northern Affairs Canada	2009	2011	Identified priority climate change areas of concern and monitor the impacts of climate change (on water resources), adapt to changes, provide access to information (water data).
Infrastructure Vulnerability to Permafrost Degradation	Yukon government (EMR-YGS; HPW-TEB)	Indigenous and Northern Affairs Canada	2009	2011	Identify priority areas of concern and monitor the impacts of climate change on infrastructure and vulnerability of Yukon government buildings to permafrost thaw.
Compilation of Energy Sector Case Studies	Yukon government (EMR-ESC);	Natural Resources Canada	2014	2015	This project looks at case studies where actions to mitigate and adapt to climate change in the energy sector have merged to determine how such actions can be repeated elsewhere. The co-benefits of such an approach include a reduction in the overall cost of responding to climate change that ensures the energy sector is both climate-friendly and climate-ready.
Temperature Trends and Impact on Energy Demand	Yukon government (EMR-ESC);	Natural Resources Canada	2014	2015	This project will evaluate the impacts of climate change on how Yukon manages energy by evaluating future electrical demand and supply and subsequent implications for energy resource planning. This work will identify potential risks and opportunities for the Yukon energy sector and inform energy resource planning going forward.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Permafrost and Risk Assessment of Key Buildings and Infrastructure in Ross River	Yukon College (Yukon Research Centre - Northern Climate ExChange);	Natural Resources Canada	2013	2015	This project will develop guidelines and best practices for building management in Ross River in response to permafrost thaw that are transferrable to other northern jurisdictions.
Assessment of recent past and current permafrost conditions under Front Street, Dawson City, Yukon	Yukon government (EMR-YGS; HPW-TEB) Yukon College (Yukon Research Centre-Northern Climate ExChange)	Transport Canada	2014	2015	Using permafrost data from the Yukon government's Department of Energy, Mines and Resources, Highways and Public Works, and The Northern Climate Exchange to assess permafrost degradation in Dawson City to inform development, monitoring, maintenance and management decisions.
Arctic Char Fish Silage Project	Yukon College (Yukon Research Centre - Cold Climate Innovation),	Yukon College (Yukon Research Centre-Northern Climate ExChange)	2013	2014	Research project to investigate the production of silage from arctic char waste products.
Canada-Yukon Growing Forward Agreement for various Agriculture projects	Yukon government (EMR-AG)	Canadian Northern Economic Development Agency	2012	2018	This project provided support to the Northern Greenhouse Initiative, advance Yukon agriculture and provide advice to Yukon farmers, processors and agri-businesses in all aspects of farm management, production, processing, marketing, conservation techniques, new farm technology and farm financing.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Climate Change Information and Mainstreaming Program (CCIMP)	Yukon government (ENV-CCS), Yukon College (Yukon Research Centre-Northern Climate ExChange)	Yukon government-Environment	2010	2016	Provide support and expertise required for the integration of climate change considerations into projects, planning and decision-making processes for Yukon government departments.
Establishment of baseline data collection sites and assessment of permafrost response to climate warming for transportation infrastructure in the Yukon and NWT	Yukon government (HPW-TEB)	Transport Canada	2013	2016	Established baseline data collection sites and assessed permafrost response to climate warming for transportation infrastructure in the Yukon and NWT.
Yukon Mines Wastes and Climate Change	Government of Canada (NRCAN), Yukon College (Yukon Research Centre - Northern Climate ExChange)	Natural Resources Canada	2011	2013	Identified priority areas of concern and impacts related to climate change for Yukon mine waste sites.
Yukon Climate Trends and Projections	Yukon College (Yukon Research Centre - Northern Climate Exchange)	Yukon Environmental and Socio-Economic Assessment Board (YESAB)	2011	2012	Analyze historical climate information and identify impact on YESAB's six assessment districts.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Alaska-Canada Climate Biome Shift	University of Alaska-Fairbanks	Ducks Unlimited Canada	2010	2012	Identify priority areas of concern that are undergoing climate-driven ecological pressures.
Vuntut Gwitchin Climate Change and Health Research in Northern Yukon: ---PHASE I: "Gwich'in Youth and Scientists Climate Change and Health Research Symposium in Northern Yukon: What do our changing homelands mean for our health?" ---PHASE II: "What do our Changing Homelands mean for our Health? Phase II: Knowledge into Action" ---PHASE III: "Community Action on Climate Change and Food Security Adaptation in Old Crow"	Vuntut Gwitchin First Nation; Arctic Institute for Community-Based Research	Health Canada	2008	2009	Multi-phased project to solicit community feedback on local climate change impacts in the Vuntut Gwitchin traditional territory, research historical adaptations to food insecurity, and develop new actions to improve community food security.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Documentation, Mapping and Identifying Traditional Medicines	Champagne Aishihik First Nation	Health Canada	2014	2015	Project details unavailable.
Good Medicine: Understanding and adapting to the effects of climate change on the use of traditional medicine	Little Salmon Carmacks First Nation	Health Canada	2014	2015	Project details unavailable.
Integrating Indigenous Knowledge and Public Health into a Community Contaminant and Climate Change Monitoring Program	Yukon River Inter-Tribal Watershed Council	Health Canada	2012	2013	Held focus groups with FN citizens and government officials from Tr'ondek Hwech'in, Selkirk, White River, Kluane, Carcross-Tagish to discuss areas of concern re: water contamination, and to identify sites for water sampling.
Climate Adaptation Strategies: An Intergenerational Effort to Combine Indigenous Knowledge and Western Science	Yukon River Inter-Tribal Watershed Council	Health Canada	2013	2014	Collected same water samples from five locations in five Yukon communities; held an intergenerational (youth and elder) workshop in each community to talk about climate change concerns and adaptation interests.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
First Nation Climate Change Policy: A Regional Indigenous Approach to CC Adaptation, Health, and water governance	Yukon River Inter-Tribal Watershed Council	Health Canada	2014	2015	Water Action Planning: based on previous research, develop a water action plan to outline how First Nations and their traditional knowledge can take action to address concerns regarding the impacts of climate change and contaminants on water and community health.
Nourishing our Future: Building on Kluane First Nations Community Food Security Strategy & Youth Engagement in Traditions Related to Fisheries and Fish Health in Kluane Lake	Kluane First Nation	Health Canada	2015	2016	Promoting the importance of consuming traditional foods and improving understanding of contaminant levels in Kluane Lake fish. Part of this research project included conducting interviews with Kluane First Nation (KFN) citizens and traditional knowledge experts in the community about observations regarding changes in the quality, quantity and health of fish from Kluane Lake as well as concerns about contaminants in traditional foods.
Nourishing our Future: An adaptive food security strategy to ensure the cultural and physical wellbeing of the Kluane First Nation against the impacts of climate change in the Yukon	Kluane First Nation; Arctic Institute for Community-Based Research	Kluane Renewable Resource Council	2013	2014	Project details unavailable.
Moose traditional Knowledge	Liard First Nation	Health Canada	2013	2014	Traditional Food Security and Climate Change: Liard First Nation Traditional Knowledge for Monitoring and Managing the Moose Harvest

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
A video adaptation plan for healthy foods, shelters, and education in Tr'ondek Hwech'in, Gwich'in, and Nisga'a communities	Tr'ondëk Hwëch'in, Wilp Wilxo'oskwhl Nisga'a Institute	Health Canada	2013	2014	Development of a documentary film of adaptation planning, shelter-building, and food harvesting: a Tr'ondek Hwech'in, Gwich'in, and Nisga'a collaboration
Food Security of our Future Leaders: Young Adults Build Health Capacity through Northern Community Gardens	Little Salmon Carmacks First Nation	Health Canada	2012	2013	Project details unavailable.
Mayo Talks Climate Change and Health	Nacho Nyak Dun First Nation	Health Canada	2012	2013	Project details unavailable.
To Feed Our Community Project	White River First Nation	Health Canada	2010	2011	The project focused on potential climate change impacts on people with respect to food availability and storage.
Little Salmon Carmacks First Nation Traditional Land Use Health Study	Little Salmon Carmacks First Nation	Health Canada	2010	2011	Project details unavailable.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
A Multi-Disciplinary Investigation of Climate Change Impacts on Yukon River Traditional Foods and the Implications for Health and Tr'ondëk Hwëch'in River Culture and Lifestyle	Tr'ondëk Hwëch'in First Nation	Health Canada	2010	2011	The primary focus of this project was to increase the understanding of climate change and its impacts along the Yukon River within Tr'ondek Hwech'in Traditional Territory, and the associated health implications for the community.
Integrating Indigenous Knowledge and Public Health into a Community Contaminant and Climate Change Monitoring Program	Yukon River Inter-Tribal Watershed Council	Health Canada	2012	2013	The project integrated Indigenous Knowledge on climate change, human health risks, and suspected contaminated sites with site-specific community-based monitoring plans. The Yukon River Inter-Tribal Watershed Council (YRITWC) collaborated with five Yukon First Nations including Selkirk, Tr'ondëk Hwëch'in, Kluane, White River and Carcross / Tagish.
The vital harvest: year-round plant foods of Tr'ondek Hwech'in and Nisga'a Tradition	Tr'ondëk Hwëch'in	Health Canada	2012	2013	This project examined the plant foods that have traditionally contributed to a healthy and diverse diet throughout the year for northern indigenous people.
Food Security and Climate Change: Teslin Tlingit Research Food Security and Climate Change Health Impacts in Our Community	Teslin Tlingit Council	Health Canada	2010	2011	Project details unavailable

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Culturally Important Plants of the Ross River Dena, and Associated Impacts Related to Climate	Ross River Dena Council	Health Canada	2010	2011	Project details unavailable
Caribou, Culture and Climate Change	Ross River Dena Council	Health Canada	2009	2010	Project details unavailable
Keeping our traditions for the mental wellbeing of Selkirk First Nations Youth: What do we do at the fish camp when there is no fish?	Selkirk First Nation	Health Canada	2015	2016	Project details unavailable
Climate Change and Health – Linking our Past and Future through our Traditions and Culture: An Ethno-Botanical Resource Study to determine the Effects of Climate Change on Traditional Ecosystems	Selkirk First Nation	Health Canada	2009	2010	Project details unavailable
Pilot Study on the Health Effects on the Selkirk First Nation due to Climate Change	Selkirk First Nation	Health Canada	2008	2009	Project details unavailable

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Enhancing Knowledge Transfer to Decision Makers with Respect to Climate Change Impacts on the Cryosphere	Yukon College (Yukon Research Centre-Northern Climate ExChange), Risk Science International	Natural Resources Canada	2012	2013	This project aims to enhance the resiliency of the mining and transportation sectors to climate change through the creation of knowledge products that communicate snow and permafrost information to industry decision-makers.
Scenario Planning for New Wildlife Species	University of Saskatchwan, Alsek Renewable Resource Council, Yukon Wood Bison Technical Team, Yukon Elk Technical Team	Social Science and Humanities Research Council (SSHRC)	2010	2013	Applied a scenario planning approach to develop wildlife management goals and evaluate participants' perceptions of scenario planning as a development tool.
CCFM Guidebook for Practitioners: Adaptation in Canada's Forest Sector	Edwards, Pierce, and Ogden for Canadian Council of Forest Ministers	Canadian Council of Forest Ministers	2012	2015	The current guidebook, one in a series by Canadian Council of Forest Minister's (CCFM) Climate Change Task Force, provides a "how to" tool for applying the CCFM adaptation framework. It brings together many of the other tools explored in the series to provide a comprehensive approach, with phases for organizational readiness, pre-vulnerability analysis, vulnerability assessment, and adaptation of sustainable forest management.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Climate Change in our Backyard 2: Building towards an Action Plan	Champagne and Aishinik First Nation, Alsek Renewable Resource Council, Yukon government (EMR-FMB), Council of Yukon First Nations, Yukon College (Yukon Research Centre - Northern Climate ExChange)	Indigenous and Northern Affairs Canada	2008	2009	Further discuss the results of climate change in the Champagne and Aishihik First Nations Traditional Territory with community members, and to identify ways of adapting to change in this region.
Climate Change Risk and Vulnerability Assessment and adaptation strategies	Champagne and Aishihik First Nation	Indigenous and Northern Affairs Canada	2015	2016	Project details unavailable.
Cost of Adaptation for Community Housing and Infrastructure	Yukon College (Yukon Research Centre - Northern Climate Exchange)	Canadian Northern Economic Development Agency	2015	2016	Identifying adaptation costs for at-risk building stock in Old Crow, Yukon, and Arviat, NWT: This project explores the potential costs of climate change impacts on buildings and housing, as well as the costs associated with adaptive modifications for buildings exposed to different levels of risk.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Human Dimensions of a Thawing Landscape	Yukon College (Yukon Research Centre - Northern Climate Exchange)	Social Science and Humanities Research Council (SSHRC)	2015	2018	Improving understanding of how permafrost thaw may affect traditional and cultural activities can help communities develop appropriate responses: the Northern Climate ExChange and the University of Saskatchewan worked with community partners in Old Crow, Yukon, and Jean Marie, NWT, to identify how traditional land use activities may be affected by permafrost thaw.
Impacts and Adaptation in Yukon Communities	Yukon College (Yukon Research Centre - Northern Climate Exchange), Council of Yukon First Nations, Vuntut Gwitch'in First Nation, Arctic Athabaskan Council, Environment Canada (Northern Ecosystem Initiative)	Indigenous and Northern Affairs Canada	2008	2009	Awareness of the results of the National Climate Change Assessment was raised through public presentations and surveying in Yukon communities. in order to build adaptive capacity and identify communities for future climate change risk analyses.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Water Temperature Data Collection Program	Ta'an Kwäch'än Council	Indigenous and Northern Affairs Canada	2009	2011	Collected water temperature date and developed a technical report on monitoring freshwater thermal regimes and a guidebook for use of data loggers to measure water temperatures in SW Yukon.
Supporting the development of Regional Climate Change Scenarios	Yukon government (ENV-CCS); Council of Yukon First Nations; Yukon College - Northern Research Institute;	Indigenous and Northern Affairs Canada	2008	2011	Project details unavailable.
Assessing the Vulnerability to Climate Change and Adaptive Capacity of Yukon Forest Tree Species and Ecosystems"	Yukon government (ENV; EMR-FMB)	Indigenous and Northern Affairs Canada	2008	2011	Project details unavailable.
Northern Climate ExChange Community Adaptation Project	Yukon College (Yukon Research Centre-Northern Climate Exchange)	Northern Strategy Trust	2010		Climate change adaptation planning and implementation of adaptation actions in three Yukon communities.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Old Crow Climate Change Risk Assessment and Final Agreement Analysis	Arctic Athabaskan Council; Vuntut Gwitchin First Nations	Indigenous and Northern Affairs Canada	2008	2009	Local and scientific methods were used to observe and evaluate climate change impacts in Old Crow, and a final report was produced to give recommendations for further action (i.e. the development of a risk management and adaptation plan). Information concerning the assessments and other aspects of the project was collected and disseminated via General Assemblies and gatherings and presentations were conducted on climate change impacts and programs and initiatives to various forums (local, regional and national meetings and workshops).
Ecological Initiatives of the Yukon Invasive Species Council	Yukon Invasive Species Council	Environment and Climate Change Canada	2012	2013	Project details unavailable.
Climate Change Community Liaison	Council of Yukon First Nations; Yukon government (ENV-CCS)	Indigenous and Northern Affairs Canada	2016	2017	Establishment of a Climate Change Community Liaison position at CYFN to inform and enable Yukon First Nations to build adaptation capacity and develop community-led responses to local climate change challenges.
Wildfire Risk Assessment Methodology	Yukon government (CS-WFM)	Yukon government - Environment	2016	2017	Development of a potential approach to assessing climate change impacts on wildfire risk in Yukon.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Mobilizing Knowledge for developing Indigenous Community Champions for Climate Change Adaptation in Yukon	Arctic Institute for Community Based Research	POLAR Canada	2017	2019	Identifying and training local community champions in Yukon communities to build adaptive capacity, improving local responses to current and future climate change impacts.
Greater Whitehorse permafrost characterization, monitoring, and climate change analysis	Yukon government (EMR-YGS)	Indigenous and Northern Affairs Canada	2017	2021	Characterizing and mapping permafrost in the Greater Whitehorse Area (GWA).
Monitoring and planning for health impacts of Extreme Weather Events and Wildfires	Yukon government (HSS-CPRM)	Indigenous and Northern Affairs Canada	2017	2018	Exploring opportunities to improve emergency preparedness to reduce the health, social and economic impacts of extreme weather events and wildfires in the territory.
Permafrost study on Yukon government buildings	Yukon government (HPW-PMD)	Indigenous and Northern Affairs Canada	2017	2021	This project examines potential risks facing Yukon government buildings constructed on permafrost, and develops building-specific action plans to mitigate these risks and adapt to future permafrost thaw.
Yukon Climate Change Needs Assessment	Yukon government (ENV-CCS)	Indigenous and Northern Affairs Canada	2018	2021	Developing a process to gather data on climate change needs and priorities in Yukon communities, and using this data to make recommendations for future adaptation work in Yukon.
Climate Risk Assessment for Yukon government	Yukon government (ENV-CCS)	Indigenous and Northern Affairs Canada	2017	2020	Creating a climate risk framework to identify and reduce climate change related risk for Yukon government operations, programs and assets.

Title	Implementing Org(s)	Funding Org(s)	Start Date	End Date	Description
Mapping and assessing climate-related landcover change	Yukon government (ENV-FW)	Indigenous and Northern Affairs Canada	2017	2020	Mapping climate change-related landcover change to identify where and how land is changing, predict future changes, and assess vulnerability and resiliency of wildlife habitat.
Yukon Adaptation Forum	Yukon government (ENV-CCS)	Indigenous and Northern Affairs Canada	2020	2021	An event for people across sectors and communities to share information about climate change adaptation-related initiatives in Yukon.
Predicting the effects of climate change on winter ticks and their hosts in Yukon	Yukon government (ENV-AHU)	Indigenous and Northern Affairs Canada	2017	2021	This project will provide an understanding of the impacts of climate change on wildlife parasites and support proactive management decisions.
Kluane watershed salmon climate change adaptation project	Yukon government (ENV-WR)	Indigenous and Northern Affairs Canada	2017	2021	Mapping and monitoring groundwater quality in Kluane Lake and River to generate baseline information about the preferences of the keystone chum salmon species for spawning areas.
Linking a changing climate with a changing traditional diet	Yukon government (EMR-AG)	Indigenous and Northern Affairs Canada	2017	2021	This project aims to improve understanding of the importance of self/family, community, and territory food sufficiency and sovereignty in the face of changing climate and to inform Yukon strategies and policies with respect to climate change adaptation for local food systems.
Permafrost vulnerability mapping - Dempster Highway Km 65-200	Yukon government (HPW-TEB)	Indigenous and Northern Affairs Canada	2018	2021	Providing a tool for Yukon Highways and Public Works (HPW) to proactively consider threats to the Dempster Highway from the melt of massive ice-bodies.
CCPN program administration	Yukon government (ENV-CCS)	Indigenous and Northern Affairs Canada	2017	2021	Supporting Yukon government's capacity to advance Climate Change Preparedness in the North funded climate change adaptation initiatives within and outside government.