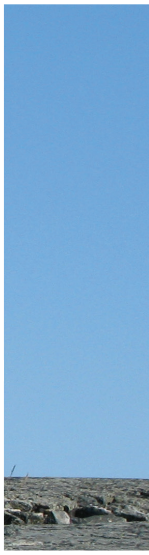
ATULIQTUQ: ACTION AND ADAPTATION IN NUNAVUT

# CLIMATE CHANGE ADAPTATION ACTION PLAN FOR WHALE COVE (TIKIRARJUAQ)

2010



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CANADIAN INSTITUTE OF PLANNERS | INSTITUT CANADIEN DES URBANISTES
*Shaping our Communities Sustaining Canada's Future* | *Bâtir nos communautés Pour un Canada viable*

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ATULIQTUQ: Action and Adaptation in Nunavut is a collaborative project of the Government of Nunavut, the Canadian Institute of Planners, Natural Resources Canada and Indian and Northern Affairs Canada. The Climate Change Adaptation Action Plan for Whale Cove (Tikirarjuaq) was prepared by Katie Hayhurst and Taylor Zeeg with the support of Kuch & Hayhurst Consulting and Compass Resource Management respectively. The authors would like to recognize the contributions of:

- Mayor, Council and Hamlet Staff
- Elders
- Community Participants
- Hunters and Trappers
- School Staff and Students
- Community Radio
- Translators, Cooks, Organizers, Volunteers

in the completion of this adaptation plan.

## Acknowledgements

This plan was a community effort involving many community volunteers and participants attending feasts, workshops, meetings, movie nights, and school events, supported by scientists, planners and government funders.

As the two Canadian Institute of Planners (CIP) volunteers involved in the pilot project for Whale Cove, we hope this Plan provides a good start to addressing climate change in the community.

We are grateful to the many people and funders who made it possible:

- Mayor, Council and Hamlet Staff
- Elders
- Community Participants
- Hunters and Trappers
- School Staff and Students
- Community Radio
- Translators, Cooks, Organizers, Volunteers
- Government of Nunavut Planning, Engineering, Education and Environment Staff
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- Canadian Institute of Planners (CIP)
- Indian and Northern Affairs Canada (INAC)

*Sincerely, Taylor Zeeg & Katie Hayhurst*

## Executive Summary

The increase in carbon dioxide levels in the atmosphere – primarily from the burning of fossil fuels and land use change – is increasing global temperatures at a rate never before seen in human history. Rising temperatures are resulting in reduced sea ice, melting permafrost, increasing severity and frequency of storms, among other changes to the earth's natural systems. Nowhere is the effect of climate change taking its toll on communities and the landscape more than in the Arctic.

To help Nunavut communities respond and adapt to the anticipated impacts of changing weather patterns, the Canadian Institute of Planners, Indian and Northern Affairs Canada, Natural Resources Canada and the Government of Nunavut launched the Nunavut Climate Change Project. Over the past two years, seven climate change adaptation plans were completed, including one for Whale Cove (see Figure 3).

Unlike many Arctic communities, Whale Cove is relatively unaffected by many of the typical climate change impacts. Due to largely being on bedrock and situated in an area of expected land lift, it is not as susceptible to impacts from melting permafrost and shoreline erosion as other communities. Sea ice loss is posing community safety risks due to increased polar bear activity; however, Whale Cove residents don't travel out onto the ice pack as often as other Inuit communities due to some residents' preference for inland game, and lack of equipment for safe sea travel. Many residents use boats to hunt caribou in other areas. Sea ice loss will likely increase access. Finally, residents are close to a reliable and large freshwater supply.

Weather variability is affecting the Inuit way of life in Whale Cove. Hunters are less able to predict weather, are getting lost more often, and are less able to use natural features (e.g. clouds, snow drifts) to navigate. This results in heightened safety issues, which may be preventing traditional gathering activities and the knowledge transfer that accompanies it.

A major focus for community members is fostering traditional knowledge transfer. Elders, youth and educators expressed concern that traditional knowledge is not being passed on, with negative affects for the social fabric of the community. A number of strategies were identified to strengthen Inuit Qaujimajatuqangit (IQ), or traditional knowledge, and the community's ability to adapt to climate change over time.

Whale Cove is, or soon will be, involved in several major planning initiatives in the short term. The community is currently undergoing a Sustainable Infrastructure Planning initiative to plan for infrastructure improvements into the future. In summer 2010 the Nunavut Department of Community and Government Services (CGS) is initiating an update to the Land Use / Community Plan. This will form the basis of Whale Cove's first zoning bylaw. There may be a

need to update the Community Economic Development plan over the next year or two. Integrating climate change planning into the existing planning efforts that constantly undergo revision and updating, is probably the single best way to develop planning capacity to address climate change, and take advantage of any benefits. We've identified a strong role for the Town Planning and Land Use Committee, the Hamlet Economic Development Office and the Government of Nunavut (CGS) to ensure climate change gets knitted into the existing planning and governance framework.

Taking action on climate change will require strong leadership. It is therefore important for the Hamlet Council to take strong positions on climate change related planning. As our planning process demonstrates, there is strong interest among members of the community to address impacts and benefits. Strong leadership is required to insure the community's interests are realized. At our fifth and final trip to Whale Cove, the Hamlet Council agreed to the following:

- Adopt the draft version of the Whale Cove Climate Change Action Plan (approval of final plan was pending completion of the document),
- Establish a new standing committee of Council to implement the new plan,
- Integrate relevant plan recommendations into relevant planning documents and bylaws,
- Distribute the climate change workbook and poster to all households in Whale Cove, and
- Distribute the main Action Plan to all local and regional committees and to appropriate territorial and federal authorities.

Whale Cove is highly dependent on the Government of Nunavut (GN) for planning and other resources. The GN can play a major role in addressing climate change in Whale Cove by recognizing and applying this plan (and future updates) as an important source document for planning and infrastructure efforts in the future. The GN can represent and relay the community's interest to relevant departments in the territorial government. Lastly, the GN is well positioned to facilitate communication and learning about climate change among all Hamlets through a co-ordinated climate change strategy for Nunavut. One way the CGS could support the Whale Cove Climate Change Plan is to establish a requirement in Community Plan RFPs that consultants have climate change experience and consider the climate change plan in their work.

In addition to this action plan, a community workbook and poster were developed for the community. The poster can be placed in homes and offices to remind people to think about climate change and prepared for it. The workbook lists ways that people can take action, and encourages everyone to do their part by making a personal commitment to help Whale Cove adapt.

# Table of Contents

## List of Tables

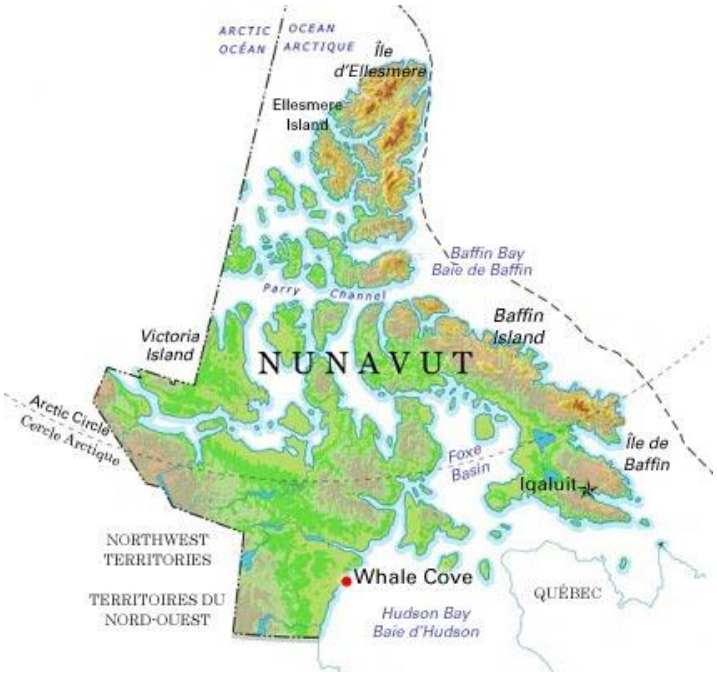


## List of Figures

# 1.0 Introduction

A region surrounded by lakes and rivers, Whale Cove originally was a spot where Inuit and Chipewyan traders used to meet with the Hudson's Bay Company. It is located in the Kivalliq Region, Nunavut on the northwest coast of Hudson's Bay (Figure 1).

**Figure 1: Map Showing Whale Cove**




The hamlet is built at the southern end of a long promontory (Tikirarjuaq, or "long point"), from which it gets its Inuktitut name (Figure 2).

**Figure 2: Whale Cove Local Map**


Today, Whale Cove has a population of about 350 people, and is primarily Inuit. Inuktitut and English are the two languages used.

The region retains its tradition of subsistence hunting and fishing using modern technology such as snowmobiles and motorboats. Arctic char and caribou are staples of the Whale Cove diet, as well as seal and beluga. Many activities are being affected by weather patterns not experienced before.

According to recent major studies, Arctic communities are expected to experience warmer temperatures, increased precipitation, increased storm severity and extent and changing wind patterns, among other weather related changes. These changes to the region's weather will impact communities in a number of ways, both positively and negatively.

To help Nunavut communities respond and adapt to the anticipated impacts of changing weather patterns, the Canadian Institute of Planners, Indian and Northern Affairs Canada, Natural Resources Canada and the Government of Nunavut launched the Nunavut Climate Change Project. Over the past two years, seven climate change adaptation plans were completed (Figure 3). These plans will form the basis for completing climate change adaptation plans in remaining Nunavut communities.

**Figure 3: Nunavut Climate Change Project Communities**


*White markers represent Phase 1 communities.

The Whale Cove Climate Change Plan is particularly timely. Whale Cove is undergoing a revision to its Community Plan beginning in summer 2010 and the climate change plan is expected to be a key input into that process. The Community Plan then forms the basis of the Zoning Bylaw. The climate change plan will also inform other important plans and processes such as the Community Economic Development Plan and the Infrastructure Sustainability Plan, also currently under development.

## 2.0 Plan Development

The Whale Cove Climate Change Plan was developed between March 2009 and June 2010. The planning team made five visits to the community. Three Natural Resources Canada (NRCan) scientists joined the planning team during the second visit (July 2009) to conduct a preliminary permafrost and shoreline impact assessment. A separate NRCan science team visited Whale Cove in early July 2009 to assess the water supply quantity. The CIP planning team was joined by the CGS planner on community visits.

## 3.0 Planning Process

The process used to develop the Whale Cove climate change plan is based on methods recommended by the international organization *Local Governments for*

*Sustainability (ICLEI)*. It begins with an assessment of changes to key climate variables over time (e.g., temperature and precipitation), and of the effect of these changes on things like sea level, permafrost, sea ice, and other natural features. These changes affect human communities in various ways. Communities rank the importance of each impact, as a basis for developing strategies to address potential threats and opportunities.

# 4.0 Climate Change

## 4.1 Global Climate Change

Climate change refers to changes to the average weather or weather variability of a region or the planet over time. It is measured by changes in temperature, precipitation, wind, snow and ice cover and other weather indicators.

The key climate change indicator that scientists look to is average surface temperature of the earth. Over the past 50 years, the global average temperature increased by 0.65°C. It was approximately double that in Canada's Arctic, where the effects of climate change tend to be more severe than southern latitudes.

Global ocean temperature is also an important factor to consider due to its effect on surface temperatures. The world's oceans are absorbing much of the heat added to the earth's climate system and as the ocean circulates, much of that heat will release into the atmosphere, increasing the warming effect over time.

The Intergovernmental Panel on Climate Change (IPCC) is widely regarded as the world authority on monitoring and reporting climate science. In its 4$^{th}$ Assessment report in 2007, the IPCC states that "most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in [human caused] greenhouse gas concentrations." The increase in carbon dioxide levels in the atmosphere – primarily from the burning of fossil fuels and land use change – is increasing global temperatures at a rate never before seen in human history. Rising temperatures are resulting in reduced sea ice, melting permafrost, and increasing severity and frequency of storms, among other changes to the earth's natural systems. Nowhere is the effect of climate change taking its toll on communities and the landscape more than in the Arctic.

## 4.2 Climate Change in Whale Cove

We focussed on temperature and precipitation as the two key climate variables pertaining to climate change. Both historical and projected trends were assessed. We projected changes to temperature and precipitation over the next 75 years, looking at a range of possibilities.

All historical weather data comes from the weather station at Rankin Inlet. There is a weather station at Whale Cove airport but the weather recordings are incomplete. Rankin Inlet is approximately 100 km north of Whale Cove.

Temperature and precipitation projections were developed through the use of the Canadian Climate Change Scenarios Network (CCCSN) website. Details of methods and results are listed in Appendix A.

Summary of results:

Temperature

- The average annual temperature in Whale Cove increased by 2°C over the past 30 years. There is greater warming during fall and winter months than other parts of the year.
- There is greater variation in temperatures over the past 10 years, consistent with community members telling us the weather is less consistent.
- Community members are aware of changing temperatures. The greater warming trend in the fall, winter and spring months correlate with community members' observations of late fall freeze up and early spring thaw of water bodies. The warmer winter trend also correlates with reports of thinning sea ice and reduced sea ice extent.
- Temperature in Whale Cove is projected to increase by between 2.8 and 4.8˚C from now through 2085.

Precipitation

- Annual average precipitation in Whale Cove increased slightly over the past 30 years.
- There is increased precipitation in the winter and spring months (more rain than snow) and increasingly drier summers.
- Annual precipitation is projected to increase by between 11 and 33% from now through 2085.
- Based on the historical trends, one would expect the majority of precipitation increases would occur during winter and spring.

Weather Variability

- Increased high and low temperature extremes and increased storm frequency, intensity and extent are being observed across the Arctic. Whale Cove residents reported similar observations. Inuit hunters are less able to predict weather, read cloud formations and travel safely through snow due to changing weather patterns and snow quality.
- Winds the past few summers are reportedly too strong for fishing by boat on many days. As well, wind directions are different than the past, which in turn makes it difficult for Inuit hunters to read the winter landscape and interpret the direction of windward drifts.

- Community members report increasingly volatile and unpredictable weather is increasing the frequency and severity of hunting and travelling accidents.

## 5.0 Climate Change Effects

This section summarizes the climate change effects on the earth's natural systems in Whale Cove. Details and supporting maps are in Appendix B.

Sea Ice

- A near total loss of summer sea ice is expected in the Arctic by the end of this century.
- Less sea ice allows higher waves and storm surges to reach shore, causing greater shoreline erosion and flooding.
- Reduced sea ice is opening new shipping routes which are leading to increased trade, tourism and science and increased potential for marine impacts such as contaminant spills and wildlife disturbance.
- Warmer temperatures are causing later fall freeze up and earlier spring thaw, which is affecting hunter safety and wildlife habitat.
- There is reduced habitat for marine wildlife to rest, pup and feed, which in turn reduces Inuit hunting and wildlife-viewing tourism opportunities for coastal communities.

Ground Thaw

- Warmer temperatures cause increased summer thaw depth.
- Greater melting causes ground settlement and instability leading to damaged buildings and infrastructure.
- Due to the ground thaw, the lower part of town is more sensitive to manmade disturbances. Some buildings may destabilize. There may be some thaw settlements under roads.
- Proposed buildings or infrastructure in the lower part of town required geotechnical studies.
- Flat areas over bedrock provide solid ground for construction.
- See maps in Appendix B.

Sea Level Change

- Sea level change is the result of warming oceans and melting ice caps and glaciers.
- In Whale Cove over the next 90 years, sea level will probably fall between 55 cm and 0 cm.

- Unlike many Arctic communities sea level rise will likely not pose a threat for Whale Cove. However, a sea level decrease (due to land lift) may pose a challenge for the barge dock.

Fish, Wildlife and Vegetation

- Due to a general warming trend, many plant species are expected to extend their range northward over the coming century. The northward extension of southern wildlife species will increase competition for food, alter mortality/reproductive rates and increase the spread of diseases.
- Aquatic species will also be affected in terms of abundance and range, though extinction of Arctic species is unlikely.
- Whale Cove residents are aware of changes to their natural world. Community members report sighting new species of birds, new types of shrubs, taller willow trees in some areas, and loss of fresh lake fish in lakes that are becoming shallower or disappearing altogether.
- The Inuit in Whale Cove reported changes in the numbers, movements and activities of animals such as bears, birds, insects, and muskoxen. Animals and people are being disturbed by more and new insects.

Ozone Depletion

- Harmful rays from the sun may affect humans, wildlife and vegetation.
- Unsafe levels of rays can cause skin cancer, sunburns, cataracts and other ailments in humans; reduced food availability in ecosystems and decreased productivity in marine life
- Harmful levels of UV radiation are highest during spring months.

Surface Water

- No significant water quality concerns have been identified.
- With the small population relative to the freshwater available, climate change impacts may not greatly affect the community's water supply.
- Warmer climate or a hot summer could affect water quality in small lakes/ponds.
- Some small lakes/ponds may disappear over time.

## 6.0 Taking Action on Climate Change

The purpose of this section is to prioritize impacts and develop strategies for adapting to possible changes. The main focus of our team's 4th visit to Whale Cove was a one day workshop to prioritize impacts and identify strategies. Our planning team later identified potential leaders based on community input, targeted

consultation, and professional judgement based on our understanding of the Whale Cove planning context learned over the past 14 months.

## 6.1 Community Values

The Whale Cove Climate Change Plan is guided by community values. Values guide how important impacts are to the community and how resources should be allocated accordingly. To better understand the community's values about climate change, we focused part of our 3rd trip on the question:

*What does a healthy, prosperous Whale Cove look like in 50 years?*

Participants' responses ranged widely yet a natural bundling emerged. The headings below represent broad value categories, and provide a useful framework for prioritizing impacts, and developing strategies for action and implementation.

1. The value of *cultural knowledge*, also referred to as *Inuit Qaujimajatuqangit (IQ),* is recognized and fostered.

- Elders pass on IQ to the younger generation
- There is an ability to practice traditional ways and knowledge
- There is an ability to live off the land

2. The Hamlet is a *safe* place to live, work and play.

- It is safe to hunt on the land (related to cultural knowledge)
- It is safe in town from polar bears
- Buildings and infrastructure are safe and comfortable

3. *Community well-being* is fostered through economic development and human health.

- Community members have the ability to make a good livelihood
- There are economic development opportunities
- Members of the community are healthy

4. *Environmental stewardship* is practiced and applied in decision-making.

- Whale Cove pollutes less and consumes less
- Whale Cove uses alternative energy

5. The community is *adaptive* in responding to the negative effects of climate change, and taking advantage of opportunities.

    - The community learns ways to adapt to climate change through education, knowledge and preparedness

The categories are best thought of as tools for linking impacts to things the community cares about. These values are also useful for ongoing work or even other planning efforts.

## 6.2 Identifying Priority Impacts, Developing Strategies

A number of impacts were identified by the community, the science teams and research. Impacts were categorized at the 4th community workshop and by the planning team.

It is important to note that attendance at the 4th community workshop fluctuated throughout the day, so we didn't always have adequate representation of community members. However, those in attendance were knowledgeable about the issues and familiar with the planning process since its inception.

Impacts are prioritized as high (H), medium (M), or low (L) in the table below. Strategies for addressing impacts were identified through workshops, scientist visits and one-on-one meetings. A recommended lead is identified for each strategy (Table 1).

**Table 1: Impacts, Priorities, Strategies and Implementation**

| Value Category | Community Impact | Priority | Strategies for Action | Implementation | |
|---|---|---|---|---|---|
| | | | | Recommended Lead | Supporters |
| Cultural knowledge / IQ | There is less opportunity for traditional knowledge transfer due to decreased berry picking. | H | - Travel to islands to pick berries (with boats)<br>- Hold family / community BBQs to share knowledge<br>- Expand knowledge-sharing beyond own family | Community members | |
| | Have to travel further to fish. | H | - Avoid overfishing<br>- Monitor fish abundance and access to fishing spots<br>- Education around fish habitat | GN / Conservation Office | Community members HTA |
| | There is less hunting activity / knowledge transfer due to unpredictable weather. | H | - Expand HTA programs that provide funding to send out 4 or 5 hunters to gather food.<br>- Create hunter apprenticeship program to train youth about hunting. Elders take youth on extended hunting trips as part of training | EDO | GN / INAC / HTA |
| | Harder to get traditional food due to less snow on trails during cold season. | H | - Greater use / availability of amphibian vehicles (land/water/snow) | GN / Conservation Office | Community members |
| Safety and Comfort | Graveyard is running out of space and graves are sinking. Currently on fine gravel. | H | - Address in land use / community planning process<br>- Identify gravel source for this and other projects | GN / CGS Town Planning and Land Use Committee | Hamlet Council Sustainable Infrastructure Plan |
| | Ice is softer during freeze-up period. | H | - Provide information on water quality and water quality monitoring | GN / CGS | Hamlet |
| | Lack of gravel available for construction. | H | - Don't take gravel from beach / shoreline as it accelerates erosion<br>- provide map to community of gravel source | GN / CGS Town Planning and Land Use Committee | Hamlet Council Sustainable Infrastructure Plan |
| | Potentially impeded barge access if there is additional sea level fall / land lift (see section 5). | H | - The Hamlet is assessing widening the barge dock by 30 feet and should assess if that is sufficient given possible land lift<br>- Assess potential deep sea port on other side of peninsula | GN / CGS Town Planning and Land Use Committee | Hamlet Council |

| Value Category | Community Impact | Priority | Strategies for Action | Implementation: Recommended Lead | Implementation: Supporters |
|---|---|---|---|---|---|
| | Adapting to new climate changes. | H | - Integrate climate change plan recommendations into:<br>o Economic Development Plan<br>o Sustainable Infrastructure Plan<br>- Incorporate climate change plan recommendations into consultant terms of reference / RFP documents for land use / community plan update | GN / CGS<br>Town Planning and Land Use Committee<br>EDO | Hamlet Council |
| | Poor drainage/ potential thawing at lower town site (see section 5). | H | - Conduct specialized geotechnical studies before establishing buildings. | GN / CGS<br>Town Planning and Land Use Committee | Hamlet Council |
| | Uncertainty about locating new buildings / infrastructure. | H | - Bedrock areas in upper town site provide solid ground for construction. It necessitates some levelling of the ground (see section 5.2 of this report). | GN / CGS<br>Town Planning and Land Use Committee | Hamlet Council<br>Sustainable Infrastructure Plan |
| | Can't make igloos because snow too soft / different. | H | - Igloo building education for hunters and youth<br>- Education about importance and use of emergency equipment (tent, GPS)<br>- Community training in search and rescue | HTA | GN / Conservation Office<br>Search and rescue department |
| | Harder to predict weather. Less certain when it's safe to hunt and travel. Increasing number of accidents. | H | - Search and rescue<br>- Education about importance and use of emergency equipment (tent, GPS) | HTA | GN / Conservation Office |
| | Unreliable sea ice. Can no longer tell by the colour if ice is thick enough for travel. | H | - Seek information from ice researcher at University of Manitoba.<br>- Map safe ice routes, put on community website | GN / Environment (climate change department) | HTA<br>EDO |
| | Polar bears staying closer to shore - increased dangers. People going out on land less, hunting less, young people getting less experience. | H | Don't leave bear attractants around camp or community<br>Use electric fences to block bears from town<br>Travel in groups | GN / Environment | |

| Value Category | Community Impact | Priority | Strategies for Action | Implementation: Recommended Lead | Implementation: Supporters |
|---|---|---|---|---|---|
| **Community Well Being** | More industry coming to Whale Cove. More economic opportunities. Potential greater fragmentation of landscape. | H-M | - Opportunities should promote culture of the region<br>- Local involvement in decision making process<br>- Hold open houses for people to learn about issues | EDO | GN / CGS |
| | Warmer summers. | M | - Take advantage of more swimming opportunities<br>- Record water levels of lakes (may decline) | Community members | Hamlet |
| | Inuit becoming more reliant on imported foods and equipment. Higher costs, food reliability | H-M | - Pursue wholly owned Inuit co-op that sells furs, game, good food, etc.<br>- Certified Inuit butchers to render game for sale (co-op), with good local control | EDO | GN / CGS |
| | Likely greater shipping / tourism traffic in Whale Cove due to less sea ice. | M | - Support economic activity that is culturally sensitive and engages the community and provides local opportunities<br>- Hamlet Council remain engaged and monitor closely | Hamlet Council | EDO |
| | Less traditional food gathering due to various aspects of climate change. | M | - Teach to farm in Nunavut (greenhouses?)<br>- Alternative food choices and healthy diet<br>- Teach youth how to hunt and fish | EDO | |
| | Inability to manage climate change impacts on its own. | M | - Co-ordinate with other Hamlets in Nunavut<br>- Support Territory-wide climate change strategy | Hamlet Council | EDO |
| **Environmental Stewardship** | Greenhouse gases from energy. | H | - More wind power (conduct feasibility study)<br>- Foster a proposal for wind farm (jobs, clean energy)<br>- Less airplane travel<br>- Assess potential for combined heat and power (CHP) technology at power plant<br>- Possible electricity grid connection (underwater cable, Manitoba Hydro) | EDO | Hamlet Council<br>GN / Energy<br>GN / Environment<br>GN / CGS |
| | An area of concern is the earth dam at the community dump. The dam may be increasingly exposed and sensitive to erosion, increased risk of contaminating the ocean. | H | - The community is currently considering some improvements to the facility. There is an opportunity to redesign the surface water management strategy at the dump and reduce the potential for contaminated water entering the marine ecosystem | GN / CGS Sustainable Infrastructure Plan | Town Planning and Land Use Committee |
| | More bugs due to warmer summer, more vegetation. Animals/people bothered more. | L | - Greater awareness of insects / bites / risks | GN / Community Nurse | Community members |

## 6.3 Ability to Adapt

One of the core values identified by community members is the ability of Whale Cove to successfully adapt to climate change. The community expressed this as the need to be *able to adapt* by responding to the negative effects of climate change, and taking advantage of opportunities.

Based on input from the community and some of the climate change planning literature, we identified several objectives to help guide the community in developing ways to adapt:

- Increase education and awareness about climate change
- Monitor changes to the community and Inuit way of life
- Develop skills and new technology / resources
- Use planning processes to deal with climate change
- Foster traditional knowledge transfer (IQ)

Table 2 lists ideas developed at the 4th community workshop in Whale Cove for ways to improve the community's ability to adapt to climate change.

**Table 2: Ideas and Strategies for Improving Whale Cove's Ability to Adapt**

| Objectives | Strategies |
|---|---|
| **Increase education and awareness** | |
| Topics to learn about:<br>- alternative energy<br>- traditional way of living<br>- reduce pollution<br>- Nunavut specific science curriculum that addresses climate change effects/impacts and new economic reality (e.g. tourism, new industry)<br>- Learn ways the community can influence type of economic activity (culturally appropriate, low impact industry) | - School activities to learn about climate change: drawing, word games, activities, writing stories, poster projects, mapping<br>- Starting a recycling program (a lot of pop) |
| **Monitor change** | |
| - Youth undertake responsibility to learn about climate change impacts and traditional knowledge and monitor changes to community | - Schools provide hands-on experience to monitor change, develop monitoring projects to make climate change interesting |
| **Develop new skills** | |
| - The community continually update hunting and gathering skills and familiarity with technology (e.g. GPS, mapping software, rescue equipment, survival equipment) | |
| **Develop planning capacity** | |
| - The community continually build skills to address climate change impacts through community and land use planning | - Include climate change planning and monitoring in the Town Planning and Land Use Committee Terms of Reference |

| | |
|---|---|
| | - Consider climate change during community / land use plan updates |
| **Foster traditional knowledge transfer** | |
| - Changes to the land and people due to climate change is incorporated into IQ and passed down through generation. This will build awareness and develop abilities to adapt to change. | - IQ is hard to learn in school. There needs to be a continuous effort, an ongoing program. Not just once in a while.<br>- Land Skills program in school is just one or two hours. Kids don't benefit very much.<br>- Reinstate the Cultural and Language Education and Youth program (federal), which hires elders to take youth out for mulit-day trips to hunt / dress meat / gather, etc |

Through greater education, monitoring, skill development, planning and knowledge transfer, Whale Cove can increase its ability to successfully adapt to climate change.

# Appendix A – Historical and Projected Temperature and Precipitation

Climate Change Projections are based on 25 Global Climate Models (CGMs) from the most recent IPCC 4th Assessment. Using a series of tests provided by CCCSN, we selected CGMs that are likely most applicable to a local area by matching a local weather station's historical data with the baseline data used in each CGM. This logic implies that any modelling effort in which the baseline data used by the model approximates historical weather for a specific location serves as a useful proxy for weather projections in that area. Note, the CGM outputs are *not predictions*, but *projections* based on a number of assumptions and large, complex computer models. While the projections are not likely going to be 100% predictive, they are the best available information for many of these communities.

Three GCMs were selected to represent potential temperature and precipitation projections:

- BCM2.0 – Bjerknes Centre for Climate
- CNRMCM3 - Centre National de Recherches Meteorologiques
- ECHO-G - Meteorological Institute, University of Bonn Meteorological Research Institute of KMA Model and Data Groupe at MPI-M

Each model includes three GHG emission scenarios. GHG emissions are one of the major drivers of climate change within the weather models:

- A2 – Aggressive growth in GHG emissions
- A1B – Moderate growth in GHG emissions
- B – Low growth in GHG emissions

A range of scenarios is used because GHG emission growth is largely influenced by human activity and the degree of GHG mitigation efforts, which remain uncertain and in flux.

## Temperature

The average annual temperature trend in Whale Cove shows a 2°C increase over the past 30 years, with increased volatility over the past 10 years (Figure 4). The increased volatility is shown by the high and low spikes from 1999 onward on the graph below. However, warming trends are not distributed evenly over the seasons (Figure 5). An assessment of temperature trend increases for each season indicates a 4°C increase over the winter months, a 2°C increase over the spring months, a minimal increase over the summer months, and a 3°C increase over the fall months.

Community members are aware of changing temperatures. The greater warming trend in the fall, winter and spring months correlate with community members' observations of late fall freeze up and early spring thaw of water bodies. The warmer

winter trend also correlates with reports of thinning sea ice and reduced sea ice extent.

**Figure 4: Whale Cove Annual Average Temperature, 1981 - 2008 (˚C)**

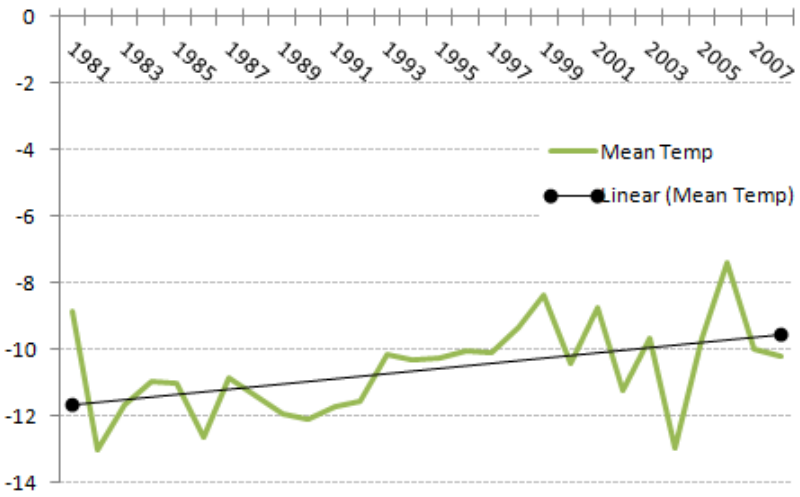
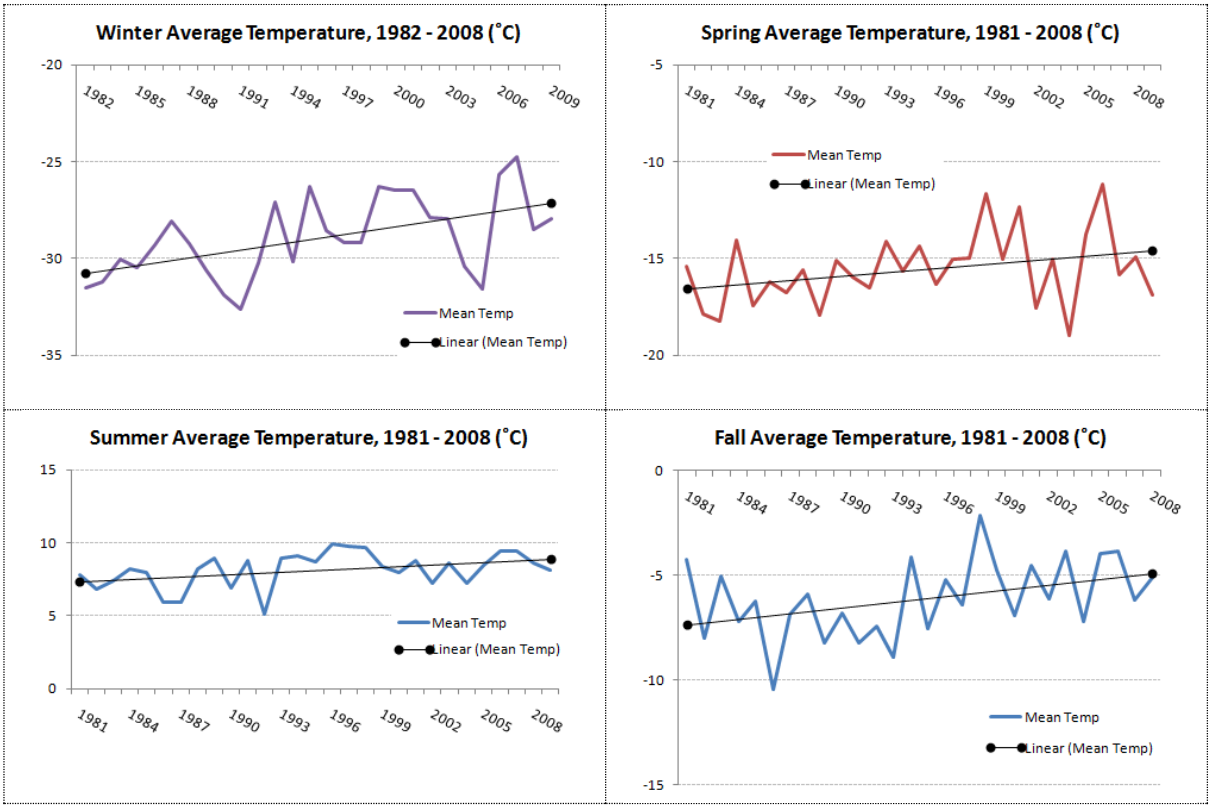



**Figure 5: Whale Cove Historical Temperatures, by Season**



Temperature projections vary considerably depending on the model and GHG emissions scenario. Table 3 summarizes the range of possible temperature projections.

**Table 3: Whale Cove Range of Temperature Increase Projections**

| | Low GHG Growth Scenario | Moderate GHG Growth Scenario | Aggressive GHG Growth Scenario |
|---|---|---|---|
| 2025 | 1.5 – 2˚C | 1.5 – 2˚C | 1.5 – 2˚C |
| 2055 | 2.2 - 3˚C | 3.2 - 4˚C | 3 – 3.5˚C |
| 2085 | 2.8 – 3.8˚C | 3.5 – 4.4˚C | 4.3 – 4.8˚C |

In summary, temperature in Whale Cove is projected to increase by between 2.8 and 4.8˚C from now through 2085.

## Precipitation

Annual average precipitation in Whale Cove shows only a slight increasing trend over the past 30 years (Figure 6), remaining steady at approximately 300 mm / year. On average, total snowfall is approximately 120 cm/year and snow cover on the ground is on average 30 cm. Similar to historical temperature, the seasonal distribution tells a different story (Figure 7). The winter trend shows an increase of approximately 25 mm over the past 30 years whereas the summer trend decreased by about 40 mm. The trend lines suggest increased precipitation in the winter and spring months, contrary to constant levels in the fall and increasingly drier summers.

Community members reported less snow cover during winter months, which correlates with Arctic wide reports of reductions in annual snow cover extent of 10%/year and reduced snow cover depth. There is a seeming contradiction: It appears historical precipitation data shows an increasing trend whereas community and arctic wide reporting identifies a decreasing trend in snow. There could be a few explanations for this: 1) due to warming, it is possible there is more precipitation but less snow (i.e., more rain); 2) As a peninsula, Whale Cove would be susceptible to high winds, which may in turn blow snow cover out to sea; 3) the perception of where deeper snow used to be might change with new directions in prevailing winds.

Reduced snow levels combined with warming trends are raising challenges for Inuit hunters. Non-motorized travel is becoming more difficult due to softer ground conditions while the lack of snow makes is harder to travel by snowmobile over the tundra.

**Figure 6: Whale Cove Annual Average Precipitation, 1981 - 2008 (mm)**

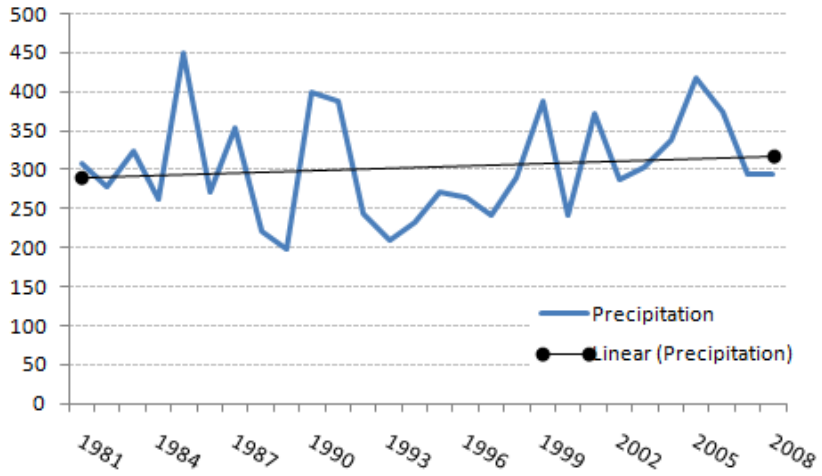
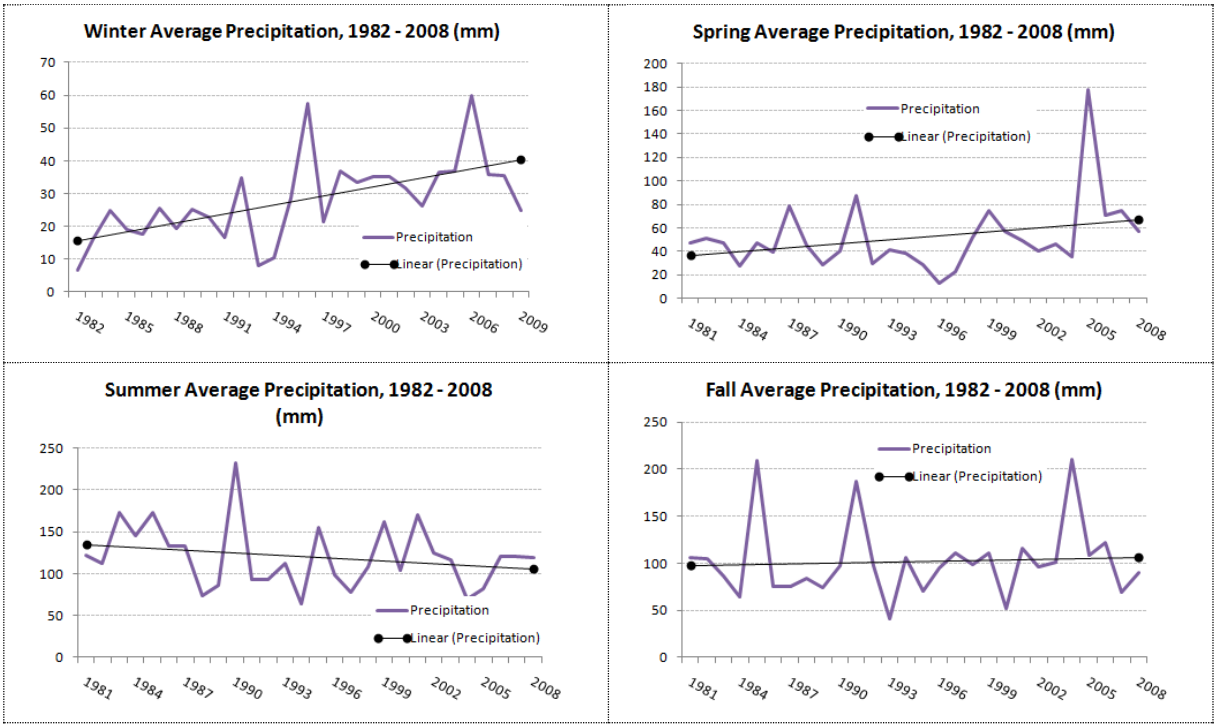



**Figure 7: Whale Cove Historical Precipitation, by Season**



Precipitation changes are summarized in Table 4. Like temperature, precipitation projections vary considerably depending on the model and GHG emissions scenario. **Error! Reference source not found.** summarizes the range of possible precipitation rojections.

**Table 4: Whale Cove Range of Precipitation Projections**

| | Low GHG Growth Scenario | Moderate GHG Growth Scenario | Aggressive GHG Growth Scenario |
|---|---|---|---|
| 2025 | 1 – 12% | 2 – 15% | 3 – 8% |
| 2055 | 5 – 14% | 14 – 18% | 12 – 17% |
| 2085 | 11 – 21% | 18 – 22% | 18 – 33% |

In summary, annual precipitation is projected to increase by between 11 and 33% from now through 2085. Mean annual precipitation in Rankin Inlet from 1981 to 2008 was approximately 300mm. Increases of between 11 and 33% suggest average precipitation could increase by between 33 and 99mm. Based on the historical trends, one would expect the majority of that precipitation increase would occur during winter and spring months.

# Appendix B – Details of Climate Change Effects

This section summarizes the climate change effects on the earth's natural systems in Whale Cove. In some cases we relied on Arctic-wide reports to fill any information gaps. [1] But in most cases, there was enough information available from community input, the science teams, and our analysis of historical and projected weather data.

From the outset of the planning process, it was evident that Whale Cove community members (in particular, elders and hunters) were aware of many changes to the Arctic landscape identified in scientific reports. For example, residents reported that sea level has been falling, contrary to popular media accounts of sea level rising. This phenomenon was explained by the NRCan scientists as isostatic glacial lift. The land lift is a result of glaciers melting thousands of years ago. As the glaciers melted, it was like a weight was lifted off the land and it began to rise. In Whale Cove, the land is likely to continue to rise faster than sea level. This makes it seem like sea level is dropping.

In other cases, community views are different than the messages they often hear about climate change. For example, a number of polar bear subpopulations are declining, likely due to a loss of sea ice. However, from the perspective of Whale Cove residents polar bear sightings are increasing. This may be due to the ice edge not forming as far out into Hudson's Bay (due to later fall freeze up and warming winters) so the polar bear migration route from Churchill and Arviat northward is routed closer to Whale Cove. Inuit local knowledge and input is essential for understanding climate changes and their impacts.

## Loss of sea ice

Decreased sea ice thickness and extent in the Arctic is well documented. According to the IPCC 4th Assessment Report, annual average Arctic sea ice extent has shrunk by 8% since 1978 with more than double that reduction during summer. The Arctic Climate Impact Assessment (ACIA) report suggests a near total loss of summer sea ice in the Arctic by the end of this century.[2]

Less sea ice allows higher waves and storm surges to reach shore, causing greater shoreline erosion and flooding. Reduced sea ice is opening new shipping routes which are leading to increased trade, tourism and science and increased potential for marine impacts such as contaminant spills and wildlife disturbance. Warmer temperatures are causing later fall freeze up and earlier spring thaw, which is affecting hunter safety and wildlife habitat. There is reduced habitat for marine

[1] Arctic-wide impacts and effects are based on two Arctic impact reports recently completed: 1) Fugal, C. and Prouse, T.D. (2008): Northern Canada; in From Impacts to Adaptation; Canada in a Changing Climate, edited by D.S. Lemmen, F.J. Warren, J. Lacroix, and E. Bush. Government of Canada, Ottawa, ON, pg 57-118, and 2) Hassol, Susan, J. (2004). Arctic Climate Impact Assessment.

[2] The ACIA is an independently reviewed assessment of arctic impacts, involving hundreds of scientists over 4 years and local indigenous knowledge.

wildlife to rest, pup and feed, which in turn reduces Inuit hunting and wildlife-viewing tourism opportunities for coastal communities.

### Thawing Permafrost

Warmer temperatures cause increased summer thaw depth. Greater melting causes ground settlement and instability leading to damaged buildings and infrastructure. Some waste containment facilities depend on the frozen ground to contain raw sewage facilities. As the permafrost degrades, the risk of sewage leakage increases. Melting permafrost is also leading to reduced soil stability and resulting mudslides, river run off, and the draining of wetlands and lakes that were historically contained by the permafrost.

Michel Allard (Centre d'études Nordiques, Université Laval) conducted a broad assessment of Whale Cove ground conditions in July 2009. The assessment was intended to support land use planning in the Whale Cove climate change plan. Allard suggested the active layer may have increased by about one metre in bedrock and up to several decimetres (i.e. 20-30 centimetres) in soils such as till. In poorly drained areas on superficial sediments (such as the lower part of the Hamlet) this makes the ground more sensitive to manmade disturbances and may also destabilize some buildings and cause some thaw settlements under roads.

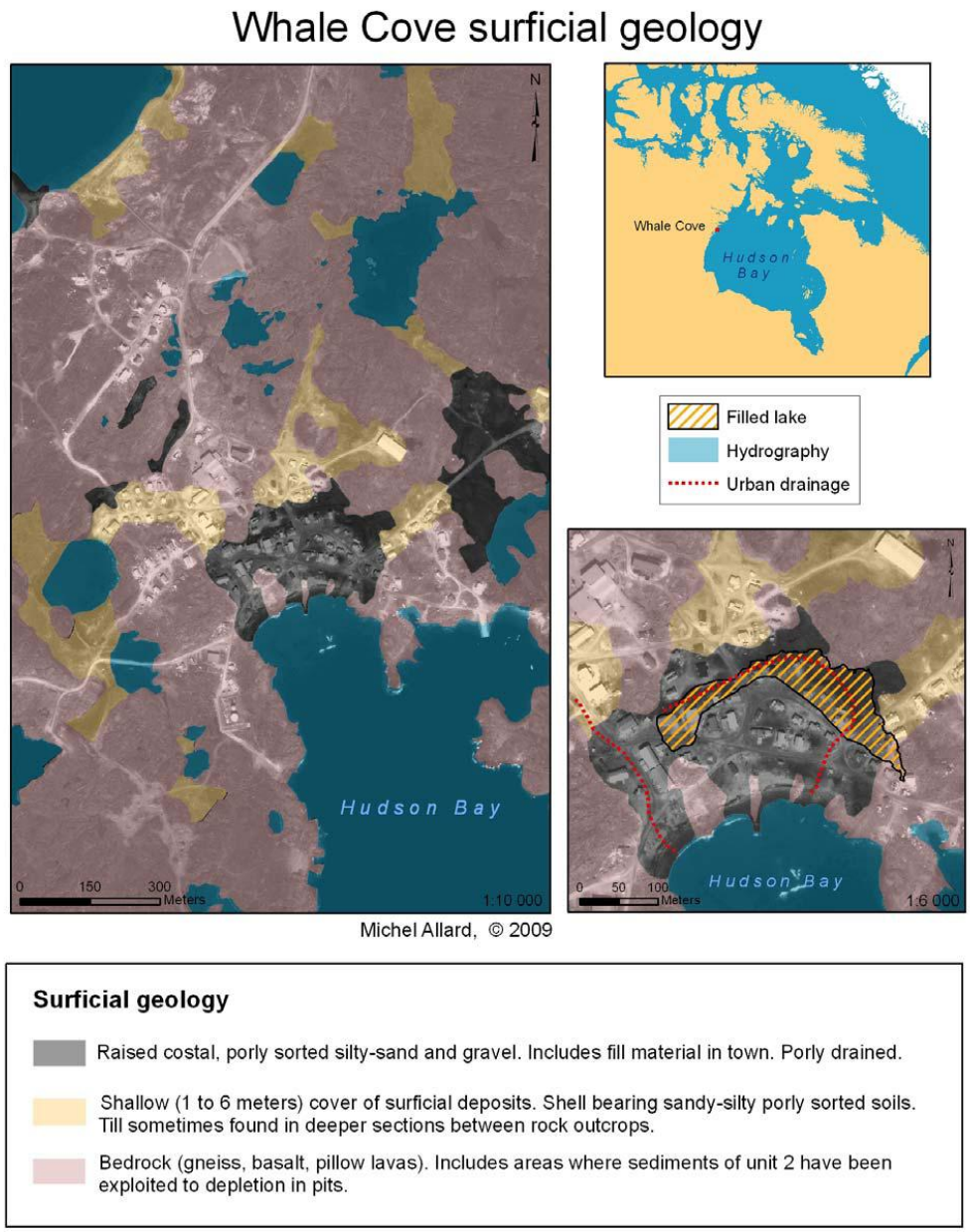
Figure 8 illustrates broad categories of the surficial geology of Whale Cove. The first map unit consists of sandy-gravelly, poorly sorted, soil that is generally found at low elevations (in lower townsite). In many places within this map unit drainage is poor in summer as the perched water table over the top of the permafrost is close to the surface. This map unit includes an area of fill material, also extracted from marine sediments in pits, that was used to fill a shallow pond in the lower, older part of the community. The former pond area appears in the inset of Figure 8 as the striped area. It must also be mentioned that the artificial soil at this former pond site was contaminated a couple of decades ago by a spill of diesel fuel near the power station. One geotechnical study done in this area indeed reports contamination from hydrocarbons. Terrain of this map unit needs specialized geotechnical studies before establishing buildings. For instance, the only large building in Whale Cove built on thermosyphons is located on these sediments (the garage that recently burned).

The second map unit in Figure 8 represents shallow (up to about 6 meters) shell-bearing sandy-silty poorly sorted soils found in hollows between rock outcrops. In the deepest part of those deposits some till appears to be present. These shoreline sediments were laid down by waves and coastal ice during land emergence. They are the main source of fill material used in the community from extraction in numerous shallow pits, many of them being now depleted (and mapped within the bedrock unit).

The third map unit is the bedrock that occurs over vast expanses of terrain. Since the topography is rather flat and gently rolling over wide areas, this terrain type provides

solid ground for construction. It necessitates some levelling that can be done by adding some fill material (Figure 8).

**Figure 8: Whale Cove Surficial Geology**




Source: Allard, M. (2009). Whale Cove: Permafrost conditions and issues for land management

## Sea level Change

Natural Resources Canada commissioned a report entitled, "Sea-level Projections for Five Pilot Communities of the Nunavut Climate Change Partnership" (James, T. et al, 2009). The citations in this section are based on the James report. Estimates of the range of sea-level change expected in the next 90 years (2010 to 2100) for five communities in Nunavut were derived from an assessment of published estimates of projected global sea-level change and an evaluation of vertical land motion.

Average sea level change from 1961 to 2003 was approximately 1.8 mm/yr, but the rate appears to have accelerated in the last decade to approximately 3.1 mm/yr. Sea-level change is correlated with global temperatures, and because temperatures are projected to rise in the 21st century, the expectation is that global sea level will continue to rise, quite possibly at larger rates than recently observed.

The degree to which sea level change will affect Whale Cove depends on several factors. A warming and expanding ocean surface in combination with melting glaciers, ice caps and the large Greenland and Antarctic ice sheets will cause sea level to rise. However, the rising levels are not expected to be uniform across the world's oceans, for two reasons:

1. Sea level fingerprinting: The reduced gravitational pull of a melting ice sheet causes the surface of the ocean to sink. As well, the reduced surface load causes the Earth to respond elastically and the nearby land rises. The net response near the ice sheet is that sea-level falls substantially, even though a melting ice sheet causes global sea-level to rise on average. "Sea level fingerprinting" is important to incorporate into projections of sea-level change, especially for Nunavut. The territory is host to some Arctic ice caps and is relatively close (on a global scale) to the Greenland ice sheet and thus is especially sensitive.

2. Vertical land motion: Most of Canada was glaciated up until about 8,000 years ago. During this time, the weight of the ice pushed down the earth under the glaciated area. The weighted area caused areas outside the glaciated area to "bulge". As the ice sheets began to melt, the decreased load caused the earth beneath the melting sheets to rise whereas peripheral areas began to subside. Most of Nunavut was a heavy glaciated area so this area continues to rise today. Within the region of uplift, the rates differ from one location to another because the ice was thicker in some places than in other places, and because ice sheet thinning and deglaciation occurred at different times in different parts of Canada.

Fourteen sea level projections were identified. Estimates range from a rise of 15 mm to 196 mm between 2010 and 2100. The fingerprinting effect from 4 sources was estimated assuming a contribution of 1 mm/year of sea level contribution from each source (Table 5). For example, for every 1 mm/year the melting Greenland ice sheet contributes to global sea level, the sea level will *fall* at Whale Cove by 0.4 mm/year. The actual amount that each source will contribute to global sea level varies

considerably depending on the scenario of meltwater from each source. James et al incorporated a range of scenarios into their overall sea level change estimates.

**Table 5: Fingerprinting Effect at Whale Cove from Different Sources**

| Greenland ice sheet | Antarctic ice sheet | Glaciers and ice caps | Thermal expansion of ocean surface |
|---|---|---|---|
| -0.4 | 1.05 | 0.35 | 1.0 |

Source: James, T et al (2009)

Vertical land motion is the other major factor affecting sea levels in Whale Cove. James et al estimate a land lift of approximately 8.4 ± 2 mm/year between 2010 and 2100, or approximately 76 ± 18 mm by 2100.

Total estimated sea level change over the next 90 years depends on the scenarios incorporated into the estimate. James et al chose to show a range of projections based on two scenario bundles. The first bundle includes 20$^{th}$ century historical trends (2 scenarios) and IPCC estimates (8 scenarios). The second bundle includes bundle 1 plus 4 additional projections that came out after the IPCC 4$^{th}$ Assessment (Table 6). The range increases when the post IPCC scenarios are included.

**Table 6: Projected Sea Level Change at Whale Cove by 2100**

| | Minimum Sea Level Rise | Maximum Sea Level Rise |
|---|---|---|
| Scenario Bundle 1 | -70 mm | -45 mm |
| Scenario Bundle 2 | -70 mm | 15 mm |

A number of scenarios adopted in the analysis are extreme estimates. James et al considered the probability range of sea level rise for each community based on the authors' judgement, based on current knowledge and information (Table 7). It is probable that these estimates will be revised in the future. As shown, sea level is likely to range from a *fall* of -55 cm to neither a fall nor rise over the next 90 years.

**Table 7: Probable Range of Sea-level Change in Whale Cove at 2100**

| Minimum Sea-level Change | Sea-level Will Probably not be Less Than | Sea-level Will Probably not be More Than | Maximum Sea-level Change |
|---|---|---|---|
| -70 cm | -55 cm | 0 cm | 15 cm |

A falling sea level regime may have several effects in Whale Cove. Natural Resources Canada commissioned a coastal vulnerability assessment on behalf of the project.[3] Several observations were noted in relation to sea level change and its impact on Whale Cove coastal infrastructure:

- Under falling relative sea level, assuming unchanging storminess and sea ice, exposure and vulnerability to storm surge flooding at Whale Cove is expected to decrease.
- Given falling relative sea level and a resultant low exposure and sensitivity to storm surge flooding and erosion, vulnerability is expected to remain low.
- An area of concern is the earth dam at the community dump. Depending on the rate of increase in severity and frequency of storm waves relative to the rate of relative sea level fall, the dam may be increasingly exposed and sensitive to erosion. Given the risk of contaminated surface waters entering the marine ecosystem should the earth dam be breached, and that the community is currently considering some improvements to the facility, there is an opportunity to redesign the surface water management strategy at the dump and reduce the potential for contaminated water entering the ocean.

### Fish, Wildlife and Vegetation

Arctic-wide scientific reports describe a number of likely changes to fish, wildlife and vegetation throughout the Arctic.[4] Due to a general warming trend, many plant species are expected to extend their range northward over the coming century. It is expected the Boreal forest will replace between 11-50% of the sub-Arctic tundra. The northward extension of southern wildlife species will increase competition for food, alter mortality/reproductive rates and increase the spread of diseases. Aquatic species will also be affected in terms of abundance and range, though extinction of Arctic species is unlikely.

Whale Cove residents are aware of changes to their natural world. Community members report sighting new species of birds, new types of shrubs, taller willow trees in some areas, and loss of fresh lake fish in lakes that are becoming shallower or disappearing altogether. The Inuit in Whale Cove reported changes in the numbers, movements and activities of animals such as bears, birds, insects, and muskoxen. Animals and people are being disturbed by more and new insects.

### Ozone Depletion

Ozone depletion, though not the same as the greenhouse gas effect, will also be affected by a warming climate, and especially affect Arctic peoples. The chemicals that caused ozone depletion were phased out through the enforcement of the

[3] Manson, G. (2009). Summary of Coastal Vulnerability Investigations at Whale Cove Nunavut.
[4] Fugal, C. and Prouse, T.D. (2008): Northern Canada; in From Impacts to Adaptation; Canada in a Changing Climate, edited by D.S. Lemmen, F.J. Warren, J. Lacroix, and E. Bush.

Montreal Protocol (1987, last revised 1999). However, ozone-depleting chemicals remain in the atmosphere and the influence a warming climate has on the stratosphere to trigger ozone depletion is expected to worsen. A well-functioning ozone layer absorbs ultraviolet (UV) radiation from the sun, protecting the earth's surface from harmful levels. When the ozone layer is depleted, harmful UV levels reach the planet's surface, affecting humans, wildlife and vegetation. Unsafe levels of UV rays can cause skin cancer, sunburns, cataracts and other ailments in humans; reduced nutrient cycling in ecosystems and decreased productivity in marine life at the bottom of the food chain, to name just a few examples. Harmful levels of UV radiation are highest during spring months.

The ability of Arctic communities to anticipate and adapt to these effects will determine to what degree the likely consequences of climate change are negative or beneficial.

### Surface Water

The community freshwater supply has been sourced from small nearby lakes in the past. In 1991, the Hamlet and the GN located and developed a larger lake north of the town site and has been using this as a reservoir source since that time. No significant water quality concerns have been identified. With the small size of the population relative to the stored volume of freshwater available, climate change impacts may not greatly affect the community's water supply. At the preset time excess freshwater leaves the reservoir naturally during the summer months and flows out to the sea.

Warmer climate in the future (or a hot summer) could have an impact on the water quality of small bodies of water where some people traditionally collect drinking water. Some of these very small sources may disappear altogether.

WARMING OF THE CLIMATE SYSTEM IS UNEQUIVOCAL, AS IS NOW EVIDENT FROM OBSERVATIONS OF INCREASES IN GLOBAL AVERAGE AIR AND OCEAN TEMPERATURES, WIDESPREAD MELTING OF SNOW AND ICE, AND RISING GLOBAL AVERAGE SEA LEVEL.

*IPPC Fourth Assessment Report*