

CHAPTER THREE

ARCTIC TRADE-OFFS

The Implications of a Rapidly Warming North

The global atmosphere is an ever-changing reservoir where what enters the air by way of marine and terrestrial sources is subjected to a broad range of oxidation processes before being recycled into the world's oceans or back to the land surface. The two main mechanisms by which this is accomplished are through erosion and wind transport and through the scavenging of these chemicals in the atmosphere by rain and snow and their return to the Earth and its oceans by way of precipitation. Rain and snow carry a great deal of planetary freight. As it happens, snow is a better scavenger of particulates than rain is. This is a significant factor in regions like the Canadian Arctic that are covered by seasonal snow for much of the year.

When we think of Canada's cold regions, obviously we think of snow. But snow is never just snow. Falling snow carries within it small bits of the Earth's crust, usually in the form of dust composed principally of calcium or magnesium. It also carries weak acids and trace metals along with neutral organic materials such as pollen, airborne plant parts, seeds and insects and other living things small enough to be carried up into the atmosphere by wind. Like liquid water, snow also carries within it almost everything humans dump into the atmosphere, including contaminants like polychlorinated biphenyls (PCBs), persistent organic pollutants (POPs) and mercury, all of which are introduced into Arctic ecosystems from the south. Many of the most problematic pollutants are carried northward by globally circulating winds and brought to the ground in the snow that falls in the Arctic.

The concentration of atmospheric pollutants in the Arctic is not an easy problem to address, for it is planetary in origin. As our world spins beneath the thin clothes of its atmosphere its very rotation acts rather like a centrifuge, drawing from the equator to the poles everything put into the air anywhere in the world. These air-borne contaminants are brought back down to Earth as a result of being scavenged from the atmosphere in the process of snow formation and the merging of multiple crystals to form larger snowflakes. These substances find their way into snow at the point of its formation. Ice crystals most often form in the atmosphere as a result of the freezing of super-cooled water droplets at -40°C , a temperature not uncommon during the Arctic winter. Researchers have determined that ice crystal formation is catalyzed by a process called contact nucleation. Ice nuclei normally consist of sea-salt aerosols, particulate organic debris or fine particulate clays that originate as dust motes. Ice crystals may form by direct deposition of water vapour onto ice nuclei or by water droplets either touching ice nuclei or through the scavenging of nuclei.

It is difficult to imagine just how much material can be transported in the atmosphere and deposited by way of snowfall. Even though much of the high Arctic is a cold desert, the accumulation of atmospheric contaminants from the south in the cold winter air turns snow into a precipitate of diluted poison. Wind gathers the contaminants in drifts, where they wait to be mobilized by the spring melt. Contaminants are further concentrated when the snowdrifts feed spring flows. In the meantime, however, these contaminants bioaccumulate in the bodies of the animals that drink the water and in the bodies of the people who depend on these animals as their food source.

Few Canadians appear to be aware of the fact that economists around the world are now warning of an emerging new scarcity that will affect every sector of the global economy. This growing penury is defined by very real and increasingly apparent limits to the capacity of the environment and our water to absorb and neutralize the unprecedented streams of waste that humanity is releasing into it. The gravity of this problem may not become obvious until we realize that we ourselves are becoming walking

contaminant sites. Nowhere is this more evident than in the Arctic. In a recent study, Canadians were tested for the presence of 88 harmful chemicals in their bodies. A First Nations volunteer from a remote community in Hudson Bay was found to have 51 of the chemicals in her system. Arctic environments are so contaminated with substances that have been carried north by the global atmosphere and deposited there by rain and snow that some Inuit women have been advised to begin weaning their babies earlier in order to reduce exposure to contaminated breast milk.

THE ENVIRONMENTAL CHALLENGES

AIRBORNE MINE TAILINGS

While oil sands operations in Alberta are hardly the only source of airborne particulate matter in Canada, they demonstrate the nature of the problem. A December 2009 paper in the prestigious US journal *Proceedings of the National Academy of Sciences* reported that oil sands development in the Athabasca River basin is a greater source of contamination than previously realized.

Lead author Erin Kelly, a post-doctoral researcher working under the supervision of Dr. David Schindler at the University of Alberta, had discovered that during four months in the winter of 2008, some 11,400 tonnes of airborne particulates fell onto the snowpack within a 50 kilometre radius of the Suncor and Syncrude bitumen upgrading facilities. Of this amount, an estimated 391 kilograms were found to be polycyclic aromatic hydrocarbon compounds that are known to be toxic to aquatic life.

This is equivalent to having 600 tonnes of bitumen fall from the sky. At some of the monitoring sites, an oil slick had formed on the surface of the melted snow. Some sites showed that the concentration of polycyclic aromatic compounds present in tributary streams of the Athabasca increased by as much as eight times normal as a result of nearby mining and related activities, essentially rebutting the argument that all of the contamination in the area's watercourses is an entirely natural consequence of water streaming through exposed bitumen deposits. The report indicated that over the course of a full year an estimated 34,000 tonnes of particulates

falls annually within that 50 kilometre radius, or nearly five times the volume of emissions reported by the industry. This, the report claimed, was the equivalent of a major oil spill each year.

Since particulate deposition rates in the 1970s were as great as they are today, because smokestack precipitators had yet to be installed, this situation has likely persisted for 30 to 40 years. As a result, current background concentrations of polycyclic aromatic compounds in surface soils, vegetation, snow and runoff over a broad area of the boreal forest may be measurably greater than true background concentrations contributed naturally by oil sands deposits in the region. Fortunately, the effects of these particulates appear to decline by the time the waters reach Lake Athabasca, though deformations in fish could still result from contaminant levels of this magnitude upstream.

Kelly's PNAS paper confirmed the serious defects of the joint government, industry and stakeholder operated Regional Aquatic Monitoring Program, which it criticized for lacking scientific oversight and peer review of monitoring and research results; failing to provide data to the public; and using faulty methods to analyze, interpret and report data in a timely and transparent way. The paper argued that more than 10 years of inconsistent sampling design, inadequate statistical power and the use of "monitoring-insensitive analytical practices" had resulted in the failure to detect major sources of toxic contaminants in the Athabasca watershed.

In conclusion the Kelly paper recommended oversight by an independent board of experts to make better use of monitoring resources and ensure that data were available for independent scrutiny and analysis. In order to limit bad press abroad, both federal and provincial governments scrambled to respond to the need for improved independent monitoring, which has since been established. Though promising, it remains to be seen whether renewed efforts to accurately measure the airborne effects of such oil sands operations will change anything. It is clear, however, that the problem of contamination of our snowfalls is becoming serious, especially in the North. The scale and intensity of oil sands development and the complexity of the manner in which polycyclic aromatic compounds are transported in the atmosphere demand no less than

the highest quality of scientific attention. The fate of the Athabasca and of the entire Mackenzie River system of which it is part depends on it.

PERMAFROST LOSS

Permafrost is defined as ground that remains at a temperature below 0°C for at least two consecutive years. Permafrost can take a number of forms. It can comprise bedrock, sediment, soils or organic materials such as peat that may or may not contain ground ice. It has been estimated that permafrost in one form or another lies beneath more than 22 million square kilometres of the Arctic and sub-Arctic regions, and that some two million square kilometres – nearly 10 per cent of the Arctic region – is underlain by ice-rich permafrost.

Though all permafrost can be altered by warming and thawing, the melting of ice-rich permafrost is particularly problematic in that it results in feedbacks that produce noticeable effects on ground surface stability, microtopography, hydrology, ecosystem function and the carbon cycle. A recent monitoring initiative drilled some 850 boreholes in 200 active permafrost layers throughout the Arctic. The results demonstrated a general warming trend in permafrost layers throughout the 1990s and early 2000s. Evidence suggests that warming has been most pronounced in the northern continuous permafrost zone and most recently along the Arctic coast. Canadian researchers, however, have also discerned rapid permafrost loss in the discontinuous permafrost zone in the southern regions of the Northwest Territories. This observation is consistent with findings in Russia which suggest that while warming in the continuous permafrost zone has generally not resulted in thawing during the past 60 years, widespread thawing in the discontinuous zone appears to be occurring throughout the northern circumpolar world.

Researchers have also discovered that there is a great deal we don't know about the dynamics of permafrost thawing. It appears that vulnerability of permafrost to climate warming is complicated by surface properties such as snowcover, vegetation, the thickness of the topmost active layer of the soil above the permafrost, which freezes and thaws seasonally, and interactions between surface

water, groundwater and soils. Changes in these complicated relationships can lead to both positive and negative feedbacks to permafrost stability, allowing permafrost to exist in some areas at mean air temperatures as high as +2°C along the southern margin of the discontinuous permafrost region and at the same time degrade at mean temperatures as low as -20°C in the high Arctic.

Continuous vegetation cover can also reduce mean soil temperatures by as much as 6°C. In contrast, the presence of standing surface water can raise temperatures at the water-sediment interface by as much as 10°C, which can make permafrost vulnerable to thawing at even the highest northern latitudes. While resulting changes in landforms due to permafrost thawing are of growing concern everywhere in the Arctic, the threat of loss of terrain stability is only one problem this thawing is causing.

PERMAFROST CARBON EMISSIONS

Dr. Katey Walter Anthony is an associate professor at the University of Alaska in Fairbanks who is an expert on what is currently known about the critical relationship between permafrost loss and methane and carbon releases in the Arctic. Permafrost, Walter notes, contains approximately 1700 gigatonnes of carbon, or roughly twice the amount that is presently found in the atmosphere. Release of this carbon from thawing permafrost is a well-recognized global risk because it may cause feedback amplification of the anthropogenic warming due to greenhouse gas emissions already occurring elsewhere. This feedback begins with the thawing of organic matter containing carbon dioxide and methane, which in itself increases the surface temperature, further warming the top layer of frozen soil, which in turn accelerates further melt and further carbon dioxide and methane release.

Walter explains that there are two permafrost observation networks in the world, and both were asking the same two questions: How much methane and carbon dioxide is being released through permafrost thaw? and How important will permafrost carbon feedback be in a future warmer world?

To begin answering these questions, Walter investigated the gas bubbles which rise from thermokarst lakes in northern Alaska

and Siberia. (Thermokarst terrain is land dented with depressions caused by soil collapse when the underlying permafrost thaws. Thermokarst lakes, also called thaw lakes, form when meltwater gathers in these depressions.) In summer, methane bubbles up through the water in these lakes and is released into the atmosphere. In winter, however, the methane collects under the ice and, if suddenly released, can be ignited. There are millions of lakes in the Arctic accumulating and bubbling gases. What we need to know, observed Walter, is how much of an issue this might be in terms of future climate effects.

Walter and her colleagues have surveyed some 200 lakes in the northern hemisphere and have discovered that they can be classified into “yedoma” and “non-yedoma” lakes. (Named for the Yedoma region in Siberia, yedoma is a particular type of extremely ice-rich permafrost.) It is the yedoma lakes that matter. This type represents only 9 per cent of the region’s lakes, but they are a source of 35 per cent of the methane such lakes produce. Yedoma lakes are Pleistocene in origin. The soils that surround them are composed of between 50 per cent and 90 per cent soil carbon. What is interesting about these soils is that decomposition had not advanced far before permafrost locked them in cold.

By studying the yedoma soil permafrost profiles, Walter calculated that some 14–34 teragrams of methane was being released each year in the Arctic from lakes and that total carbon dioxide and methane releases from ecological sources were in the order of 50 teragrams a year. Walter and her colleagues projected that Arctic marine systems were likely contributing an additional 1–17 teragrams of methane released per year. Because the Walter team were unable to determine the extent of release of methane from geological sources such as pockets in subsurface geological strata, the total methane and carbon dioxide emissions from the northern circumpolar boreal region remain unknown.

Walter has, however, been able to determine how current permafrost thaw and resulting greenhouse emissions might compare with releases in the past. She did this by examining sediments that show the progression of change over time during the life of a typical northern thermokarst lake. The end point of this change appears to

result in lakes eventually being drained, at which time the lake bottoms typically refreeze. Walter then examined how much carbon and methane was stored in Holocene sediments.

Research into this topic revealed some surprises. Walter and her colleagues observed that yedoma lakes are sequestering carbon at a rate five times faster than any other lake system. The reason for this is that these lakes are cold and deep, and when trees or other organic materials fall into them, decomposition is very slow.

Walter developed a time profile showing when the yedoma lakes were formed and then laid that time profile over a profile of associated methane releases and carbon sequestration. She then laid different radiative forcing scenarios over the same time profile. These profiles in juxtaposition showed the cumulative change in time of the permafrost soil carbon pool. Walter concluded from these analyses that permafrost thaw beneath yedoma lakes was an important source of atmospheric methane and a positive feedback to climate warming in the early Holocene. She also noted that permafrost thaw also contributed at the same time to carbon sequestration. The most important finding for us today, however, is that future widespread permafrost thaw will reverse the mitigating role of Arctic lakes by releasing into the atmosphere much of the carbon sequestered in these systems for the past 10,000 years.

The next question Walter addressed was whether or not methane hydrates could be expected to threaten humanity with further climate disruption in the future. Yes, Walter said, methane hydrates are a concern but not immediately. Present-day emissions from hydrates are low. Walter and her colleagues estimated that centuries of warming would be needed to induce large-scale hydrate releases from permafrost. That said, Walter also noted that she and her colleagues were witnessing very large lake seeps, which showed there was a big difference between ecological sources of methane release, and geological seeps, which can be a constant source of methane bubbles. The number of geological seeps is potentially very large, Walter reported, perhaps as much as seven orders of magnitude more numerous than ecological seeps. Ecological seeps, she noted, are bacterial in origin, while geological seeps are far more complex and most often related to

the proximity of coal formations and natural gas reservoirs near or linked to the surface.

What we have, Walter concluded, is “a very leaky cryospheric cap” and this cap is deteriorating under warming conditions. At present, permafrost caps methane and carbon dioxide releases, but the cap is melting and glaciers are disappearing, causing decompression of subsurface geological structures and isostatic rebound, which releases thermogenic methane. Similar processes, Walter noted, are clearly active in areas where glaciers are disappearing in Greenland and Iceland.

Returning to the question of whether the catastrophic release of methane hydrates in the circumpolar Arctic should trouble anybody’s sleep, Walter noted that the model projections of cumulative emissions from methane releases suggest that permafrost carbon feedbacks could be very important as global temperatures rise in the future. Assuming that biogenic methane represents 2.3 per cent of the carbon emitted from thawing permafrost, Walter and her colleagues estimated that this source could represent 16 per cent to 50 per cent of warming due to permafrost carbon feedback by 2100. This amount represents 1 per cent to 3 per cent of the warming projected to be due to anthropogenic emissions. This suggests a global temperature increase of 0.29°C from permafrost carbon feedback.

Walter noted also that, at present, permafrost carbon feedback is not included in future warming scenarios put forward by the Intergovernmental Panel on Climate Change. Carbon decay of organic materials takes 150 years, she observed, which means that permafrost thaw will release substantial amounts of carbon after 2100.

Walter has also extended her analysis to the potential commercial value of both biogenic and geological releases of methane. She noted that in discussion with energy companies these releases were evidently not considered to be of economic value, because they were too dispersed.

Also put forward, in the context of the rate of deterioration of the cryospheric cap holding back the vast carbon reserves in the Arctic, was the idea that it would be wise to create a “climate change rapid response team.”

Walter's haunting image of a leaky cryospheric cap is a compelling one. What she describes is an Arctic permeated by carbon – a veritable sink of biogenic and geological sources of methane leaking into the atmosphere, and the only thing that is preventing wholesale release and runaway warming feedbacks is winter cold that slows the process and keeps the leaky cap of permafrost partially in place. That cap, however, is breaking down. Though Walter hasn't said it in so many words, what we are facing in the Arctic is a carbon release time bomb. Only by keeping the Arctic cold can we prevent that bomb from going off.

FROZEN SUBSEA METHANE

A related problem is the amount of methane trapped in the cold marine sediments of the polar oceans. In their book *Methane Hydrates in Quaternary Climate Change: The Clathrate Gun Hypothesis*, authors James Kennett, Kevin Cannariato, Ingrid Hendy and Richard Behl explain how methane comes to be stored in polar oceans and why warming that leads to the mobilization of this gas could destabilize the global climate.

Biologically generated methane is almost exclusively produced as an end product of metabolism by a large group of primitive anaerobic microbes called methanogens. Among the most ancient forms of life on Earth, these microbes only exist in the absence of oxygen, which to them is a deadly poison. Methane production, or methanogenesis, can therefore only take place in water or under other conditions defined by the absence of oxygen. Methanogenic microbes can produce huge volumes of methane under the right anoxic conditions, which are found typically in the sediments of freshwater lakes, marshes (where it is often called marsh gas), in rice paddies, flood plains and tundra peatlands and in marine sediments where organic carbon is available in sufficient concentrations.

Methane hydrates – or clathrates as they are known – are the ice-like solid form of methane produced through methanogenesis. This solid methane is produced when methane molecules are captured within a cage of water molecules at low temperature. Hydrates form from other gases as well, but the methane variety is the most

abundant and widespread, especially along the continental margins and in shallow marine basins throughout the northern polar regions.

Kennett and his co-authors point out that methane can also be generated at greater depths in these circumstances by thermogenic processes. They report that methane production from deeply buried organic matter can occur at temperatures from -80°C to $+150^{\circ}\text{C}$. Methane formed in this manner can then migrate vertically through the sediments to contribute to methane already trapped in clathrates or be released directly into the atmosphere via seawater.

Given the geographical scale of anoxic environments globally, it is not surprising that the volume of methane stored in hydrates is very large. Though they remain uncertain and speculative, global estimates of the amount of methane present in clathrate form suggest there is probably 3000 times more of it stored in this form than presently exists in our planet's atmosphere. Equivalent or even greater volumes of methane are thought to be trapped below the hydrate zone.

Clearly the volume of methane trapped in clathrates and as associated free gas is sufficiently large to play a role in global climate change. The problem of methane release from cold-water clathrates may be orders of magnitude more significant than the release of methane from thawing permafrost. Marine geologists and climate scientists have determined that the release of marine sedimentary hydrates may have been the cause of rapid climate warming in the Earth's past. It appears these catastrophic releases were caused by sea level rise and warming temperatures in waters of intermediate depth over upper continental shelves in the circumpolar North – exactly the conditions that have come into existence in our time.

THE POLITICAL CHALLENGES

THE NORTHWEST TERRITORIES: A RIVER RUNS THROUGH IT

If the Columbia is the Great River of the West, the Mackenzie is the Great River of the North. In 2009 the Rosenberg International Forum on Water Policy reported that in its estimation the Mackenzie basin

was important not just to the eco-hydrological integrity of the Northwest Territories, but to the world.

The Northwest Territories is almost entirely contained within the watershed that contributes to the Mackenzie River system. Though this is the largest river in Canada – larger even than the St. Lawrence – few Canadians have ever seen it. That does not mean, however, that it is not important. The Mackenzie basin is thought to be one of the linchpins holding North America's water-ice-climate interface together. Scientists believe that if the stability of this important eco-hydrologic system were to become compromised, it could cause the Earth's climate to wobble further out of its current equilibrium, with implications for all the ecosystems on the continent whose stability is coupled to current climate variability – which include many ecosystems in southern Canada. Such concerns are clearly not being taken lightly in the Northwest Territories. Over the past decade the people there and their territorial and Aboriginal governments have found themselves confronted with hydro-climatic changes which they cannot easily adapt to and can no longer ignore.

THE PEOPLE TAKE ACTION

The people of the Northwest Territories do not want to wait to see if methane releases from thawing permafrost or melting clathrates would result in runaway global warming. Neither do they want the landscape they live on to have disappeared from beneath their feet before they started to act. They recognized that one of the only immediately effective ways to adapt quickly to the growing number of negative consequences and costly feedbacks associated with a rapid change in climate is to manage water effectively. In order to assure their way of life, major water policy reform was clearly necessary.

Such reform is not easy, but because there was less debate in the Northwest Territories about water than about many other resource-related issues, it was agreed that affirmation of a new water ethic could be a means of ultimately achieving greater adaptive capacity to climate change while generating a great many other benefits along the way.

There was, however, a great deal of anxiety about how such reforms should be achieved. The NWT encountered all the same classic obstacles that southern jurisdictions face when they confront the need for water policy reform. The official departments responsible for water governance did not have adequate resources to deliver on full water policy reform. Jurisdiction over water was badly fragmented and institutions were often highly territorial with respect to their own powers. The entire system was bogged down under earlier precedents and projects. Both local and outside interests were invested in those precedents and did not want to interrupt a familiar and comfortable status quo. These issues are challenges everywhere, of course. But on top of this the NWT had unresolved indigenous land claims; the pending devolution of political powers to the territory from the federal government; and larger matters related to Arctic and northern sovereignty. There were also pressing competing issues such as the need for more and better housing, better education and more jobs to keep young people in the region.

Reforming water policy in the midst of all this seemed impossible. Concerns were openly expressed that, even in the face of obviously dangerous climate change threats to the region's social and economic future, existing political structures and institutions could prove incapable of dealing with such complex issues. It was realized that if this was in fact the case, NWT residents would have no choice but to accept that it was simply impossible to adapt their water management practices to growing climate change effects. This meant they were doomed to ongoing diminishment and loss of culture and landscape as their future birthright.

The people of the Northwest Territories, however, had too close a relationship with the place where they live, to accept such a fate. They realized that if they could manage their water differently, the way of life of most people living in the NWT wouldn't have to vanish. Fortunately a leader emerged in the form of environment minister and deputy premier Michael Miltenberger. Miltenberger and other Aboriginal government leaders worked together to make change possible.

So what did the people of the Northwest Territories do that allowed them to break out of the mould and change the way they

relate to where and how they live? Unlike so many others today, the people of this region were out on the land enough to have first-hand experience of climate change effects they could see with their own eyes. They did not allow themselves to be prevented from breaking out of the prison of inaction by well-funded and carefully orchestrated efforts to deny or minimize the threat posed by hydro-climatic change. They recognized that what rising temperatures were doing to the function of the larger global water cycle was the place to start in understanding and acting upon the need to adapt to changing climatic conditions.

The people collectively agreed that diminishment and loss of culture and landscape were simply unacceptable to them. They came together around a common vision, which was to ensure not only that the water quality and flow of the Mackenzie would remain unaltered, but that their current way of life and relationship to place could remain unaltered as well.

THEIR GOVERNMENTS FOLLOW THROUGH

The story might have ended right there, with fine words and good intentions, but the prospect of losing their way of life was completely unacceptable to the people of the Northwest Territories. Governments at all levels acted. Departments responsible for water governance found adequate resources to deliver on full water policy reform. Earlier precedents and projects were embraced with reforms. Attention was and continues to be paid to unresolved land claims, and pending devolution of political powers to the Northwest Territories is now well advanced.

But it is in water policy reform that the NWT truly succeeded. The Northwest Territories became the first provincial or territorial government in Canada to clearly and legally define adequate access to clean water as an inalienable human right. Next, the territorial government and its Aboriginal and federal partners set out to craft its landmark *Northern Voices*, *Northern Waters* water stewardship strategy.

It has been observed that this stewardship strategy is a precedent-setting document nationally and globally because of the way it was crafted and because of the degree of accountability and

transparency it demanded of everyone involved in its implementation. What is unique about the strategy is that all Aboriginal and community governments in the Northwest Territories *expected* to be involved from the outset in the development of the strategy and throughout all implementation and evaluation phases. While it was expensive and time-consuming to develop the strategy in this way, even at times frustrating to all participants, the collaborative manner in which it was crafted is the key to the strategy's success. In the case of the Northwest Territories, co-development of the strategy means co-implementation.

It is also important to note that the *Northern Voices, Northern Waters* strategy document was guided by a holistic ecosystem approach based on watershed-scale management ideals. Within this framework, effective monitoring and research programs of the kind funded by the Canadian Foundation for Climate and Atmospheric Science were identified as critical to the successful implementation of the strategy. This element has already yielded important results. When, in 2011, federal Environment Minister Peter Kent announced the closure of 21 of 23 monitoring stations in the Mackenzie system, the territorial and Aboriginal governments of the NWT were able to point to their water strategy as a reason for reversing that decision. This in itself is evidence that the NWT approach is already being integrated into other government programs that promote or overlap into water stewardship. These include drinking water quality frameworks; municipal water management practices; land-use plans pursuant to land claims; hydroelectricity and transmission plans; and protected areas, fisheries and greenhouse gas strategies.

WHAT MIGHT CANADA AND THE REST OF THE WORLD LEARN FROM THE NWT EXAMPLE?

The Northwest Territories has demonstrated to the rest of the country and to the world that through hard work and persistence of vision a relatively small population with limited resources and only a tiny budget can effect meaningful change. Doing the right thing is not a question of austerity or affluence but of priority and focus. It is a matter of leadership at all levels working together. It is no longer possible anywhere to say it can't be done. The Northwest Territories

just did it. But the NWT story does not end there. Their real success only begins with the *Northern Voices*, *Northern Waters* stewardship strategy.

It has been the dream of many Canadian water experts that short-sighted southern water policy would not only be stopped dead at the NWT border, but its very contact with the holistic principles to which the Territories aspired would become the foundation of water policy reform that would radiate back south to positively affect all of Canada. Miraculously, that appears to be exactly what is happening.

Somehow, the Northwest Territories summoned the courage, administrative capacity and scientific wherewithal and claimed the necessary moral ground to permit them to negotiate the kind of progressive transboundary agreement it signed in March of 2015 with upstream Alberta. It is this agreement that is paving the way for similar pacts with the Northwest Territories' other riparian neighbours.

There were a number of criteria and principles upon which the NWT strategy was founded that were deemed worthy of consideration in provincial and other jurisdictions in southern Canada. Though it was so obvious that at first it was missed, the most important thing said about the NWT water strategy is that it demonstrated that governments at a number of levels can do exactly what governments are supposed to do when faced with a serious societal threat: govern. Those agencies responsible for the development of the strategy took their fiduciary and legal responsibilities for the management of water and watersheds in the Northwest Territories seriously. They did not back away from the project because water policy reform on this scale was too difficult to agree on or too politically sensitive to address, as so often happens in other jurisdictions. They did not bow behind closed doors to individual sectoral interests or hold back on the extent of reform in response to special pleading. They did what so many governments never seem to manage: take charge, collaborate with affected constituencies and find and implement solutions that hopefully will work over the long term. The NWT did what was necessary, not what was easy. The territorial governments got the whole job done, not just the parts of it that would have been an easy short-term political sell.

THE MACKENZIE RIVER BASIN BILATERAL WATER MANAGEMENT AGREEMENT

In March of 2015, leaders in the Northwest Territories capitalized on the strength of *Northern Voices*, *Northern Waters* to establish new and enhanced transboundary relations with one of their upstream neighbours based on the principles of the strategy. With Merrell-Ann Phare as chief negotiator, the NWT team crafted a landmark agreement with Alberta relating to the future joint management of the Mackenzie basin. This agreement – the first in the country to institutionalize a co-operative adaptive response to changing eco-hydro-climatic circumstances over time – should be a source of lasting pride and inspiration to the two signatory jurisdictions and to the nation for decades to come.

The pact is remarkable in a number of ways. Its foundation rests on the same depth of Aboriginal input and accommodation concerning rights and the perpetuation of traditional ways of life as the water stewardship strategy whose values and structure it reflects. The agreement includes provisions related to the roles water plays in ecosystem function, and to local cultural connection with those roles. It is also similar to the Northwest Territories water strategy in that it was collaboratively crafted and its conditions are such that people who live in or care about the Mackenzie basin can hold governments accountable for honouring not just the letter of the agreement but also its principles.

Like all transboundary agreements, however, the Northwest Territories–Alberta pact will require considerable ongoing collaborative attention if it is to meet its objectives. This agreement and the other, complementary ones currently being negotiated with British Columbia, Saskatchewan and Yukon rely heavily on keeping a finger on the pulse of eco-hydro-climatic circumstances throughout the Mackenzie basin. This will require a long-term commitment by all of the jurisdictions in the Peace–Athabasca–Mackenzie system to careful, precise monitoring and effective, meaningful and timely sharing of data. The test of this agreement will be the extent to which resources are allocated to meet these conditions now and over time.

The national and international significance of the NWT *Northern Voices, Northern Waters* stewardship strategy derives from the patient and inclusive manner in which it was crafted and implemented, and from the ongoing engagement through which its effectiveness will continue to be thoughtfully monitored and evaluated. In that it respects traditional knowledge and ways of life in the context of basin-wide aquatic ecosystem health, the agreement represents a landmark in integrated watershed management. Its example demonstrates that in fact there are no real jurisdictional, legislative, constitutional or political obstacles to the creation of a sustainable future. All it takes is political will and competent, persistent leadership.

In 2015 the Northwest Territories made history. And because the NWT stuck by the principles implicit in their own strategy, everybody in Canada has won. By their example they have shown that the road is open for reconciliation in this country; for correcting the mistakes of the past; and for collaboration on a better, more secure, more just and ultimately far more sustainable future for all. What the NWT has done is exactly what the rest of Canada needs to do: they have created a practical water policy framework that will provide hope for a sustainable future for all who live in the Mackenzie basin.

Analysis of the Northwest Territories response to the need to adapt as soon as possible to climate change effects on water, however, leaves us with more questions than answers. First, shouldn't we be supporting the kind of scientific research that will allow us to understand and proactively get to work on the kinds of hydro-climate changes that are beginning to appear and that according to all climate models are likely to accelerate everywhere in Canada in the future?

Shouldn't we in the south be supporting and emulating the Northwest Territories in its efforts to achieve economic and environmental sustainability in the face of hydro-climatic change?

Shouldn't we be looking at the parameters established in the NWT water strategy to provide overarching guidance in water policy reform in southern Canada?

Shouldn't we be cultivating the same kind of leadership provincially and nationally that has been demonstrated in the Northwest

Territories, so that we can be sure that water quality and availability issues associated with climate change don't limit our social and economic future?

Isn't it time for a nationwide water strategy?

