WATER WAYS:
VULNERABILITY TO FRESHWATER CHANGES IN THE INUIT SETTLEMENT REGION OF NUNATSIAVUT, LABRADOR

CHRISTINA ALISON GOLDHAR

WATER WAYS: VULNERABILITY TO FRESHWATER CHANGES IN THE INUIT SETTLEMENT REGION OF NUNATSIAVUT, LABRADOR

A thesis submitted to the
School of Graduate Studies of
Memorial University
in partial fulfilment of the
requirements for the degree of
Master of Arts

by

CHRISTINA ALISON GOLDHAR

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Department of Geography
Faculty of Arts
Memorial University
St. John's, Newfoundland and Labrador
August, 2011

ABSTRACT

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Christina Alison Goldhar
Memorial University

Advisor:
Dr. Trevor Bell

This thesis explores the vulnerability of Nunatsiavut residents to changes in freshwater through case studies in Nain and Rigolet. The current implications of these changes on community water security, food security, and livelihoods are discussed through an approach that emphasizes local perceptions and preferences, considering the experiential dimensions of freshwater changes. A total of 121 individual and household interviews and 13 targeted interviews were conducted in Nunatsiavut in fall 2009 and fall 2010. These findings were complemented by climate data, river discharge records, municipal water system characteristics, and other data gathered from secondary sources. Findings reveal residents have experienced freshwater changes that are presently challenging their ability to access preferred drinking water sources and food sources, and are exacerbating existing financial barriers that restrict time spent on the land. These challenges may intensify in future due to projected implications of climate variability and change on freshwater ecosystems in the region.

ACKNOWLEDGEMENTS

The journey traveled in producing this thesis was smoothed and supported by many kind and generous people. To begin with, I would like to thank my supervisor, Dr. Trevor Bell, for his sustained commitment to this project, his incisive feedback and direction, his encouraging faith in me, and his ingenuity in moments when it was needed the most. I would like to thank my supervisory committee, Dr. Ratana Chuenpagdee and Dr. Johanna Wolf, for their patient guidance throughout this process, and their sharp, thoughtful comments on earlier drafts of this thesis.

This research would not have been possible without the support and participation of Rigolet and Nain residents. Special thanks to Tanya Pottle and Sarah Karpik for their invaluable research assistance, to study interpreters Katie Winters and Maria Dicker, and to staff at the Rigolet Inuit Community Government, the Nain Inuit Community Government, and the Nunatsiavut Government. In particular, I would like to thank Dan Michelin, Sarah Blake, Charlotte Wolfrey, Sandi and Karl Michelin, Richard Pottle, Ralph Shiwak, Sarah Leo, Dasi Ikkusek, Sidney Maggo, Karen Dicker, Tabea Solomon, Marina Biasutti-Brown, Tom Sheldon, and John Lampe. I would also like to thank Michael Kearney at Municipal Affairs for his assistance early in the project.

Maxine Budgell patiently transcribed the majority of interviews used in this study and Callista Coldwell assisted with the analysis of river discharge records for Rigolet. I would like to thank Charles Conway for producing the maps used in this thesis, and Dr. Arn Keeling for providing helpful feedback on an earlier draft of chapter 2. I would like to acknowledge the organizations that funded this research for their interest in this project and for their generous contributions: ArcticNet, the IPY CAVIAR project, and INAC. In closing, I would like to thank my parents Jerry and Melanie Goldhar, my sister Bethany Goldhar, my partner Jean-Sébastien Boutet, his parents Marc Boutet and Micheline Guibord, and friends for their enticing distractions, continuous encouragement, and support.

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LIST OF ACRONYMS

ATV: all-terrain vehicle/off-road bike

BWA: boil water advisory

DWS: drinking water system

FAO: Food and Agriculture Association

IGI: infectious gastrointestinal illness

INAC: Indian and Northern Affairs Canada

MWS: municipal water system

NICG: Nain Inuit Community Government

RICG: Rigolet Inuit Community Government

THM: trihalomethane

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CHAPTER 1

Introduction

1.1. Introduction

I've come to think of this thesis as a story. A story that began long before the words on this page and that will continue moving in unknown directions, writing itself on the landscape of Labrador and the mindscape of its inhabitants long after my own experiences with it have come to an end. Through this introduction I hope to illuminate some of the many influences that have shaped the construction of this story (conceptual framework), the processes that led to its development (methodology), and the form by which this story will be revealed in the pages to follow (thesis structure and outline). Before turning to these matters though, I would like to begin with the beginning and briefly describe the setting and research context from which this story emerged.

1.2. Setting and Research Context

In 2002 a workshop was held in Nain, Labrador with participants from across Nunatsiavut (at the time the region was referred to as the Labrador North Coast) with the intention of documenting Inuit observations of climate change. This workshop was part of a larger initiative spanning all four Inuit-occupied regions of Canada (Labrador, Nunavik, Nunavut, and the Invialuit Settlement Region) and culminated in the publication of "*Unikkaaqatigiit*-Putting the human face on climate change" (Nickels et al. 2005). While the study discussed a broad range of environmental changes noted by Inuit in the arctic, within the Labrador study it was the reports of changing freshwater systems that I found to be the most salient. Residents of the Labrador North Coast described a decrease in the seasonal availability of freshwater in the region, leading to local concerns regarding the availability and quality of water formerly sourced for drinking on the land. The study mentioned that residents were buying water from the store to bring with them on the land as a result of these drinking water concerns (Communities of Labrador et al. 2005). Initially, it was the images of hunters carrying bottled water with them on hunting trips that struck me the most, in part because it conflicted with the misguided, static image of traditional Inuit culture that I held.

A request from the AngajukKâk of Rigolet (community leader or mayor), Dan Michelin, to the Research Advisory Committee of the Nunatsiavut Government for a follow-up study in the community about drinking water, and interest in the project expressed by residents during a community visit in June 2009, eventually led to the selection of Rigolet as the case study location for my research. I visited both Nain and Rigolet in June 2009 to chat with residents and community leaders about the possibility of working in the community and to learn of their research needs, interests, and expectations of researchers and research projects. I put up colourful posters translated into Inuktitut and wrote radio announcements informing residents of the purpose of my visit, where I was staying in town and how to contact me about the project after I left (Appendix I and Appendix II). After a series of informal one-on-one chats in both communities, and a more formal round table discussion about the project in Nain, it was clear that the research interests of Rigolet more closely reflected my own pre-existing interests in the region at that time.

With a population over three times that of Rigolet, Nain attracts a large number of research projects demanding time and resources of residents and community leaders. While some residents expressed interest in the project, the majority I met conveyed a sense of ambivalence about the possibility of "yet another" research project in their town. However, at the request of the Nunatsiavut Government, in partnership with the Nain Inuit Community Government (NICG), and following successful reception of the project in Rigolet, field research was expanded to include Nain in 2010. The Nain portion of this project forms part of a larger initiative assessing climate change impacts and community adaptation in Nain, funded by Indian and Northern Affairs Canada (INAC), while the Rigolet study was funded by ArcticNet and the International Polar Year (IPY). To some extent this project is a response to existing concerns and research interests held in Rigolet and Nain, as expressed within the *Unikkaaqatigiit* workshops and to me directly while visiting the communities. Simultaneously, it aims to answer an academic research problem and has been informed by theory and literature separate from the context of the community. More formal discussion of the academic research context and contribution to the literature is presented in Chapters 2 and 3 of this thesis.

1.3. Aims and Objectives

The primary aim of this project is to understand the relations of Rigolet and Nain residents with freshwater in their watersheds. More specifically, this project aims to characterize the vulnerability and resilience of residents to changing freshwater ecosystems in the context of climate variability and change. This thesis has four main objectives:

i. Describe the Rigolet and Nain drinking water system, resident preferences, perceptions, and uses of the various sources of drinking water available to the community.
ii. Identify the ways in which Nunatsiavut residents are affected by and sensitive to changing freshwater conditions (i.e. What conditions are problematic for people and the ecosystems upon which they depend?).
iii. Determine the ways in which residents are adapting to these changing conditions (i.e. How are residents coping with or responding to freshwater changes affecting them? What changes can be accommodated by existing ways of life in the community?).
iv. Establish what factors or conditions enhance or obstruct community adaptability to changing freshwater conditions.

1.4. Conceptual framework

The aims and objectives of this project have been strongly influenced by the climate change vulnerability literature, and in particular the work of the IPY project: "Community Adaptation and Vulnerability in Arctic Regions" (CAVIAR). The CAVIAR research program aims to better understand "how arctic communities are affected by environmental changes in order to contribute to the development of adaptive strategies and policies" through the integration and synthesis of comparable case study findings from across the circumpolar north (Smit, Hovelsrud, and Wandel 2008, 2). The conceptual framework and methodology of this thesis are largely consistent with those put forth by CAVIAR (see: Smit, Hovelsrud, and Wandel 2008; Hovelsrud and Smit

2010). The concept of "vulnerability" and the "vulnerability approach" embraced by the human dimensions of climate change research community and employed by CAVIAR have been integral components of this thesis, as have notions of a "drinking water system" and "water security" adapted from existing water studies and the food security literature. These terms and influences are described below.

1.4.1. A vulnerability approach to freshwater systems change

Vulnerability is commonly defined as "susceptibility to harm" (Ford and Smit 2004; Adger 2006). The vulnerability approach within human dimensions of climate change research evolved from concepts of vulnerability in natural hazards literature (Hewitt and Burton 1971; Hewitt 1983), and through the influences of political ecology, human ecology, human geography, entitlement theorists within the fields of international development, food security, and livelihoods (Sen 1981, 1984; Bohle, Downing, and Watts 1994; Blaikie et al. 1994), and concepts of resilience within social-ecological systems literature (Holling 1973; Berkes and Folke 1998; Walker 2002). For a discussion of the research traditions shaping the vulnerability approach, and the evolution of the framework itself, see Kelly and Adger (2000); O'Brien et al. (2004, 2007); Ford and Smit (2004); Patt, Klein, and de la Vega-Leinert (2005); Adger (2006); Eakin and Luers (2006); Ford, Smit and Wandel (2006); Füssel and Klein (2006); Füssel (2007); Ionescu et al. (2008); and Smit, Hovelsrud, and Wandel (2008).

While there are competing conceptualizations of the term vulnerability within the climate change literature, in this study it refers to "the manner and degree to which a community is susceptible to conditions that directly or indirectly affect the wellbeing […] of the community" (Smit, Hovelsrud, and Wandel 2008, 4). Vulnerability therefore concerns the holistic concept of "well-being", which is recognized as locally or contextually defined through the perspectives of community residents. The vulnerability approach used in this study has been additionally inspired by the "values-based" approach described by O'Brien and Wolf (2010), and emphasizes local preferences and values, considering the experiential dimensions of changing freshwater systems in connection with climate change.

Community vulnerability to the effects of climate change is commonly studied through case study and analogue methodologies (Ford et al. 2010), encompassing both anthropogenic and non-anthropogenic drivers of change at various temporal and spatial scales. Vulnerability is a function of the manner and degree to which a community is exposed and sensitive to changing conditions (exposure-sensitivity), and the ability of a community to cope with or recover from this exposure-sensitivity (adaptive capacity; Figure 1-1; Ford and Smit 2004; Smit, Hovelsrud, and Wandel 2008). While case studies typically assess the vulnerability of a community to the full spectrum of climate change effects, this thesis focuses on changes influencing freshwater ecosystems only, as noted above. Due to time and resource constraints the scope of study has been further narrowed to include a consideration of existing changes only (recent past and present changes experienced by residents), rather than existing and future changes.

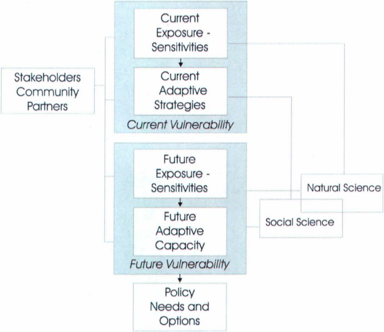

Figure 1-1. Elements of the vulnerability assessment framework
(Smit, Hovelsrud, and Wandel 2008).

1.4.2. Drinking water systems and water security

The concepts of a "drinking water system" and "water security" used in this study are introduced here and are further developed in Chapter 2. Approaches to understanding water security commonly emphasize elements of access, availability, and safety. While there are many definitions of water security presented in the literature, I have yet to come across a definition that emphasizes the role of preferences and have therefore drawn on the food security literature in an attempt to accommodate this gap. Recent case studies within Inuit communities of Alaska, arctic Canada and Greenland have illustrated the importance of considering food preference within existing definitions of food security. They argue, food preference is an integral component of food "quality" as experienced by the individual, and is thus an important dimension of food security (Van Esterik 1999; Gregory, Ingram, and Brklacich 2005; Lambden, Receveur, and Kuhnlein 2007; Loring and Gerlach 2009; Ford 2009; Goldhar and Ford 2010; Goldhar, Ford, and Berrang-Ford 2010). The Food and Agriculture Organization (FAO) defines food security as a state where "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (1996). Van Esterik (1999), Gregory, Ingram, and Brklacich (2005), and Ford (2009), amongst others, have defined it as the ability to acquire safe, nutritionally adequate and culturally acceptable foods in a manner that maintains human dignity. While not explicitly addressing water security, Marino et al. (2009), highlight the relative nature of health perceptions and the existence of locally specific ideas about drinking water quality. Responding to the contributions of this literature, this study has intentionally conceptualized notions of "water security" to include all sources of drinking water available to a community. This notion recognizes the diversity of water qualities, sources, preparation and treatment methods, and preferences valued across diverse communities, thereby creating space for drinking water practices unassumed by the water security discourse. As used in this study, "water security" signifies an ability to access a sufficient quantity of *desirable*, clean drinking water.

The notion of a "drinking water system" is intimately linked to that of water security. The concept has been adapted from the idea of a "food system" described within the food security literature by Gregory, Ingram, and Brklacich (2005)[1] and later used by Ford (2009). A "drinking water system" comprises dynamic interactions between and within biogeophysical and human environments which result in the collection, distribution, and consumption of water. It is a social-ecological system or a human-environment system as it encompasses the synergistic relationship between both human and environmental components. This concept closely relates to the notion of a "human-hydrological system" adopted by Alessa et al. (2008) and is strongly influenced by the social-ecological systems literature and resilience theory. The notion of a drinking water system is used in this study to contextualize water security approaches and the implications of freshwater changes in the attributes of Nunatsiavut communities. See Chapter 2 for a detailed discussion of this concept.

1.5. Methodology and Methods

As mentioned earlier, the methodology employed in this study has been shaped by the "community-based" vulnerability framework described in the CAVIAR literature (Smit, Hovelsrud, and Wandel 2008; Hovelsrud and Smit 2010). Consistent with this model, this study produced a locally-grounded case study developed with the support of community residents and the substantial contributions of local researchers in Rigolet (Tanya) and Nain (Sarah). Data were gathered through a series of mixed methods, including a review of secondary sources, semi-structured household and structured individual interviews, key informant interviews, and participant observation conducted in

[1] Gregory, Ingram, and Brklacich (2005, 2141) describe a food system as a set of "dynamic interactions between and within biogeophysical and human environments which result in the production, processing, distribution, preparation, and consumption of food".

Rigolet, Nain, and all communities of Nunatsiavut (including Makkovik, Postville, and Hopedale). These observations and data collection methods are discussed at greater length in Chapter 2 and Chapter 3. Please see Appendix III for the interview guide.

The initial stages of the research process are described above in "Setting and research context". After visiting to discuss the project with the communities and the Nunatsiavut Research Advisory Committee in June 2009 (see Table 1-1), I returned to Rigolet in September 2009 to commence fieldwork. Upon arriving, I posted similar colourful notices around the community as I did during my visit in June and wrote a radio announcement introducing myself, reminding residents of the purpose of my visit and how to contact me, and advertising that I was seeking a research assistant.

Table 1-1 Timeline illustrating thesis progress

Tasks	Dates
Literature review, development of preliminary thesis proposal and community contacts	Sept-June 2009
Community consultation visit in Rigolet and Nain	June 2009
Fieldwork preparation, application for university ethics approval, research application to the Nunatsiavut Research Advisory Committee	July-Aug 2009
Fieldwork season 1: Data collection in Rigolet, Makkovik, Postville, Hopedale, and Nain	Sept-Oct 2009
Interview transcription, qualitative data coding, secondary data collection, data analysis	Nov 2009-Aug 2010
Fieldwork preparation	July-Aug 2010
Fieldwork season 2: Data collection in Nain	Sept 2010
Interview transcription, qualitative data coding, secondary data collection, data analysis	Oct 2010-Jan 2011
Dissertation writing and revision	Feb-Aug 2011

I began working with Tanya within my first week in the community. She proved to be an invaluable support both for the project and for myself, gently correcting my cultural missteps and guiding my stumblings as I adjusted to life in Rigolet. Together, we conducted eighty-nine household interviews over three weeks in the community. We were initially aiming to complete thirty interviews (through a random sample of fifty households) but quickly became aware that a far larger number of residents were interested in participating in the project than we had foreseen. While I believe the honorarium we were offering contributed to the enthusiasm of some project participants[2], the timing of fieldwork (in fall after most residents had returned to the community from summer trips on the land and before freeze-up when many residents leave for winter trips), the familiarity and involvement of residents in the project before commencing fieldwork, the reflection of existing community interests within research objectives, the relative lack of research fatigue in the community, the support for the project expressed by the Nunatsiavut Government and the Rigolet Inuit Community Government (RICG), and finally, Tanya's incredible prowess as a research assistant, all played important contributing roles. After completing household interviews and some key informant interviews with Tanya in Rigolet, I headed up the coast to conduct additional key informant interviews with municipal water workers and community leaders in Makkovik, Postville, Hopedale, and Nain to help contextualize the responses of Rigolet residents.

I returned to Nain in September 2010 and with the help of Sarah who was working as a research assistant for the Nunatsiavut Government at the time, and interpreters Maria and Katie, we conducted thirty-two household interviews from a random sample of fifty households. See Chapter 2 for further details regarding methods used in Nain.

During a final trip to Rigolet and Nain in 2012 I will report study findings to the community by visiting participating households and meeting with interested members of the community governments and the Nunatsiavut Government.

[2] In both Nain and Rigolet we offered a 40-dollar gas or food voucher to each household participating in the project, as recommended by the Nunatsiavut Research Advisory Committee. Interviews lasted between fifteen minutes and two hours.

1.6. Thesis structure and chapter contributions

This thesis follows the manuscript option as offered by the School of Graduate Studies at Memorial University. It contains two manuscripts intended for future publication (Chapter 2, Goldhar, Bell, and Wolf 2011a; Chapter 3, Goldhar, Bell, and Wolf 2011b), and two additional chapters (Chapter 1 and Chapter 4) that collectively fulfill thesis requirements as specified by the School of Graduate Studies. The contributions of each chapter to these requirements are illustrated in Table 1-2. In following the manuscript option there is some necessary overlap in each of the two manuscripts (such as within the methods sections) as they are required to function as complete papers independent of additional thesis contents.

Table 1-2. Thesis structure and chapter contributions

Chapter	Contribution
Chapter 1. Introduction	Setting and research context Identification of the research problem Description of the study site and justification of its selection Aims and objectives Conceptual framework Methodology and methods Thesis outline
Chapter 2. Drinking water systems in Rigolet and Nain, Nunatsiavut: Rethinking existing approaches to water security	Academic research context Identification of the research problem Conceptual framework Aims and objectives Methods Description of the study site Research results Analytical discussion Conclusions
Chapter 3. Vulnerability to freshwater changes in the Inuit Settlement Region of Nunatsiavut, Labrador: A case study from Rigolet	Academic research context Identification of the research problem Conceptual framework Aims and objectives Methods Description of the study site Research results Analytical discussion Conclusions
Chapter 4. Conclusion	Summary of study findings and identification of how they address thesis objectives Critical reflection on thesis methodology and project limitations Participant feedback and suggestions

1.6.1. Chapter summaries and contributions

Chapter 2: Drinking water systems in Rigolet and Nain, Nunatsiavut: Rethinking existing approaches to water security

The first manuscript and second chapter of this thesis presents a conceptual framework for understanding water security grounded in the notion of a "drinking water system" that, along with the vulnerability framework discussed in Chapter 3, has had a significant role in shaping the development of this thesis. The chapter details the drinking water system characteristics of Rigolet and Nain, discusses drinking water preferences and risk perceptions held by residents, and assesses factors contributing to water security in both communities. The paper is situated within the context of freshwater ecosystem changes observed and projected for the region and across the arctic as a consequence of climate variability and change. The implications of current system changes on the water security of arctic residents have yet to be addressed in the literature and will inform future water security in the arctic. This chapter addresses objective one of the overall thesis.

Case study findings reveal a preference for untreated drinking water gathered from outdoor sources, such as running brooks or melted ice, over store-bought water or tap water in both communities. A preference for water gathered from the land over tap water and store-bought water was expressed by 91 percent of respondents in Nain and 78 percent of respondents in Rigolet. These sources continue to be consumed in both communities despite the relative convenience of alternative sources of drinking water. Findings further reveal that access to a sufficient quantity of desirable, clean, drinking water is compromised for some residents. Elders and others with limited physical abilities, households with minimal income and capital, and newcomers to the community and others without well-developed social networks or knowledge of the region experience additional challenges to their water security relative to other sectors of the population. These vulnerable sub-populations may be in need of additional support to adjust to changes negatively affecting their water security in the future.

Chapter 3: Vulnerability to freshwater changes in the Inuit Settlement Region of Nunatsiavut, Labrador: A case study from Rigolet

The second manuscript presented in this thesis describes the vulnerability and resilience of Rigolet residents to changing freshwater conditions within the Hamilton Inlet watershed. This paper argues that the exposure of arctic communities to freshwater changes and their capacity to adapt are largely shaped by the attributes of people's relationship with freshwater and freshwater ecosystems. The data presented in this chapter addresses thesis objectives two to four.

The chapter opens by situating the study within the climate change and freshwater systems change literature, and focusing the academic research problem the study intends to address. The research context is further developed through a discussion of the lifestyle and livelihood characteristics of Rigolet residents, the biophysical qualities of the Rigolet study site and the Hamilton Inlet watershed, the contributions of previous water studies in the region, and the attributes of the Rigolet drinking water system. The chapter details data collection methods used in the project and presents results from the Rigolet case study.

Study participants confirmed previous observations of freshwater changes within the region, as described within *Unikkaaqatigiit* workshops (Communities of Labrador et al. 2005). Residents described a decrease in the seasonal availability of freshwater, affecting households to varying degrees relative to drinking water preferences and sources accessed, hunting routes, cabin locations, and food sources, amongst other lifestyle and livelihood traits. These changes were noted to affect the ability of households to access preferred drinking water sources (water security), the success of waterfowl hunts (food security), and existing financial barriers that restrict their time spent on the land (affecting subsistence livelihoods and land-based activities valued by residents). Households are responding to these changes by consuming drinking water that they deem to be of lesser quality than preferred sources, filling large bottles with tap water or purchasing water to carry with them on the land, and traveling farther in search of new waterfowl hunting grounds and reliable sources of freshwater for drinking.

The capacity of households to adapt to changing freshwater conditions is supported by a familiarity with the dynamic characteristics of freshwater systems in the region, knowledge of the surrounding landscape and the ecosystems upon which the community depends, access to resources such as hunting supplies, fuel, and cash, and the availability of diverse sources of drinking water and food.

Chapter 4: Conclusion

The final chapter offers a summary of the contributions of the thesis. The relevance of the research findings to the project aims are discussed, along with a critical reflection on the limitations of the study. Participants contributed feedback and a variety of suggestions regarding the performance and management of their municipal water system, drinking water accessibility in their community, and possible directions for future research. Their thoughtful comments are summarized at the end of the chapter.

1.7. Co-Authorship Statement

Christina Goldhar, Dr. Trevor Bell, and Dr. Johanna Wolf are co-authors of the two manuscripts appearing in this thesis. Dr. Trevor Bell secured funding for this project while Christina Goldhar and Dr. Trevor Bell jointly designed the research. Christina Goldhar coordinated the project and completed data collection and analysis with the guidance and support of Dr. Trevor Bell and Dr. Johanna Wolf. Christina Goldhar drafted both manuscripts while all authors provided revisions and approved of the final documents.

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CHAPTER 2

Drinking water systems in Rigolet and Nain, Nunatsiavut: Rethinking existing approaches to water security

Abstract

Changes in the availability of freshwater and diminishing water levels of surface water bodies have been observed by residents of many arctic communities across North America. Simultaneous biophysical changes in freshwater ecosystems have been documented by the scientific community, and future climate variability and change is likely to result in further alteration to freshwater ecosystems in northern high latitudes. These trends are potentially harmful to arctic residents who rely on their watersheds to provide essential sources of food and water; few studies, however, have considered the challenges these changes pose for water security in the arctic. A baseline understanding of drinking water preferences, perceptions, and factors contributing to current water security is additionally missing from the literature. This paper introduces an approach to understanding water security that is grounded in drinking water preferences, perceptions, and the attributes of a community drinking water system. The approach emphasizes drinking water access, availability, quality, and desirability, and is developed through case studies carried out in Rigolet and Nain, Nunatsiavut. A total of 121 individual and household interviews and thirteen key informant interviews were conducted in Rigolet and Nain in fall 2009 and fall 2010. Case study results reveal restricted access to a sufficient quantity of desirable, clean drinking water for some residents of both communities. Water security stresses are experienced by elders and others with limited physical abilities, households with lower income and capital, and newcomers and others lacking well-developed social networks and knowledge of the local watershed. These challenges may be exacerbated in the future due to projected implications of climate variability and change on freshwater ecosystems in the region.

Keywords

Water security
Arctic
Nunatsiavut, Labrador
Drinking water system
Drinking water perceptions
Drinking water preferences

2.1. Introduction

Water security is an emerging area of research in arctic Canada and stems in part from questions concerning the implications of climate variability and change on arctic freshwater ecosystems. These questions arose from observations of biophysical changes in freshwater ecosystems shared by arctic residents and documented through empirical studies by researchers in the scientific community. Findings from this research describe changes in river discharge volumes, runoff trends, seasonal precipitation totals, and surface area and water levels of freshwater bodies across the arctic.

Small declines in discharge of North American rivers flowing into the Arctic Ocean were documented by Déry and Wood (2005), while Déry et al. (2005) noted significant declines in discharge of thirty-six out of forty-two rivers draining into Hudson Bay, James Bay, and Ungava Bay from 1964 to 2000. Assessing US Geological Survey data from nine stream monitoring stations in central and northern Alaska (each with about fifty years of data), Hinzman et al. (2005) revealed increasing trends in runoff within glacial-fed basins, and decreasing trends in river basins lacking large glaciers. Yoshikawa and Hinzman (2003) found a reduction in surface area of twenty-two out of twenty-four thermokarst ponds from 1950 to 2000 within discontinuous permafrost zones on the Seward Peninsula in Alaska. Reflecting on similar findings from a study conducted in Siberia, Smith et al. (2005, 1429) warn, "the ultimate effect of continuous climate warming on high-latitude, permafrost-controlled lakes and wetlands may well be their widespread disappearance".

Changes in the availability of freshwater and lowering water levels of surface water bodies have been noted by residents across Nunatsiavut (Communities of Labrador et al. 2005), and in many arctic communities across North America. Huntington et al. (2005) noted observations of gradually lowering levels of surface water bodies in Baker Lake, Nunavut, commencing in the 1960s and accelerating since the 1990s. Similar changes have also been documented by the communities of Kugaaruk and Repulse Bay, Nunavut (Communities of Arctic Bay et al. 2005). Drying trends have also been observed in western communities of the Inuvialuit Settlement Region (ISR), including Ulukhaktok (Communities of the Aklavik et al. 2005). These observations are further discussed by Pokiak (2005) in describing the recession of two lakes outside of Tuktoyaktuk, Inuvialuit, where whitefish were formerly abundant, and low water levels in the lake feeding the municipal water system (MWS) in the community. In response to a significant drop in water levels and the subsequent loss of fish, communities of the ISR have dredged fish channels to encourage future fish populations (Nickels et al. 2005). The communities of Ivujivik, Puvirnituq, and Kangiqsujuaq, Nunavik, noted diminishing amounts of annual rain and snowfall and lower water levels of lakes and rivers in the region, leading to resident concerns regarding the quality of drinking water gathered by the community (Communities of Ivujivik et al. 2005).

The biophysical changes experienced by residents and described in these studies are potentially harmful to human communities living within these watersheds and relying on them to provide essential sources of food and water (Berner et al. 2005; White et al. 2007). These trends may continue in the future as climate variability and change continues to modify the spatial and temporal distribution of freshwater and alter freshwater ecosystems in the arctic (Wrona et al. 2006; Bates et al. 2008). Despite an acknowledgement of these concerns in the literature, few studies have identified the implications of current and future freshwater trends on the well-being of arctic residents, or their ability to secure adequate sources of food and water. There is further need to understand drinking water consumption practices and perceptions in arctic communities. As stated by Alessa et al. (2008b, 155) "…documenting and characterizing the dynamics of sociocultural perceptions of freshwater is critical to anticipating how communities will respond to changing hydrological regimes". To inform future considerations of water security, a baseline understanding of drinking water system characteristics, drinking water perceptions, preferences, and factors contributing to the current water security of residents is needed.

Through the support of findings from a field-study conducted in the self-governed Inuit settlement region of Nunatsiavut, Labrador, this paper introduces an approach to understanding water security that is grounded in the perspectives of residents, and the attributes of community drinking water systems. Water security is conceptualized as a function of water access, availability, quality, and desirability. The inclusion of all four of these dimensions is intended to create space for drinking water consumption practices and preferences that may differ from those currently assumed by the norms of the water security discourse. The paper goes on to identify factors contributing to water security in the communities of Rigolet and Nain, Nunatsiavut, highlighting drinking water preferences, perceptions, and current challenges confronting the drinking water systems of both communities. The paper concludes by drawing connections between these findings and those of similar studies in other arctic communities and calls for further consideration of the implications of climate variability and change on water security in the arctic.

2.2. What is water security?

The definition of water security introduced above has been informed by recent discussions within the arctic food security literature. These discussions have emphasized the importance of considering food preference within existing definitions of food security (e.g. Kuhnlein et al. 2004; Lambden, Receveur, and Kuhnlein 2007; Loring and Gerlach 2009; Ford 2009; Goldhar and Ford 2010; Goldhar, Ford, and Berrang-Ford 2010). They argue food preference is intimately linked with the experience of food (in)security and should be regarded as an integral dimension of food "quality" and thus food security (Van Esterik 1999; Gregory, Ingram, and Brklacich 2005; Lambden, Receveur, and Kuhnlein 2007; Ford 2009; Loring and Gerlach 2009; Goldhar and Ford 2010; Goldhar, Ford, and Berrang-Ford 2010). The Food and Agriculture Organization (FAO; 1996) defines food security as a state where "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Van Esterik (1999), Gregory, Ingram, and Brklacich (2005), and Ford (2009), amongst others, have defined it as the ability to acquire safe, nutritionally adequate and culturally acceptable foods in a manner that maintains human dignity.

Similar discussions within the arctic drinking water literature have emerged highlighting the relative nature of health perceptions and the existence of locally specific ideas about drinking water quality (e.g. Marino et al. 2009), though these discussions have yet to explicitly address water security. While there is substantial literature that investigates drinking water preferences and perceptions (e.g. Auslander and Langlois 1993; Levallois, Grondin, and Gingras 1999; Anadu and Harding 2000; Doria 2006; Jones et al. 2006, 2007; Burlingame and Mackey 2007), these considerations have yet to be incorporated into prominent water security definitions. Approaches to understanding water security commonly emphasize elements of access, availability, and safety. An often-cited definition presented at the Second World Water Forum at The Hague in 2000, states: "water security means ensuring that freshwater, coastal, and related ecosystems are protected and improved; that sustainable development and political stability are promoted; that every person has access to adequate safe water at an affordable cost to lead a healthy and productive life; and that the vulnerable are protected from the risks of water-related hazards". The aspects of this definition that concern human drinking water highlight elements of access, safety, cost, health, and productivity.

2.3. (Re) conceptualizing water security

The concept of water security presented in this study is founded in the notion of a drinking water system (DWS), and is drawn from the idea of a "food system" that underlies concepts of food security described by Gregory, Ingram, and Brklacich (2005)[3] and later used by Ford (2009). A DWS comprises dynamic interactions between and within biogeophysical and human environments that result in the collection, distribution and consumption of water. While the notion is intentionally anthropocentric, approaching water through a human needs-based lens and specifically concerning human consumption of drinking water, the DWS is a social-ecological system or a human-environment system and encompasses the synergistic relationship between human and environmental components. This concept closely relates to the notion of a "human-hydrological system" adopted by Alessa et al. (2008a) and is influenced by the social-ecological systems literature (e.g. Berkes and Folke 1998; Berkes and Jolly 2001) and resilience theory (e.g. Holling 1973).

Freshwater gathered from the land, treated and distributed through the MWS, or purchased from the store are all important sources of water supplying the DWSs of many northern communities. The DWS itself, however, consists of elements far more diverse than supply alone. Adapted again from the work of Gregory, Ingram, and Brklacich (2005) and Ford (2009), a drinking water system encompasses components of: i) water access (including elements of affordability and allocation); ii) water availability (with elements including supply and distribution); iii) water quality (including elements of safety); and iv) water desirability (including elements of preference, perception, and value). The primary contribution of this conceptualization within existing water security

[3] Gregory, Ingram, and Brklacich (2005, 2141) describe a food system as a set of "dynamic interactions between and within biogeophysical and human environments which result in the production, processing, distribution, preparation, and consumption of food".

approaches is the inclusion of desirability, illustrated through elements of preference, perception, and value. Use of the DWS concept grounds water security understandings within the attributes of a community and locality. "Water security" signifies an ability to access a sufficient quantity of *desirable*, clean drinking water in a manner that maintains human dignity. Water insecurity exists when the DWS is stressed, compromising one or several components (Figure 2-1).

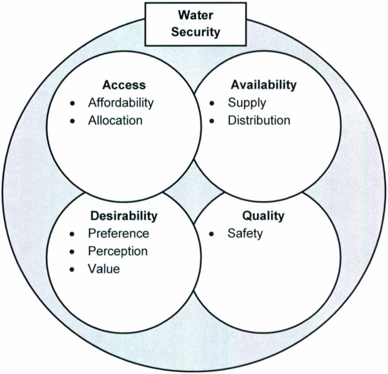

Figure 2-1. Dimensions of water security (adapted from Ford 2009).

Stresses influencing DWSs may be induced by a variety of factors such as biogeophysical changes in a watershed limiting water availability, challenges affecting the distribution of municipal tap water diminishing water quality, or rises in the cost of fuel restricting the accessibility of drinking water sources. Through the lens of water security presented above, limited access to preferred water sources alone implies a degree of water insecurity. Water security can be threatened despite one's ability to acquire a sufficient quantity of clean water that would meet daily health requirements. The significant role of water preferences in shaping community water security was clearly highlighted by residents of the Inuit Settlement Region of Nunatsiavut, where this study was situated. The following section introduces the study area and the context that has shaped the formation of this research.

2.4. Nunatsiavut case study: Study area

Nunatsiavut is located on the northern coast of Labrador and covers roughly 15,800 km^2 (Figure 2-2). The region is situated within the taiga-tundra transition ecozone, characterized by rocky barrens and low-lying vegetation typical of tundra environments, and a sporadic treeline framing forests of thick spruce, birch, poplar, and aspen (Ames 1977). The cold Labrador Current draws arctic waters down the coast of Labrador and moderates the local climate, lowering temperatures below those experienced at similar latitudes inland in Canada (Banfield 1981). The region is classified as Dfc or "subarctic" within the Köppen climate classification system and is characterized by short, cool summers and long, cold winters (Christopherson and Byrne 2006).

Figure 2-2. Nunatsiavut, Labrador is indicated by the shaded regions on this map and comprises Labrador Inuit Settlement Areas and Labrador Inuit Lands. Map produced by Charles Conway, Department of Geography, Memorial University, 2011.

Nunatsiavut achieved self-governance in 2005 following the establishment of the Labrador Inuit Land Claims Agreement after more than three decades of negotiations (Nunatsiavut Government 2011). The five communities located in Nunatsiavut are dominantly Inuit (91 percent)[4] and range in population size from 219 in Postville to 1034 in Nain (Table 2-1). No roads connect any of the communities to each other or to the south of Labrador, though residents travel frequently by motorboat along the coast in the ice-free season and by snowmobile in winter. Movement in and out of the locality of the settlement is fluid and frequent as residents rely on surrounding environs for firewood and drinking water, and commonly make trips of varying length to cabins to participate in hunting, fishing, and other land-based activities. These practices have evolved from generations of movement between seasonal camps along the coast and up major water ways inland during pre-settlement periods (Fitzhugh 1977).

[4] For a detailed discussion of the complex ethno-history of the region see Brice-Bennett, Cooke, and Davis (1977), Kennedy (1985), and Plaice (2009).

Table 2-1. Descriptive socio-economic statistics for Nunatsiavut communities.

Characteristic	Nain	Hopedale	Rigolet	Makkovik	Postville	Nunatsiavut	Newfoundland and Labrador
Population 2006	1034*	530	269	362	219	2414	505,469
Change in population 2001-2006 (%)	-10.8	-0.05	-15.1	-5.7	1.9	-6	-1.5
Median age	26.4	25.5	31.2	29	32.8	29	41.7
Median income, family after tax	42,112	38,528	44,416	46,720	no data	42,944	43,398
Average household size	3.7	3.5	3	3.1	3.1	3.3	2.5
1st language: English (%)	71	71	97	94	98	80	97
1st language: French (%)	0**	2	0	3	0	0	0
1st language: Other (%)	29	29	0	6	0	19	2
Aboriginal (%)	92	90	93	88	91	91	5
Unemployment rate	27.9	32.5	31.8	37.1	30	31.9	18.6

* Census data are commonly flawed in Nunatsiavut. The Inuit Community Government of Nain reported an underrepresentation of population size by roughly 10% in the 2006 census (NICG, personal communication, September 2011).

** All figures less than 1 are represented by 0.

(Statistics Canada 2007)

Small, weather-dependent flights enter the communities transporting goods, residents, contractors, and the occasional researcher or tourist. During summer months a ferry services the coast, providing goods and transportation opportunities at lower cost than flight transportation allows. As is characteristic of "diverse economies" or "mixed-subsistence/cash" economies, residents are engaged to varying degrees within the capitalist wage-based system. Income earned through waged employment and social transfer payments is supplemented by the procurement of traditional foods and goods harvested from the land and the sea. The subsistence and cash economies are so closely intertwined in Labrador, as they are in many regions of the arctic, that boundaries differentiating the two are largely superficial.[5] As discussed by Wenzel (2000, 62) regarding small Inuit communities in Nunavut, harvesting activities are conducted "under conditions in which money has become as fully a part of the subsistence environment as food or other natural raw materials".

2.5. Methods

Data were collected for this study through a variety of methods from spring 2009 to winter 2011. In Rigolet, the project was developed during a series of meetings with residents and community leaders in June 2009. Resident feedback and suggestions were incorporated into the research design, including the timing of fieldwork, methods of data collection, possible language considerations, and the interview guide. The Nain portion of the study was developed in partnership with the Nain Inuit Community Government (NICG) and the Nunatsiavut Government in winter 2009. Research in both Nain and

[5] For a similar point regarding Greenland see Dahl (1989).

Rigolet was conducted through the support of a research assistant from the community; in Nain two interpreters joined the research team.

In September 2009, eighty-nine semi-structured household interviews (88 percent response) were conducted in Rigolet, followed by thirteen key informant interviews in each Nunatsiavut community (Postville, Makkovik, Hopedale, and Nain). Key informant interviews were conducted with representatives of the Inuit Community Governments of each community, municipal water workers, health care workers, a minister in the cabinet of the Nunatsiavut Government, and other community leaders. In September 2010, thirty-two semi-structured household interviews (64 percent response) were conducted in Nain. All interviews in both communities were conducted with adults (age eighteen and over) and commenced with a short, structured component asking the perspectives of a single household representative. The structured component of the interview contained questions about drinking water preferences and perceptions, while semi-structured questions concerned the performance of the municipal water system, drinking water consumption practices, and the general aesthetic characteristics of tap water, store-bought water, and water collected from the land.

As the population of Rigolet is much smaller than Nain it was possible to include all 101 households in the interview sample, while a random sample was selected in Nain. Attempts were made to spatially balance the Nain household sample, ensuring selected households were evenly distributed throughout the community and throughout the water distribution system. This was done to minimize possible bias stemming from diverse tap water attributes and household proximity to drinking water sources. All homes were numbered on a community map and fifty households were selected using a random number generator.

The majority of interviews took place in participant's homes and were conducted in English, with Inuktitut interpretation available. Data analysis was an iterative process that commenced in the field. Interview data were transcribed, coded manually through a process inspired by "constructivist grounded theory" (Charmaz 2003, 2006; Bryant and Charmaz 2007) and analyzed in conjunction with water reports gathered in the communities and field notes from participant observation. The study was approved by the Nunatsiavut Research Advisory Committee and by the Interdisciplinary Committee on Ethics in Human Research at Memorial University. When interview quotes are used to illustrate study results, respondents are identified by a pseudonym. Findings from Nain were first presented in an unpublished report for Indian and Northern Affairs Canada (INAC) in March 2011 (Goldhar et al. 2011).

2.5.1. Sample characteristics

The social and demographic characteristics of the *structured interview* sample describe individuals who volunteered to represent their household in this portion of the study. A single volunteer was requested to respond to a series of questions regarding their personal drinking water preferences and perceptions. Thirty-three percent of the population of Rigolet participated in the structured interviews, while 3 percent participated in Nain. Household members participating in the *semi-structured interviews* responded collectively and included all interested adult residents of the home (up to four members participated). No social or demographic characteristics were collected from household respondents as no comparable census data are available at the household scale in either community. Rather, as noted earlier, care was taken when randomly selecting the Nain sample to spatially balance the sample to ensure the location of respondent's homes varied in proximity to drinking water sources available in the community, and were evenly spread throughout the municipal water distribution system.

Women were overrepresented within the structured portion of the interviews in both Nain and Rigolet (by 10 percent in Rigolet and 17 percent in Nain; Table 2-2). The participation of women in this portion of the study may have been encouraged by the presence of a female research team, and may have additionally been influenced by the timing of research and gender roles in the community. While interviews were conducted during evenings and weekends, and occasional appointments were made with respondents in advance of interviews, the majority of participants were approached during door-to-door visits at their homes during the day. The higher proportion of women working as "homemakers" in both communities relative to men, and the disproportionate participation of men in land-based activities and employment outside the community may have contributed to the likelihood of women being home during the day. Similar factors may account for the overrepresentation of older age cohorts that no longer work and are more commonly available at home during the day. Adults over the age of sixty were overrepresented by 7 percent in Rigolet and 13 percent in Nain.

Table 2-2. Structured interview sample characteristics in Rigolet and Nain relative to census data.

	Variable	Rigolet sample* (%)	Rigolet census data (%)	Nain sample** (%)	Nain census data (%)
Gender	Male	42	52	33	50
	Female	58	48	67	50
Age	15-29	6	37	17	38
	30-44	33	26	27	30
	45-59	44	26	33	22
	60-74	10	9	20	9
	75+	8	2	3	1
Occupation	Unemployed/ Unemployment rate**	9	31.8	9	27.9
	Part-time worker	7		6	
	Full-time worker	46		46	
	Casual or seasonal worker	17		9	
	Other***	21		30	
Miscellaneous	Years living in the community (average)	35.7		38.6	
	Weeks per year spent on the land (average)	5.8		2.75	
Household	Adults (18 yrs.+) in home (average)	2.1		2.3	
	Children in home (average)	0.7		1	

*n=89 in all categories with the exception of occupation where n=87

**n=33 in all categories with the exception of age where n=30

***Includes all participants presently seeking employment. Census data represents the unemployment rate in the community.

****Includes all participants not currently employed and not presently seeking waged work. This category encompasses subsistence hunters and fishers, homemakers, elders, etc.

(Statistics Canada 2007)

Both Nain and Rigolet have a significant portion of young people that have been underrepresented in this study. The youngest age category of fifteen to twenty-nine years was underrepresented by 31 percent in Rigolet and 21 percent in Nain. The study intentionally targeted adults (age eighteen and over). Consequently, the age category of fifteen to twenty-nine years used within the census data is not directly comparable to the sample characteristics of the study. This may account for part of the underrepresentation of this age grouping in the sample, though it is likely that generational expectations played a stronger contributing role. The customary role of elders and older generations as teachers and guides in the community may have diminished the likelihood that youth would volunteer to partake in the structured interview while in the presence of an older household member. The structured interview samples in Rigolet and Nain are therefore not representative of the broader community population and no attempts have been made to scale up findings or offer an analysis founded in gender or age characteristics. Descriptive statistics used to illustrate structured interview findings have been analyzed and presented in conjunction with findings from semi-structured household interviews, key-informant interviews, participant observation, and secondary sources.

2.6. Water security in Nunatsiavut: DWS attributes in Nain and Rigolet

Drinking water sources available within DWSs in Nunatsiavut communities include chlorinated tap water, store-bought water, and water gathered from running brooks, lakes, ice melt, and other sources on the land (Figure 2-3A, 2-3B). The latter sources were referred to as "water on the land" in Rigolet and "fetched water" or "fresh water" in Nain by participants of this study. The following section presents study findings alongside supporting literature and commences with a description of watershed characteristics in the regions of Rigolet and Nain. Drinking water access, availability, and quality attributes are then emphasized within a discussion of each drinking water source available to residents. The drinking water preferences and perceptions of study participants are then described.

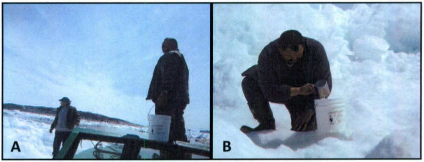

Figure 2-3. Fetching water on the sea ice outside Nain in spring 2010.
(A) Looking for drinking water on the melting ice pans; (B) Collecting water to bring back to the community. Photos courtesy of Tabea Solomon, 2010.

2.6.1. Watershed characteristics

The availability of water gathered from the land and water supplying the MWS in Nain and Rigolet is subject to seasonal and inter-annual fluctuations and longer-term trends shaped by climate conditions in the region. The community of Nain is situated on the boundary of the Tikkoatokuk Bay and the Kogaluk/Notakwanon watersheds. The research team was unable to locate a map depicting watershed boundaries on a sufficiently fine scale to discern which watershed the community supply is located within and whether it is fed by both catchments. There are no hydrometric stations located in the

Tikkoatokuk Bay watershed and only one in the Kogaluk/Notakwanon watershed. Discharge records for this station show strong seasonal differences with maximum flow experienced in the melt season of June-August and minimum flow in the winter months of December-February (Figure 2-4).

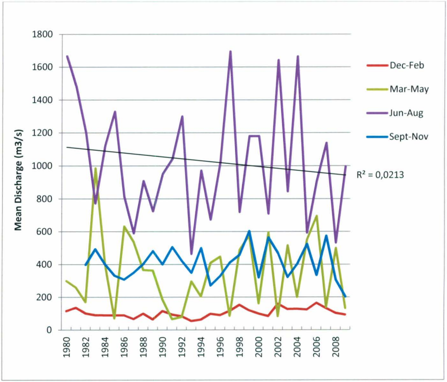

Figure 2-4. Seasonal discharge for Ugjoktok River below Harp Lake (55°14'2"N, 61°18'6"W) with linear trend lines, 1980-2009: Hydrometric station 03NF001. (data retrieved from: Environment Canada 2010)

Rigolet is situated within the Hamilton Inlet watershed which is fed by both the Naskaupi and Churchill Rivers. While there are no hydrometric stations located within the watershed, discharge records for the Nakaupi River show strong seasonal differences similar to those illustrated by the Ugjoktok River, noted above. Maximum flow is experienced from June to August when the river is flush with snowmelt and precipitation, and minimum flow occurs from December to February (Figure 2-5). Linear trend lines indicate a long-term decline in summer flow (June-August) within both records, and a more subtle decline in fall flow (September-November) within the Naskaupi record. However, r^2 values are less than 0.3 in all cases, indicating a weak fit.

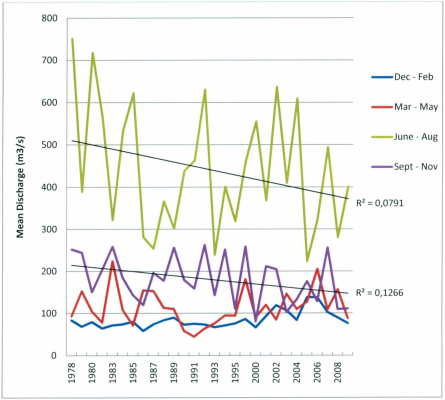

Figure 2-5. Seasonal discharge for Naskaupi River below Naskaupi Lake (54°7'54"N, 61°25'36"W) with linear trend lines 1978-2008: Hydrometric station 03PB002.
(data retrieved from: Environment Canada 2010)

Goldhar, Bell, and Wolf (2011) describe observations by Rigolet residents of decreases in the seasonal availability of water within the Hamilton Inlet watershed commencing within the last thirty years. Residents noted a decrease in water levels in the region during summer months and discussed the implications of these changes on their ability to successfully hunt and harvest foods, and gather drinking water from the land. Forty-three percent of participating households in Rigolet noted decreasing water levels in the region, while 34 percent noted no changes, and 24 percent were uncertain (Goldhar, Bell, and Wolf 2011). Similar findings emerged in Nain where 48 percent of households observed diminishing water levels in the region, while 52 percent noted no changes. Nain participants appear to be affected less dramatically by observed changes than Rigolet residents and described an abundance of freshwater available in all seasons in the region, despite aforementioned changes. Resident observations of decreases in the seasonal availability of freshwater in Nunatsiavut have also been documented by Communities of Labrador et al. (2005) who note gradual drying trends over the last forty to fifty years with accelerated changes since the 1990s.

2.6.2. Water gathered from the land

Water and ice have been gathered from the land and the sea by *Nunatsiavummuit* (Nunatsiavut Inuit) for generations. Water is typically gathered in plastic buckets from sources surrounding the community and carried back home on foot or by snowmobile, all-terrain vehicle (ATV), or other vehicle. Residents in need of a vehicle are restricted to accessing water during seasons that coincide with their mode of transport (enabling snowmobile owners to access water in winter and ATV owners to collect water in spring, summer, and fall). As the practice of gathering water is physically demanding, elders noted an inability to collect water on their own and typically rely on family or friends to fetch water for them. In addition, residents without access to a vehicle or money to cover fuel costs noted having difficulty collecting water. Physical health and access to transportation either through household capital or social bonds are therefore important factors determining the ability of residents to gather water from the land.

In the eyes of the health science community, water sources gathered from the land pose a potential human health risk as they are not examined for the prevalence of bacteria or other harmful contaminants. The drinking water literature in the region is relatively limited, though two studies addressing water quality have monitored the presence of total coliforms and *E.coli* in untreated water samples (Martin et al. 2007; Harper et al. 2011). Harper et al. (2011) found a significant positive association between bacteriological variables in raw water samples and water volume input (snowmelt plus rainwater) in Nain from 2007 to 2008. Their findings suggest an elevated risk of infectious gastrointestional illness stemming from the consumption of untreated surface water during spring and summer when water volume input (and runoff) is at its peak.

In a study conducted in Nunavik, Martin et al. (2007) tested water samples of raw water gathered from drinking water collection sites and individual storage containers in the communities of Umiujaq, Puvirnituq, Ivujivik, and Kangiqsujuaq. Water analyzed from the storage containers appeared to be more highly contaminated than raw water samples gathered at their source. In conclusion, Martin et al. (2007, 200) called for systematic environmental monitoring of drinking water collection sites and an educational campaign aimed at "raising residents' awareness of the risks associated with raw water consumption". Both Harper et al. (2011) and Martin et al. (2007) drew attention to the human health risk of consuming untreated water, and the possible amplification of this risk in the future due to projected climate changes.

2.6.3. Tap water

As a remote, sparsely populated region, Nunatsiavut has a relatively recent history of tap water provision. The construction of the MWSs in Nain and Rigolet was initiated by the province of Newfoundland and Labrador in the late 1970s and development has continued to today with the construction of new housing units. Residents are responsible for the cost of connecting their home to the main water line and not all homes in Nain are presently serviced by the MWS. Some other homes have no running water due to an inability to pay for the cost of fixing previously frozen pipes, or to pay municipal utility taxes and electricity bills (including two participating households in Nain, and one in Rigolet). An outdoor community tap in Nain known as the "water fountain" provides chlorinated water to these residents, though it is prone to freezing in winter. All homes are connected to the MWS in Rigolet and no community tap is available.

Tap water in all Nunatsiavut communities is pumped from surface water supplies; in both Rigolet and Nain these sources are lakes that have been dammed to elevate water levels. The supply is pumped into a water treatment facility where it is filtered to eliminate large particles and then chlorinated before moving through an underground gravity-flow distribution system. High density poly-ethylene pipes (thirty centimetres in diameter on the main line) carry water to the majority of homes in the region. Consumption levels are elevated in both communities during winter months due to "system bleeding" whereby residents are encouraged to maintain a constant flow of water running through their taps and town maintenance workers systematically flush the main lines to prevent freezing. Freezing of the lines in Nain commonly leads to cracking and leaks, elevating water turbidity and necessitating additional chlorine to be added to the distribution system.

A similar need for additional chlorine is present in the Rigolet system in response to high levels of organic matter in the water supply, leading to the production of excessive trihalomethanes (THMs). THMs are disinfection by-products from the chlorination process that are produced through the reaction of chlorine with organic compounds found in untreated water sources. Studies have shown positive associations between exposure to THMs, such as chloroform, and cancer (Morris et al. 1992; Mills et al. 1998), as well as reproductive and developmental effects (Reif et al. 1996; Mills et al. 1998; Dodds et al. 1999). Although unequivocal causation has yet to be demonstrated, in the interest of prudence, and following toxicological studies showing the carcinogenic effects of chloroform in rodents (National Cancer Institute 1976), Health Canada established its first set of drinking water guidelines limiting THM consumption to 350 ppb in 1978 (Driedger and Eyles 2003). This guideline was modified in 1993 to reflect the US guideline of 100 ppb. THM concentrations in Rigolet tap water averaged 208 ppb in 2008 (108 ppb above national drinking water guidelines) according to a draft report of a THM reduction study commissioned by the province (Noseworthy 2008)[6].

Boil water advisories (BWAs) frequently affect the MWSs of both Nain and Rigolet. Two advisories lasting a total of twenty-two days were issued in Nain from September 2009 to August 2010, while three were issued in Rigolet lasting a total of ninety-five days during a similar twelve-month period[7]. This is more than the average number of 1.5 BWAs per year in the province (Department of Environment and Conservation 2009). Four of these five BWAs resulted from maintenance and repairs to the water distribution system. Perceived frequency of BWAs in Rigolet is much higher than records show, with residents recalling up to four times the actual number in the year preceding the study. This question was not asked in the Nain study.

Water samples are collected bi-monthly by the town maintenance staff in Nain and Rigolet and sent to the Department of Environment and Conservation in Goose Bay for analysis. A BWA is issued "when there is reason to suspect possible pathogen contamination of a community's drinking water" (Department of Environment and Conservation 2009, 17), and therefore does not necessarily result from a failed bacteriological test. When the MWS is shut down due to maintenance or repairs (such as flushing the main lines), the NICG and the Rigolet Inuit Community Government (RICG)

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[6] A final report has yet to be issued.

[7] This accounts for all BWAs archived by the RICG and the NICG. At the time of accessing these records some staff in Nain expressed doubt that the two advisories noted were an accurate representation of all BWAs experienced by the community in the previous twelve months.

issue a precautionary BWA. BWAs may only be lifted after two consecutive water samples are deemed satisfactory by the Department of Environment and Conservation[8]. At times advisories are unnecessarily prolonged resulting from delays in sample transportation to Goose Bay due to weather-related flight cancellations (particularly in Nain), the need for samples to be analyzed within twenty-four hours of collection, and the infrequent operating hours of the laboratory in Goose Bay (open Mondays-Wednesdays at the time of this publication).

2.6.4. Store-bought water

Store-bought water has been available in Nain and Rigolet since the late 1990s. Tap water filtered through a reverse-osmosis system is sold in refillable bottles and a variety of brands of bottled water are shipped into the communities in summer and flown in during winter along with most other goods. The availability of bottled water is primarily determined by the ability of store owners to successfully anticipate demand when placing stocking orders and the frequency of "fair-weather" flights into the communities in winter. Weather conditions therefore directly influence bottled water availability in winter months. The cost of bottled water is prohibitively expensive for the majority of households in Nain and Rigolet and these costs are elevated in winter when supply is limited and the additional costs of flight transportation are added. Residents of Rigolet noted spending up to thirty dollars for a case of twelve 500 ml bottles of water in winter

[8] A "satisfactory" bacteriological test requires zero colonies of total coliforms and *E. coli* per 100 ml sample and the maintenance of a satisfactory *free chlorine residual* throughout the distribution system. The latter is the level of detectable chlorine in water samples collected from throughout the distribution system. A minimum level of chlorine must be detectable in all tap water samples.

2009 (more than 200 percent the regular price) due to short supply in the community. Refillable bottles of filtered tap water sell for roughly 15 percent of the price of bottled water in both communities (when purchased in 18.8 L volumes), though their sale is prohibited during BWAs. As a result of unaffordable bottled water prices, households in Rigolet travel by boat down the coast to Goose Bay (about 160 km over water) during ice-free seasons to stock up on a variety of supplies including bottled water, thus augmenting the availability of goods in the community. No similar practices were noted in Nain, probably due to the long distance between the community and larger population centres such as Goose Bay (about 580 km over water to Goose Bay).

2.6.5. Drinking water preferences and perceptions: Desirability of drinking water sources

Drinking water sources available in Nain and Rigolet are each viewed as unique and are used to varying degrees by study participants. To more effectively illustrate these points, participant quotes have been used in this section to communicate residents' perspectives through their own words. Quotes were selected that typify responses from the broader sample.

Tap water was the least favourable source of drinking water available to residents of Rigolet and Nain and was commonly described in negative terms by participants from both communities (Table 2-3). For the majority of Nunatsiavut residents, expectations of how an "ideal drinking water" should taste, look, and smell are shaped by experiences of water consumption on the land. Tap water is evaluated through subjective comparisons to the organoleptics of land water sources, leading residents to use comparative terms when recounting the colour, taste, and smell of tap water, and to describe tap water through its differences from these land sources. The description of water on the land as "real," "natural," and "just water" further suggests that store-bought water and tap water are compared to these sources.

"If I have a choice tap water would be my last choice." -Jake, Rigolet

"It smells gross. Tastes, I don't know. I won't drink it out of the tap. The colour is brown." - Sarah, Rigolet

Table 2-3. Household perceptions of drinking water attributes in Rigolet and Nain

Question	Community	Tap water	Store-bought water	Water on the land
How would you describe the colour, taste, and smell of your water?	Nain (n=33)	Chlorine, stale, discoloured, metal, brown, not bad	Flat, plastic, no colour, no taste, no smell, unpleasant, stale	Fresh, pure, clear, no taste, no smell, real, cleaner, brown, healthy
	Rigolet (n=89)	Brown, cloudy, chemical, Javex, groundy	White, clear, nothing, dead, plasticky, saline	Alive, white, just water, brown, clear, groundy, natural

A far greater portion of Rigolet respondents indicated that they primarily consume store-bought water in the community (47 percent in Rigolet, 6 percent in Nain; Table 2-4). This divergence may be accounted for by the increased affordability and availability of store-bought water for Rigolet residents due to the proximity of the community to Goose Bay. Fifty-eight percent of Nain residents primarily consume tap water while in the community, compared to 36 percent in Rigolet. The proportion of respondents that primarily consume land water in each community are more similar; 36 percent of Rigolet participants and 17 percent of respondents in Nain primarily consume water from land sources. A clear preference for drinking water gathered from the land was articulated in both communities, accounting for 91 percent of the sample population in Nain and 78 percent in Rigolet. The considerably larger portion of participants primarily consuming tap water in Nain and store-bought water in Rigolet may reflect a greater degree of dissatisfaction with tap water characteristics in Rigolet relative to Nain.

Table 2-4. Drinking water source preferences and use in Nain and Rigolet. Percentages may not add to 100% due to rounding and alternative responses.

Question	Community	Tap (%)	Store-bought water (%)	Water on the land (%)
1. What is your favourite source of drinking water?	Nain (n=32)	0	9	91
	Rigolet (n=89)	6	17	78
	Aggregate (n=121)	4	15	81
2. What is your primary source of drinking water in the community?	Nain (n=33)	58	6	36
	Rigolet (n=89)	36	47	17
	Aggregate (n=122)	42	36	22
3. What is your primary source of drinking water on the land?	Nain (n=33)	0	0	97
	Rigolet (n=89)	2	10	78
	Aggregate (n=121)	2	7	84

Dissatisfaction with the taste and smell of chlorine, and additional aesthetic characteristics such as colours ranging from yellow in summer to dark brown in spring, and a "groundy" (earthy) taste more common in spring, were all noted as factors dissuading potential tap water drinkers (Figure 2-6). Taste perceptions of tap water additives such as chlorine are heightened when returning to the community after a trip on the land when non-chlorinated sources were consumed.

"The town water is chlorinated, there's chlorine in it and you can taste it. You can smell it when you have a bath, when you have a cup of tea. Especially when you come back from off the land, even for a weekend. If you're drinking water from out of the brooks and you come back you can hardly drink it." – Jake, Rigolet

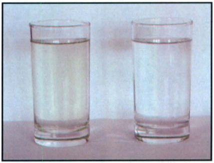

Figure 2-6. Dissatisfaction with tap water characteristics in Rigolet (left) has led some households to purchase filtered tap water (right) from the local grocery store for drinking and cooking purposes.

While the cost of bottled water restricts access for most community members, interview discussions revealed that personal preference rather than cost is the primary factor dissuading residents. Similar to tap water, store-bought water was commonly described in negative terms that signify potential health concerns and contrast it with Nature and "the natural." Words such as "plastic," "stale," and "dead" distinguish store-bought water from the "fresh," "pure," "alive," and "natural" water gathered from the land. The use of words such as "dead" and "alive" may imply water on the land is imbued with meaning that extends beyond its physical properties and forms in the minds of residents, and that these qualities are absent in tap water and store-bought water.

2.6.5.1. Drinking water risk perceptions

When asked directly, resident perceptions of tap water safety relative to water gathered from the land differed considerably in both communities (Table 2-5). Fifty-three percent of Nain respondents felt their tap water was "safe to drink", while 16 percent felt it was unsafe to drink, 13 percent felt it was sometimes safe, and 19 percent were not certain. By contrast, 75 percent of Nain participants felt water from the land was "safe to drink" relative to 25 percent who agreed that it was sometimes safe. In Rigolet, 41 percent of respondents felt their tap water was "safe to drink", while 37 percent felt it was unsafe, 12 percent felt it was sometimes safe, and 11 percent were unsure. Fifty-seven percent of Rigolet respondents felt water on the land was "safe to drink" relative to 4 percent who described land water as unsafe, 27 percent who felt it was sometimes safe, and 13 percent who were not certain.

Table 2-5. Perceptions of drinking water safety in Nain and Rigolet. Percentages may not add to 100% due to rounding and alternative responses.

Question	Community	Yes (%)	No (%)	Sometimes (%)	Unsure (%)
1. Do you feel your tap water is safe to drink?	Nain (n=32)	53	16	13	19
	Rigolet (n=86)	41	37	12	11
	Aggregate (n=118)	45	31	12	13
2. Do you feel water gathered from the land is safe to drink?	Nain (n=32)	75	0	25	0
	Rigolet (n=86)	57	4	27	13
	Aggregate (n=118)	62	3	26	9

Households indicating water from the land was "sometimes" safe highlighted the importance of avoiding stagnant water and brooks with elevated water levels and high sediment content due to excess rain or spring thaw. Techniques used by residents to ensure adequate drinking water quality on the land include: observing weather patterns and water levels, straining water through a cloth to reduce turbidity, and sensory inspection of the water evaluating the colour, opaqueness, taste, and smell. Additionally, residents have a preference for familiar water sources accessed in the past, and running water or water gathered from a source with a clear inflow and outflow, thus avoiding the consumption of stagnant water.

"I trust nature and the natural environment around here. It's the same brook that my mom and dad drank out of, my grandfather and my grandmother drank out of, and my grandfather lived to be ninety-five." –Matilda, Rigolet

While aesthetic characteristics of water play a role in informing the confidence of residents, the broader environment from which the source is accessed at the time it is accessed is also important. The suitability of a water source for drinking purposes is regarded as variable, and "white", "clear-looking" brook water may be avoided if the immediate environment of the source presents cause for concern. Two households in the Rigolet study provided examples to illustrate these considerations; the first described finding scat from wolf (*amaruk*[9]) near where they usually collect brook water, and the second described finding a dead caribou (*tuktuk*). Both households moved further upstream to collect water at that time. As water on the land is gathered directly from its

[9] Inuktitut names were retrieved from Brice-Bennett, Cooke, and Davis (1977).

source, residents have a more intimate awareness of factors contributing to drinking water suitability than they do with tap water. They are drawing on individual, household, and community experiential knowledge and deciding for themselves which sources are appropriate for drinking, rather than placing trust in municipal water workers, health authorities, and the technologies of the municipal water system.

Within both Nain and Rigolet, respondents who stated their tap water was "sometimes" safe noted seasonal changes in tap water organoleptics, the presence of BWAs in the community, and fluctuations in perceivable chlorine levels. For these residents, the chlorination of drinking water not only results in negative organoleptics, but diminishes public trust in tap water due to fears regarding negative health outcomes associated with chlorine consumption. Within Rigolet these fears are exacerbated due to knowledge of excessive THM concentrations in their tap water.

"The worst thing I find are the THMs, I keep thinking about them. When they started talking about that we started buying water at the store." –Cindy, Rigolet

In addition to the treatment of municipal water, knowledge of the multiple uses of the community tap water source, both historically and currently, shape tap water risk perception. In Rigolet, residents expressed concern regarding the use of Rigolet Pond for recreational purposes such as swimming in summer, skating in winter, and transportation as the frozen pond forms part of a snowmobile trail (Figure 2-7). Before the airport was built, the pond was used to land planes in winter, and dogsleds were mushed on the ice before snowmobile use was widespread. Respondents also expressed fears that Rigolet

Pond was contaminated when the Canadian Army was stationed in Rigolet during the Second World War[10].

Figure 2-7. Rigolet pond supplies the municipal tap water system while simultaneously functioning as a recreational area for picnics.

2.7. Discussion

Gathering water and ice from the land and the surface of the sea for drinking is a practice deeply rooted in the history of water gathering in Nunatsiavut. These practices have been maintained through the present, despite the introduction of alternative drinking water sources in recent years that arguably offer greater convenience. The reasons for the continuation of these practices extend beyond arguments of historic precedence alone, as has been discussed in previous sections. Drinking water source preferences are also shaped by organoleptics and risk perceptions. Access and availability restrictions determine whether preferred sources are consumed and to what extent.

[10] Several hundred Canadian soldiers were stationed in Rigolet from roughly 1943 to 1945 "to protect the inland waterway of Lake Melville and access to the Goose Bay air base" (D.W. Knight and Associates 2005, 3).

Findings from the Rigolet and Nain case studies indicate that access to a sufficient quantity of desirable, clean drinking water is compromised for some residents. By way of summary, Figure 2-8 illustrates some of the dimensions of drinking water access, availability, desirability, and quality contributing to water security in Nain and Rigolet. These dimensions were found to be dynamic and intimately linked. Access to store-bought water in both communities, for example, is influenced by individual and household cash resources, transportation, social bonds, the price of fuel and water, and the availability of store-bought water. The latter was found to be shaped by short-term weather conditions, long-term climate trends, the capacity of flights and shipments into the community, the ability of store-owners to successfully predict consumer demand, in addition to the ability of residents to travel to other communities such as Goose Bay to purchase auxiliary supplies. Elders and others with limited physical abilities, households with minimal income and capital, newcomers to the community, and others without well-developed social networks or knowledge of the region experience additional challenges to their water security.

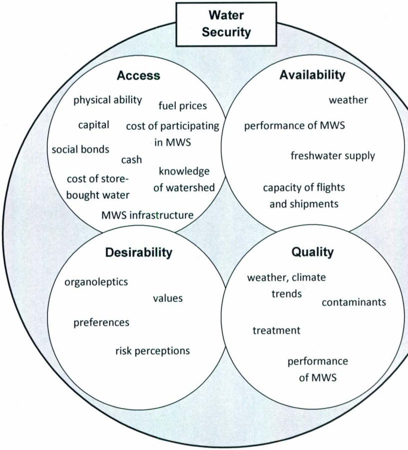

Figure 2-8. Factors contributing to water security in Rigolet and Nain.

Resident preferences for drinking water gathered from the land and store-bought water over chlorinated tap water is unsurprising when considering the physical qualities of tap water in both communities. Physical properties of tap water differ relative to the original qualities of the water source, and collection, distribution, and treatment methods. In Rigolet and Nain these properties have led to frequent BWAs and necessitate the additional use of chlorine to maintain a satisfactory free chlorine residual level throughout the distribution system, contributing to the production of excessive THMs in Rigolet. Engineering challenges in northern drinking water systems relating to permafrost distribution, the need for infrastructure technologies suitable to an extreme climate, community isolation, and a general lack of town resources all contribute to the performance of the MWS, tap water characteristics, drinking water preferences, perceptions, and ultimately the water security of residents.

Many study participants in Nain and Rigolet regard the physical quality of their tap water as substandard (31 percent felt their tap water was not "safe to drink"), and the majority (81 percent) have preferences for drinking water sources gathered from the land. These findings are consistent with drinking water perception studies conducted on the Seward Peninsula of Alaska. In a study within the communities of Shihmaref and White Mountain, Marino et al. (2009) found that the cold, remote locations of many arctic communities present a variety of engineering challenges in the installation and maintenance of centralized drinking water systems that are difficult and expensive to address. Consequently, the physical attributes of tap water (such as the colour, taste, smell, and turbidity) may be less desirable than drinking water alternatives available to the community. These characteristics contribute to personal preferences for water gathered from the land and the perception that treated water may pose a potential health threat (Marino et al. 2009).

A preference for drinking water gathered from the land and perception of its quality relative to tap water was discussed by Alessa et al. (2008b) when presenting aggregate results from a study conducted in five communities on the Seward Peninsula. Alessa et al. (2008b, 158) found that 61 percent of respondents perceived untreated drinking water sourced from a nearby river to be of "high quality", versus 18 percent who believed this water to be of "low quality". Forty-three percent of respondents perceived their municipal tap water to be of "high quality", while 42 percent perceived "medium quality", and 16 percent believed it to be of "low quality". While acknowledging that these figures are not directly comparable to findings of this study, it is notable that aggregate results from Rigolet and Nain reflect similar divergence regarding land water and tap water safety perceptions. Cumulative findings (n=118) indicate that 62 percent of participants felt untreated water gathered from the land was "safe to drink", while 3 percent felt this water was not safe to drink, 26 percent felt it was sometimes safe to drink, and 9 percent were unsure. Forty-five percent of participants felt their tap water was safe to drink, while 31 percent felt it was not safe to drink (as noted above), 12 percent felt it was sometimes safe to drink, and 13 percent were unsure.

Drinking water choice results of this study differ from those gathered during the Nunavik health survey. Reporting these results, Martin et al. (2007) state that 71 percent of

Nunavik residents consume treated drinking water delivered by tank truck, while 29 percent consume untreated water sourced from lakes, rivers, and other outdoor sources. A far less significant 42 percent of respondents from Nain and Rigolet (n=122) primarily consume treated tap water, while 22 percent primarily consume water from the land, and 36 percent consume store-bought water while in the community. It appears that the Nunavik health survey did not ask residents about store-bought water consumption, possibly accounting for part of the disparity between these findings. A second possibility is that the attributes of drinking water systems in Nunavik differ from Rigolet and Nain to the extent that the qualities of treated water are more desirable in Nunavik.

Calls for "raising residents' awareness of the risks associated with raw water consumption" voiced by Martin et al. (2007, 200) need to be assessed in conjunction with data contextualizing the attributes of community drinking water systems, drinking water preferences, perceptions, and the myriad factors shaping these perspectives. Behaviour is not determined by knowledge alone, but is shaped by perceptions, motivations, values, norms, and identity, amongst other factors (Stern 1992; Milner and Goodale 1995; Michaels 2000; Bardi and Schwartz 2003; Weber 2006; O'Brien and Wolf 2010; Frank, Eakin and López-Carr 2011). Calls for "raising awareness" regarding the risks of untreated drinking water sources fail to address questions by residents concerning the quality of their tap water and do not validate resident calls for tap water improvements. Furthermore, these initiatives fail to recognize the existence of alternative, local, and indigenous knowledge systems in arctic communities that guide drinking water behaviour.

2.8. Conclusion

Normative frameworks shaping perceptions of drinking water safety in these communities may differ from those framing western health sciences. Residents of Rigolet and Nain, for example, have time-honoured methods of determining water quality that are consistent with Labrador Inuit knowledge systems (and which are in a constant state of transformation). These systems appear to place less trust in the authority of third party knowledge (such as that of scientists) than in knowledge garnered through personal life experiences and experiences shared by respected community members and elders.

If efforts are to be made to discourage raw water consumption, they must therefore be accompanied by a recognition of the existence of equally valid and yet potentially contrasting truths concerning water "quality", as shaped by these distinctive knowledge systems. In assessing use of tap water systems by residents we need to ask how preferences and perceptions are shaped, and what values and beliefs underlie these perspectives. In the interest of water security, we need to consider how the accessibility, availability, and quality of all drinking water sources (and preferred sources in particular) can be improved.

Diverse geographies of people and place produce diverse drinking water system attributes and should inform approaches to understanding water security. The concept of a drinking water system presented in this paper provides a lens through which to view water security, grounding approaches within the contextual attributes of a community and locality. This conceptualization emphasizes water availability, access, quality, and desirability. By not presuming which water sources are desirable to users, this framework has attempted to create space for the inclusion of water knowledges and preferences existing outside the norms of the dominant water security discourse.

Residents of Nain have described diminishing water levels in their watersheds, while Goldhar, Bell, and Wolf (2011) document more advanced freshwater changes noted by Rigolet residents within the last thirty years, affecting the availability and accessibility of preferred drinking water sources, food sources, and subsistence livelihoods. Future climate variability and change will likely have significant repercussions for freshwater ecosystems in northern high latitude environments, altering habitat for aquatic wildlife, and influencing water resources relied on for human needs (Wrona et al. 2006; Bates et al. 2008; Vincent and Laybourn-Perry 2008). Current trends in freshwater availability described by residents of Labrador may continue in the future. Projections indicate reductions in stream flow by 2050 due to increases in evaporation and transpiration, despite projected increases in precipitation by 10-20 percent (Jacobs and Bell 2008). The seasonal variability of future climate and stream flow trends will greatly shape the experience of these changes for residents of Nunatsiavut, and the possible effects they may have on water security and other measurements of well-being in the region.

As climate variability and change continues to modify the spatial and temporal distribution of drinking water sources in the arctic, it has become increasingly important to identify and understand factors contributing to the water security of arctic residents. An awareness of drinking water access, availability, quality, and desirability (known as attributes of the "drinking water system" in this study) are needed to produce thoughtful, sensitive, and relevant water security research and water policy in the arctic, and across diverse communities and localities elsewhere.

Acknowledgements

This research would not have been possible without the generous support and participation of Rigolet and Nain residents. Special thanks to Tanya Pottle and Sarah Karpik for their invaluable research assistance, to study interpreters Katie Winters and Maria Dicker, and to staff at the Rigolet Inuit Community Government, the Nain Inuit Community Government, and the Nunatsiavut Government. Maxine Budgell patiently transcribed the majority of interviews used in this study and Callista Coldwell assisted with the analysis of river discharge records. Dr. Ratana Chuenpagdee and Dr. Arn Keeling provided thoughtful feedback on an earlier draft of this paper. This project was funded by ArcticNet, the IPY CAVIAR project, and INAC.

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CHAPTER 3

Vulnerability to freshwater changes in the Inuit Settlement Region of Nunatsiavut, Labrador: A case study from Rigolet

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Abstract

Residents of Nunatsiavut, Labrador report that changes in the spatial and temporal distribution of freshwater are currently challenging their ability to access preferred drinking water sources and food sources, and are exacerbating existing financial barriers that restrict their time spent on the land. Drawing on vulnerability approaches from the climate change literature, this paper explores the vulnerability of Rigolet residents to changes in freshwater. This approach emphasizes local preferences and values, considering the experiential dimensions of climate change, and draws on results from eighty-nine household interviews (88 percent response), targeted interviews, and participant observation in Rigolet. This paper argues that the exposure of arctic communities to freshwater changes and their capacity to adapt are largely shaped by the lifeways of residents and the manner and degree to which they are dependent on local freshwater ecosystems. Findings suggest that Rigolet residents are successfully adapting to existing freshwater changes in their watershed, though these adaptations have not come without sacrifice. The adaptive capacity of Rigolet residents has been supported by resource flexibility, experience-based knowledge of freshwater ecosystems, and the diversification of the local economy.

Keywords:

Freshwater
Nunatsiavut
Adaptation
Vulnerability
Inuit
Climate Change

3.1. Introduction

Observed impacts of climate variability and change on human-environment systems in the arctic are becoming increasingly well-documented. While arctic environmental systems have experienced a wide range of changes over the last 400 years (Overpeck et al. 1997), many of these changes have commenced or accelerated since the mid-1970s (Hinzman et al. 2005). Temperature changes have been both seasonally and spatially variable, with pronounced climate warming observed in the western high arctic from 1966 to 1995 (Serreze et al. 2000). Several recent changes in hydrological processes in the western arctic are associated with this warming trend. Yoshikawa and Hinzman (2003) documented reductions in surface area of subarctic lakes within discontinuous permafrost zones, and Hinzman et al. (2005) and White et al. (2007) described increasing discharge of glacial-fed rivers and decreasing discharge of non-glacial fed rivers in Alaska.

Very few studies have emerged discussing changes in hydrological processes in the eastern arctic in connection with recent climate variability and change, though residents have noted experiencing similar changes to those observed in the west. The residents of Baker Lake, Nunavut, for example, have described lowering water levels commencing in the 1960s and accelerating since the 1990s (Huntington et al. 2005). Labrador communities in Nunatsiavut have noted similar gradual drying trends over the past forty to fifty years, with more dramatic changes observed since the 1990s (Communities of Labrador et al. 2005). Minimal research attention, however, has focused on the experience of these changes or their significance in the minds of arctic residents. Beyond this narrative of change, a baseline understanding of the relationship between arctic peoples, freshwater, and freshwater systems is largely missing from the literature. This paper argues that the vulnerability of arctic communities to changes in freshwater systems is strongly influenced by the ways in which a community is dependent upon and connected with their watershed. These connections are illustrated through material relations and practices such as collecting drinking water and participating in subsistence livelihoods, in addition to less tangible connections reflected in community values, desires, and preferences. In short, the lifeways of a community strongly shape their exposure-sensitivity and adaptive capacity. A similar point was highlighted by O'Brien and Wolf when stating: "How to respond to climate change impacts depends importantly on what the effects of climate change mean to those affected. Similarly, what is considered as effective and legitimate adaptation depends on what people perceive to be worth preserving" (2010, 232).

Drawing on the vulnerability approach (e.g. Adger 2003, 2006; O'Brien et al. 2004; Füssel and Klein 2006; O'Brien and Wolf 2010), which has been widely adopted for climate change studies of northern communities (Ford and Smit 2004; Ford, Smit, and Wandel 2006; Smit, Hovelsrud, and Wandel 2008; Ford 2009; Hovelsrud and Smit 2010), this paper explores the vulnerability of Nunatsiavut communities to freshwater systems change through a case study in Rigolet. The vulnerability approach used in this study has been shaped by the Community Adaptation and Vulnerability in Arctic Regions (CAVIAR) research group (Smit, Hovelsrud, and Wandel 2008; Ford 2009; Hovelsrud and Smit 2010), developed within the human dimensions of climate change literature.

Through this lens, vulnerability is understood as "the manner and degree to which a community is susceptible to conditions that directly or indirectly affect the wellbeing [...] of the community" (Smit, Hovelsrud, and Wandel 2008, 4). Vulnerability therefore concerns the holistic concept of "well-being," which is recognized as locally or contextually defined through the perspectives of community residents. This approach has been termed "contextual vulnerability," and has been differentiated from "outcome vulnerability" in the literature (Burton et al. 2002; O'Brien et al. 2004; Füssel and Klein 2006; Ford et al. 2010). Within "contextual vulnerability" approaches, vulnerability is conceptualized as a dynamic state that is shaped by climatic conditions and the broad social, economic, environmental, and political processes that determine how climate change is experienced and which strategies are available for adaptation (Ford et al. 2010). Vulnerability is therefore not an "outcome" as described in "outcome vulnerability" but is a continuously evolving condition. The state of vulnerability is shaped by the ways in which a community is exposed and sensitive to changing conditions (exposure-sensitivity), and the ability of a community to cope with or recover from this exposure-sensitivity (adaptive capacity; Ford and Smit 2004; Smit, Hovelsrud, and Wandel 2008).

This paper aims to describe the relationship that Rigolet residents have with freshwater ecosystems in their region, and the attributes of their exposure-sensitivity and adaptive capacity to observed freshwater changes on the land. This is carried out through an analysis grounded in the experiences and understandings of Rigolet residents, relying on direct quotes derived from semi-structured interviews to illuminate the implications and significance of freshwater changes through the words of participants. Accompanying these quotes, pseudonyms have been used to identify participants in place of all names. The study was approved by the Nunatsiavut Research Advisory Committee and by the Interdisciplinary Committee on Ethics in Human Research at Memorial University.

The few freshwater studies previously completed in the region have primarily assessed the relationship between climate variability and change and drinking water quality. Harper et al. (2011) compared temporal patterns in weather, water quality, and the prevalence of infectious gastrointestinal illness (IGI) in Nain and Rigolet between 2005 and 2008. Amongst other findings, their work revealed a significant positive association between water volume input and bacteriological variables in raw water samples in Nain (Harper et al. 2011). In a study situated within the context of possible threats posed by future climate changes on drinking water quality, Martin et al. (2007) measured levels of total coliforms, *E. coli*, and enterococci in freshwater samples from locations in Nunavik where residents gather drinking water. Study findings suggest raw water from these sites is presently of "good quality" in most villages, while samples collected from individual storage containers are "more contaminated" (Martin et al. 2007). As part of a larger initiative documenting Inuit environmental observations across the Canadian Arctic, Inuit Tapiriit Kanatami (ITK) collected stories about changes in freshwater availability and drinking water from Nunatsiavut community representatives, some of which were noted earlier (Communities of Labrador et al. 2005).

Community vulnerability to freshwater changes has been investigated on the Seward Peninsula of Alaska through the use of an Arctic Water Resource Vulnerability Index

(AWRVI) developed by Alessa et al. (2008a). The index assigns a weighted, quantitative value to a set of predetermined biophysical and social indicators of vulnerability. Landscape vulnerabilities attributed through the use of the AWRVI were mapped by Alessa et al. (2008b). The vulnerability of arctic communities to freshwater changes have also been evaluated as part of broader vulnerability assessments inclusive of all observed environmental changes experienced by a community (e.g. Wesche and Armitage 2010). This is the first vulnerability study to target freshwater changes and approach vulnerability through a contextual lens in which a state of "vulnerability," or factors contributing to vulnerability are not assumed independently of study findings. Rather, the ways in which Rigolet residents are vulnerable to changes in freshwater systems have been primarily understood through their experiences and perspectives, as shared during semi-structured household interviews and informal conversations during participant observation. This is also the first study to investigate community vulnerability to freshwater change in Nunatsiavut.

This paper begins by introducing the Rigolet study site and the social, economic, and biophysical characteristics of the community and the region, in addition to the attributes of the Rigolet drinking water system. It goes on to highlight the methods of data collection and analysis used in the study. Freshwater changes experienced by Rigolet residents, the exposure-sensitivity of residents to these changes, adaptive strategies presently used, and factors contributing to the adaptive capacity of the community are then described. The vulnerability framework is used to structure an analysis of these findings within the discussion section where the current vulnerability of the community to freshwater changes is assessed. The paper concludes by summarizing key findings and reflecting on the broader significance of themes highlighted by the study.

3.2. Study area

The community of Rigolet (58°26'W, 54°11'N) is situated within the Inuit Settlement Region of Nunatsiavut on the northeastern coast of Labrador (Figure 3-1, 3-2, 3-3A). It lies within the Hamilton Inlet watershed which is fed by both the Naskaupi and Churchill Rivers that drain into the Atlantic Ocean. The community is approximately 160 km northeast of Goose Bay (the largest community in Labrador) and 324 km southwest of Nain (the largest community in Nunatsiavut). While there are no roads connecting the communities in Nunatsiavut, a ferry services the coast in summer months and flights transport goods and passengers in winter. Residents regularly travel over land through the use of snowmachines and all-terrain vehicles (ATVs) to inland hunting and fishing grounds and other communities in the region, while in summer they travel inland and along the coast through the use of motorboats (Figure 3B). Rigolet has a population of 269 people, the majority (94 percent) of whom identify as Inuit (Table 3-1; Statistics Canada 2007). Typical of many predominantly Inuit communities within the Canadian Arctic, the economy can be characterised as mixed subsistence-cash in which traditional subsistence livelihoods of hunting, fishing, and berry picking supplement income earned through waged employment (Ames 1977).

Figure 3-1. Nunatsiavut, Labrador is indicated by the shaded regions on this map and comprises Labrador Inuit Settlement Areas and Labrador Inuit Lands. Map produced by Charles Conway, Department of Geography, Memorial University, 2011.

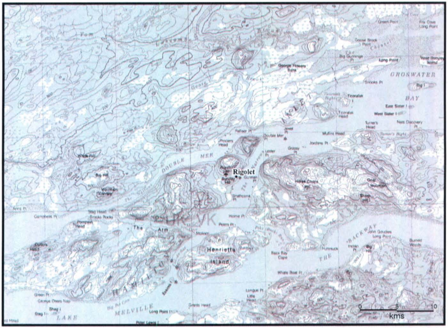


Figure 3-2. Rigolet, Nunatsiavut is situated within The Narrows which connect the saline Lake Melville with Groswater Bay. (1:250,000 cm, NTS map 13J, Rigolet)

Table 3-1. Comparison of demographic and socio-economic characteristics of Rigolet with those of Newfoundland and Labrador (NL)

Characteristic	Rigolet (%)	NL (%)
Total population	269	505,469
Female (%)	48	49
Male (%)	52	51
Population change 2001-2006 (%)	-15.1	-1.5
Age 0-14 (%)	19	16
Age 15-29 (%)	32	18
Age 30-44 (%)	23	22
Age 45-59 (%)	23	25
Age 60-74 (%)	8	14
Age 75+ (%)	2	6
Pop. Identifying as Aboriginal	94	5
Unemployment rate (%)	31.8	18.6
Mother tongue English only	98	98
English language most often spoken at home	100	98
Median income after tax $ (15 yrs+)	16,416	18,149

(Statistics Canada 2007)

Rigolet is a coastal community located in Groswater Bay, about 65 km west of where the Bay opens up into the Labrador Sea. The topography is hilly (relief in the region ranges from sea-level to about 500 m asl) and is scattered with areas of thick spruce, birch, poplar, and aspen, as well as bogs and rocky barrens covered in low-lying vegetation such as mosses, lichens, grasses, and sedges typical of tundra environments (Ames 1977; Bell 2002; Figure 3-3C). Numerous brooks, ponds, and lakes surrounding Rigolet provide habitat, nesting, and breeding grounds for various sources of country foods including brook trout (*anadlik*[11]), salmon (*kasivilik*), char (*ikkaluk*), geese (*nillik*), and black ducks (*mitirdluk*; Figure 3-3D; Ames 1977).

[11] Inuktitut names were retrieved from Brice-Bennett, Cooke, and Davis (1977).

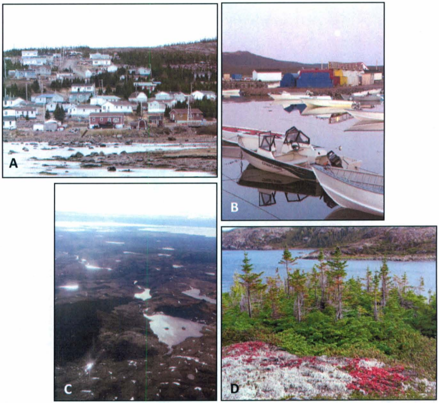
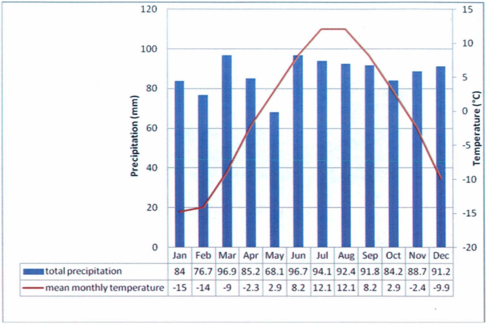


Figure 3-3.

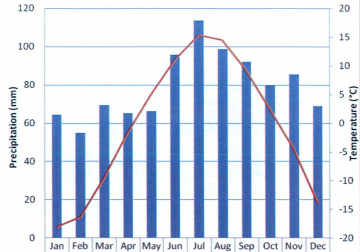
A: The community of Rigolet was originally built along the coast and more recent housing developments have extended up the hill, as seen in the background of this photo.
B: Rigolet has an active harbour with many small and medium-sized motor boats used for transportation, hunting, and fishing. The colourful gas station operated by the Rigolet Inuit Community Government (RICG) can be seen in the background of this photo (blue, red, and white tanks and building).
C: The numerous small ponds and lakes surrounding the community can be seen in this aerial view of the landscape.
D: The varied landscape surrounding the community is characterized by thick lichen and mosses typical of tundra environments, and taiga forest.

Daily average temperature and total precipitation values for the nearest climate stations – Cartwright and Goose Bay – are presented in Figures 3-4A and 3-4B. Mean annual air temperature for Cartwright and Goose Bay is -0.5 °C (Environment Canada 2010a), contributing to the persistence of isolated patches of permafrost underlying the area (Natural Resources Canada 2003). The climate of the region is classified as Dfc or "subarctic" within the Köppen climate classification system and is characterized by short, cool summers and long, cold winters (Christopherson and Byrne 2006). Rigolet is located within the Lake Melville ecoregion where the mean summer temperature is 8.5 °C and mean winter temperature is -13 °C (Bell 2002).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
total precipitation	84	76.7	96.9	85.2	68.1	96.7	94.1	92.4	91.8	84.2	88.7	91.2
mean monthly temperature	-15	-14	-9	-2.3	2.9	8.2	12.1	12.1	8.2	2.9	-2.4	-9.9

Figure 3-4A. Climate normals 1971-2000 for Cartwright (53°42'N, 57°02'W) (Environment Canada 2010a)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
total precipitation	64.6	55.1	69.6	65.4	66.2	95.8	114	98.8	92.2	80.1	85.6	69
mean monthly temperature	-18	-16	-9.6	-1.7	5.1	11	15.4	14.5	9.2	2.4	-4.5	-14

Figure 3-4B. Climate normals 1971-2000 for Goose Bay (53°19'N, 60°25'W) (Environment Canada 2010a)

Total precipitation is approximately 1000 mm per annum in the region (956.2 mm in Goose Bay and 1050 mm in Cartwright), and is seasonally variable (Figure 3-4A and 3-4B). Both Goose Bay and Cartwright display seasonal highs in precipitation during the summer months of June, July, and August (totalling 308.4 mm in Goose Bay and 283.2 mm in Cartwright) and lows during the winter months of December, January, and February (totalling 188.7 mm in Goose Bay and 251.9 mm in Cartwright). While there are no hydrometric stations located in the Hamilton Inlet watershed, river discharge records for contributing rivers are characterized by seasonal spring highs and late summer lows (Environment Canada 2010b). Linear trend lines applied to the discharge record of the Naskaupi River (Figure 3-5) indicate a long-term decline in summer flow (June-August) and a gentler decline in fall flow (September-November).

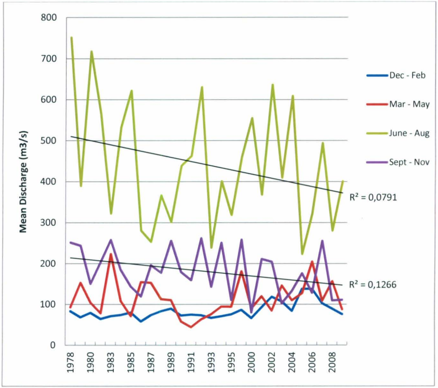


Figure 3-5. Seasonal discharge for Naskaupi River below Naskaupi Lake with linear trend lines 1978-2008: Hydrometric station 03PB002
(data retrieved from: Environment Canada 2010b)

The Rigolet drinking water system is comprised of three primary components: municipal tap water, store-bought water, and freshwater collected from the land. The municipal water system (MWS) was installed in 1988 and provides chlorinated tap water sourced from a nearby lake (Rigolet Pond) to all residents (Figure 3-6A). Store-bought water consists of bottled water or tap water filtered through a reverse-osmosis system available at the local grocery store (Figure 3-6B). Along with all other goods, bottled water is shipped into the community by sea in summer and flown in during winter months with a subsequent rise in the cost of winter goods due to flight transportation. The cost of filtered tap water remains consistent throughout the year as water is filtered onsite. Residents also source drinking water from the land, collecting freshwater from running brooks. Spending time in the region outside of community settlements is referred to as "going off on the land," or "going off," and accordingly, water gathered from running brooks is referred to as water "on the land" by residents. Water on the land is collected and consumed in the community and during land-based activities such as hunting, fishing, and "boil-ups" (daytrips on the land named for their picnic lunch, or "boil-up" involving tea and a variety of lunch foods commonly cooked over a small fire).

Figure 3-6.

A: Rigolet Pond supplies the municipal tap water system in the community.

B: Filtered tap water can be purchased in refillable bottles such as these from the Northern grocery store.

3.3. Methods

The study employed a mixed-methods approach consisting of household interviews, key informant interviews, and participant observation conducted over a five-week period in fall 2009. Rigolet was selected for this study following telephone and email conversations with the RICG and the Nunatsiavut Government initiated in October 2008, and after discussions with residents during an initial visit to the community in June 2009. During this visit, residents and the RICG expressed interest in a study that investigated the vulnerability of the community to freshwater changes observed in recent years. Resident feedback and suggestions were incorporated into the research design including the timing of fieldwork, methods of data collection, possible language considerations, and the interview guide. A research assistant from the community helped facilitate the interviews and recruit participants, provided feedback on preliminary results analysis, and acted as a community liaison and guide. As the majority of Rigolet residents primarily communicate in English (with Inuktitut comprehension levels varying throughout the community), all interviews were conducted in English with Inuktitut interpretation available to all participants.

3.3.1. Household interviews

Adult residents of Rigolet (eighteen years and older) were approached during door-to-door visits to participate in semi-structured household interviews that included a short structured component. All interested adults sharing a single residence were invited to participate in the same interview. The structured component of the interview contained questions about drinking water perceptions, source preferences, the performance of the municipal water system, and general aesthetic characteristics of tap water, store-bought water, and water collected from the land. During the remainder of the interview respondents were guided through a series of themes including perceptions of environmental changes, land-use practices, observed and anticipated freshwater changes, the implications of these changes, and adaptation responses. As a communication tool, households were asked to document observed changes in freshwater availability within the Hamilton Inlet watershed on topographic maps (1:250,000 cm) during the interviews.

Eighty-eight percent of households in the community (n=101) participated in the study. The majority of interviews were audio recorded and took place in respondents' homes, lasting between twenty minutes and two hours. A small portion of respondents preferred to not have their interview recorded and detailed notes were taken instead. Participation was voluntary and households were compensated for their time with the gift of a gas or food voucher to be redeemed in the community (as was recommended by the Nunatsiavut Research Advisory Committee).

3.3.2. Key informant interviews

A series of key informants were interviewed in all Nunatsiavut communities to contextualize the perspectives and insights offered by Rigolet residents. Respondents included community leaders working for each Inuit Community Government, municipal water workers, and a minister in the cabinet of the Nunatsiavut Government. All interviews were voluntary and audio recorded. Interview questions focused on the history of each municipal water system, existing and planned developments in the region, socio-economic characteristics of Rigolet relative to the other four communities in Nunatsiavut, and environmental and socio-economic challenges facing the community and the region.

3.3.3. Participant observation

Participation in the community helped foster trusting relationships between Rigolet residents and myself, and offered insight into the social dynamics and values of the community. I attended social functions such as a baby shower, a bachelorette party, a community dinner, a square dance, a sewing circle at the local craft shop, water gathering trips outside the community, wood collecting, and a birthday party. I also attended and observed numerous consultation sessions held with Rigolet and other Nunatsiavut communities by external parties such as Environment Canada and oil and gas multinational corporations planning to prospect in the region. Observations and reflections from these experiences were detailed in a notebook.

3.3.4. Analysis

Research analysis was an iterative process commencing in the field. Key points and emerging themes were reviewed and discussed amongst the research team and insights shaped the focus and approach of remaining research. All recorded interviews were transcribed and analyzed in conjunction with notes from participant observation and non-recorded interviews. Data were manually coded through a process inspired by "constructivist grounded theory" (Charmaz 2003, 2006; Bryant and Charmaz 2007) with final codes illustrated in Table 3-2. Descriptive statistics were used to summarize responses to a series of questions from structured household interviews.

Table 3-2. Codes used in data analysis

Category	Subcategories			
Tap water	characteristics, perceptions, preferences, collection methods, treatment, usage, access and availability	observed and anticipated seasonal and long-term changes	perceived causes, implications and adaptation response to these changes	additional observed environmental changes relating to freshwater
Water gathered from the land	*Ibid.*	*Ibid.*	*Ibid.*	*Ibid.*
Store-bought water	*Ibid.*	*Ibid.*	*Ibid.*	*Ibid.*
Boil water advisories	effects, adherence, perceived frequency and duration			

3.4. Results

3.4.1. Exposure-sensitivity

Freshwater changes experienced by community members and the exposure-sensitivity of residents to these changes (as manifest in the implications of these changes for local livelihoods and the ability to secure adequate food and water resources) are reported in this section.

3.4.1.1. Observed freshwater changes

Residents widely noted a decrease in the seasonal availability of freshwater within the Hamilton Inlet watershed. While seasonal variability and low water levels in summer are expected by residents in the region, summer water levels were reportedly lower in recent years. Forty-three percent of households described lower water levels in brooks, rivers, ponds, and wells, and in some instances the complete disappearance of ponds and brooks during summer months. Thirty-four percent of households noted no change, 24 percent were not certain, while no households reported alternative or contrasting trends in freshwater availability. Timeframes for these changes were diverse, ranging from within the last five to eight years to within the last twenty to thirty years relative to the specific source (pond, brook etc.) discussed. The following quotes represent common perceptions reported by study participants.

"There are a lot more brooks that are dried up. And there's a lot more ponds that are drying. I notice when I go out on the land to bakeapple pick, where we used to get water maybe twenty-five years ago, twenty maybe thirty years ago, the brooks there are really dried up now." -Donna

"I first started noticing about five years ago. Out around our cabin where we go in the summertime what used to be ponds are now just mud holes." -Kathy

3.4.1.2. Implications of freshwater changes

Reductions in freshwater availability have instigated an interconnected chain of implications in the community that span the numerous uses of freshwater and freshwater systems in the region. Some of these impacts are detailed below.

3.4.1.2.1. Water security

Residents reported that changes in the spatial and temporal distribution of freshwater in the Hamilton Inlet watershed are limiting the accessibility, availability, and quality of preferred drinking water sources. Seventy-eight percent of participants prefer gathering water from the land for drinking over purchasing store-bought water or consuming tap water. Seventeen percent noted that water from the land is their primary source of drinking water while in the community, whereas 78 percent primarily consume water on the land during land-based activities outside the community (Goldhar, Bell and Wolf 2011).

The majority of households have both summer and winter cabins along the coast and within the many inlets and bays surrounding Rigolet. Participants noted that water levels have decreased in brooks relied upon for drinking water at summer cabins and other areas where drinking water is sourced. While some of these sources have dried up completely, lower water levels in remaining brooks have rendered them undesirable due to the appearance of unfavourable aesthetic characteristics (such as increased opacity or brown colour due to higher sediment content), and local concerns regarding the quality of slow-moving or stagnant water on the land. Some residents noted returning home earlier than anticipated due to unforeseen difficulties obtaining suitable drinking water, while others reported consuming water they deemed to be of questionable quality as a result of water shortages (as illustrated in the following quote).

"When there's less water it's closer to the ground so it might be boggier and dirty and have more of a murky look to it. If you have ample water supply, you'll get it from a running brook which will be healthier [...] but when you have less water you start drinking it from places that are your second choice." -Sarah

In addition to "drinking *(water)* from places that are your second choice" on the land, as noted by Sarah, residents are purchasing store-bought water and filling buckets with tap water to carry with them in anticipation of low water levels (Goldhar, Bell, and Wolf 2011).

3.4.1.2.2. Food security

Waterfowl hunting grounds have been altered by a reduction of water levels in ponds along the coast, with the complete disappearance of some ponds. Ponds where geese (*nikkik*), black ducks (*mitirdluk*), blue-winged teal ducks (*hiutungiak*), and green-winged teal ducks (*sâggak*) were formerly harvested have reportedly dried up with birds moving inland to access habitat in larger ponds that have been less affected by summer water shortages. Respondents report greater difficulty successfully hunting waterfowl within larger ponds, and additional trouble accessing these new areas as they are farther from the community. Responding to these changes requires additional time and money, limiting the accessibility of hunting opportunities and reducing the amount of harvested foods entering the Rigolet food system. The following quotes illustrate some of the difficulties incurred by hunters due to the movement of waterfowl to larger ponds.

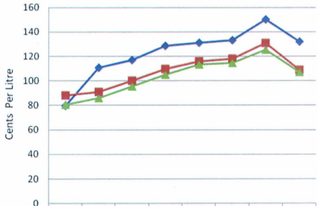
"A lot of birds are not going to places where they used to go. They used to go to certain ponds but if you walk there now there's nothing, it's all dried, hard, cracked. [...] They had to move on and find other places. [...] It makes me have to look around more. It takes more time to look around and go to where the birds are now." -Tom

"They'll go to different places where there's water. Some of the bigger ponds have water. Geese and ducks, black ducks. It makes them harder to hunt, see? When they're in big ponds they're harder to get a shot at them." -John

3.4.1.2.3. Livelihood security

Resident participation in hunting and harvesting livelihoods (known as subsistence livelihoods) has been impacted by freshwater changes in the region. Diminishing water levels have reduced the navigability of some small rivers and streams, exposing rocks and other hazards, and rendering some former routes inaccessible in late summer. These changes have influenced the safety of residents when traveling and have limited the accessibility of some former hunting grounds. Hunters are expending more fuel, time, and hunting supplies when traveling on the land, particularly when in search of waterfowl and other freshwater species due to changes affecting ponds in the region. Residents are also in need of additional cash to purchase water to carry on the land or fuel to travel to find drinking water, thus increasing the economic burden of harvesting. These changes have exacerbated the impacts of existing financial stress on subsistence livelihoods stemming from cost-of-living increases in northern communities and local increases in the cost of fuel. The cost of fuel rose 166 percent in Rigolet from 2002 to 2009 (Figure 3-7). In the following quote, Dan describes some of the costs that must be met for a two to three night summer harvesting trip on the land, and the pressures he has recently felt resulting from these escalating financial obligations.

"Gas is at almost 40-dollars a can now. When I go hunting [by motorboat] *it's almost 300-dollars a trip for two to three nights. The gas is twenty gallons of gas, maybe 120-dollars, cartridges are maybe 35-dollars to 40-dollars per box and that's not counting your food and water. [...] So when I go hunting I have to get something, bring back something to feed the family. There's no such thing as going for a joy ride now or just going hunting and not coming back with anything. You have to bring back stuff to show all the money you spent on your hunting trip."* –Dan



	2002	2003	2004	2005	2006	2007	2008	2009
Coastal Labrador North-Rigolet	79.5	110.6	117	128.7	131	133	150.2	132
Central Labrador-Goose Bay	88.2	91	100.3	110	116	118	131.2	109.2
Avalon Peninsula-St. John's	80.3	85.8	95.3	104.8	113	114.4	125.2	106.8

Figure 3-7. Automotive fuel pricing for Regular Unleaded F/S from 2002 to 2009 in Newfoundland and Labrador
(Board of Commissioners of Public Utilities 2010)

As subsistence livelihoods in Rigolet entail the hunt and harvest of foods from the land, challenges threatening the viability of these livelihoods necessarily affect food security in the community. Water security is also directly affected as residents commonly gather drinking water from the land for consumption in the community at the end of a hunting trip. Water (much like wood) is also gathered just outside community boundaries and may constitute the sole purpose of a trip. The financial implications of freshwater availability trends in the region also affect water security as cash is needed to purchase fuel to collect water or to purchase drinking water from the store. A reduction of cash resources in the community limits the variety of drinking water sources available to residents and diminishes access to preferred sources.

The following figure illustrates some of the many links connecting implications of decreasing water levels in the Hamilton Inlet watershed noted above. Despite the linear representation in Figure 3-8, these changes are embedded within a complex, coupled, non-linear social-ecological system characterized by feedbacks and discontinuous change (e.g. Holling 1973).

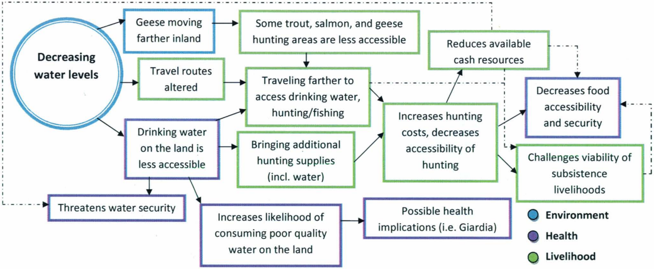


Figure 3-8. Environmental, health, and livelihood implications of decreasing surface water availability for Rigolet residents. This figure summarizes some of the implications of decreasing water levels in the region over the past twenty to thirty years, as described by study participants. Solid lines indicate a direct causal relationship, while broken lines indicate an indirect relationship.

3.4.2. Adaptive capacity

The following section discusses factors contributing to the adaptive capacity of Rigolet residents, adaptive strategies currently used by residents, and barriers restricting access to these strategies.

3.4.2.1. Experience with freshwater change

Within sub-arctic temperate regions such as Labrador, seasonal changes in precipitation, evapo-transpiration, and temperature lead to predictable water level variations characterized by summer lows and spring highs (Figure 3-5). As residents spend significant time on the land throughout the year– up to thirty weeks in the last year and 5.8 weeks on average for all households– and regularly navigate rivers, gather water from brooks and wells, fish and hunt waterfowl and other freshwater species, they are familiar with fluctuations in freshwater availability and have experience adapting to water shortages. Over time, this experience contributes to the confidence and mental preparedness of residents when faced with new water conditions, heightens their ability to recognize potentially harmful long-term trends in water availability, and supports their capacity to adapt to long-term changes in freshwater availability.

Furthermore, the practice of gathering drinking water from the land may contribute to household knowledge of seasonal water attributes (such as water levels) and long-term changes in freshwater. Even though a MWS is installed in Rigolet, dissatisfaction with tap water characteristics and a preference for water from the land has encouraged many residents to maintain long-established water gathering practices. As mentioned earlier, sixteen percent of households reported gathering the majority of their drinking water from the land while in the community, despite the availability of tap water in all homes (Goldhar, Bell, and Wolf 2011). When asked about freshwater changes observed in the region, residents commonly suggested the question should be directed to the household member in charge of collecting water from the land, and the individual most involved in land-based activities. Households spending minimal time on the land (less than one week per year) and those who primarily consume tap water and store-bought water seldom had observations to offer regarding freshwater qualities.

"I haven't collected the water on the land myself in many years so I wouldn't be able to tell you about the water." -Elsie

"To tell you the truth I don't even go to the brook because Ken usually goes and brings back the water. So I don't know if I'm the best one to answer those questions." -Mary

3.4.2.2. Adaptation strategies and barriers

Many households described a need to bring water from the community with them on the land in response to water shortages, packing water as they would sugar, tea, and additional supplies. Community water is brought onto the land in small quantities as a precautionary measure to avoid thirst when land resources are unexpectedly short, and by some households in quantities intended to sustain an entire trip on the land with the expectation that no appropriate drinking water sources will be found.

"People still go to the same places that they used to go when we were kids but I think more people have to be aware. [...] You have to be prepared and take water with you in case when you go there you can't find water when you need it, because you can't find the brook you knew was there before. It was there but it's dried up now." –Mandy

The availability of diverse drinking water sources in the community including store-bought water and municipal tap water, enhances resilience as the water security of residents is not solely dependent on the quality and quantity of freshwater available in their immediate environment.

Access to store-bought water, however, is not equally distributed throughout the community due to significant cost barriers. A case of twelve 500 ml bottles of bottled water sold for $14.28 in Rigolet and $9.99 in Goose Bay in summer 2009. This price differential is amplified further in winter and is consistent with differences in the cost of food in Rigolet relative to less remote communities such as Goose Bay, largely stemming from the added cost of transportation. Indian and Northern Affairs Canada found the weekly cost of the "Revised Northern Food Basket" for a family of four in Rigolet was 123 percent that in Goose Bay in 2009 (Indian and Northern Affairs Canada 2010). Many households that purchase bottled water noted taking their motor boat or the ferry to Goose Bay to stock up on cases while shopping for other goods. While the cost of filtered tap water is less than bottled water at the grocery store (water bottles may be purchased in sizes up to 18.8 L with refills for this size priced at $6.99), this option remains out of reach for households with limited means. Access to this source is also limited by the frequency of boil water advisories (BWAs) in the community as the grocery store does not sell filtered tap water during a BWA.

"Everyone drinks water eh? But a lot of them can't afford food let alone water." -Mike

As not all drinking water sources are considered equal by participants (with water gathered from the land preferred over other sources), it is clear they do not function as equivalent substitutes for each other when access to one source is compromised. Consumption of tap water, bottled water, or filtered tap water in place of water gathered from the land represents a decrease in water quality in the minds of those residents that prefer land water. While this adaptation strategy may result in an adequate quantity of clean water being accessed (thereby supporting some aspects of water security), it does not come without sacrifice for residents with strong preferences for non-chlorinated water sources, or who value maintaining water-gathering practices on the land. Regarding a dislike of tap water and illustrating the need to substitute preferred drinking water sources for less desirable alternatives when access is limited, Paula states:

"I don't drink that. Unless it was an emergency I will drink a glass then- if I had no water here and the store was closed and I couldn't get up to the brook. Well, then I'll sip on a little bit. Mostly if I have to use that water I'll boil it first." -Paula

Another adaptation strategy described by households involves the use of a motor boat or ATV to travel on the land in search of a brook or river with an adequate supply of freshwater. Similarly, residents like Alice (below) described traveling farther inland past dry ponds that were formerly used to hunt geese in search of new hunting grounds.

"We have to walk more, and then of course you check the pond and see if there's feathers there. If there are no feathers there then obviously the birds are not visiting the pond (or the lack of a pond). So we would normally just go to another area and check out more ponds, and check out another area, and check out another area, until we find feathers so we know that birds must be flying in." - Alice

Access to this option is restricted by the need for suitable weather conditions, knowledge of the surrounding land, time, and additional fuel. When weather conditions are favourable and resources are available, households in search of ponds or drinking water reported they "always manage to find some water."

3.5. Discussion

The following section discusses the existing and future vulnerability of Rigolet residents to freshwater changes in their watershed in the context of the climate change vulnerability literature.

3.5.1. Existing vulnerability

Rigolet residents have reported that diminishing water levels of surface water bodies within the Hamilton Inlet watershed have brought about a broad range of challenges for the community. These exposure-sensitivities have been successfully met with adaptive strategies by many participants, though these adaptations require additional time and money to access. By way of summary, Figure 3-9 provides an illustration of some of the relationships linking observed environmental changes with existing vulnerability in Rigolet, as discussed above.

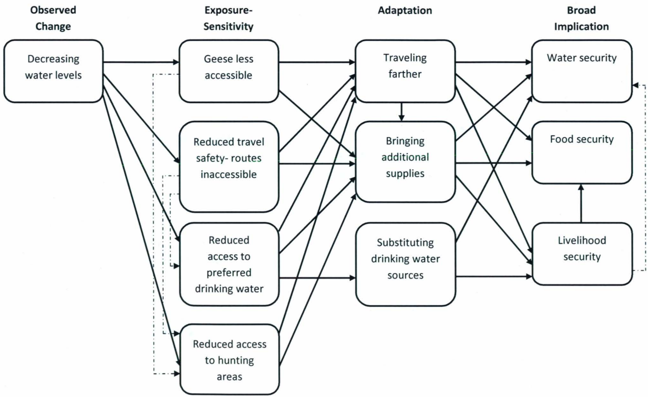


Figure 3-9. Selected relationships illustrating the connections between observed changes in water levels and existing vulnerability in Rigolet. Solid lines indicate a direct causal relationship while broken lines indicate an indirect relationship.

In Rigolet, vulnerability to freshwater change is determined by access to financial resources, experienced-based knowledge of freshwater systems, and a variety of lifestyle and livelihood characteristics. These characteristics can include: water and food sources, travel routes, cabin locations, the location of hunting and fishing grounds, and the general degree of household dependency on local freshwater systems. The positive influence of resource flexibility, economic diversity, and land-based or experience-based environmental knowledge on adaptive capacity have been well documented within the arctic vulnerability literature (Berkes and Jolly 2002; Ford, Smit, and Wandel 2006; Ford et al. 2008; Pearce et al. 2010; Wesche and Armitage 2010).

Gathering water from the land for drinking and relying on freshwater systems for foods and transportation familiarizes residents with the dynamic characteristics of the local watershed. These experiences present situations where residents have to utilize adaptive strategies in response to seasonal water shortages, heighten the ability of residents to recognize potentially harmful long-term trends in water availability, and strengthen the capacity of the community to adapt to future changes.

Simultaneously, these lifestyle and livelihood activities enhance exposure-sensitivity to changes in freshwater regimes. A household is less sensitive to local freshwater changes when it relies less on the immediate environment by primarily consuming store foods and bottled water, and pursuing a livelihood that is largely disconnected from locally available resources. The diverse lifestyle and livelihood options available in Rigolet including subsistence and waged employment, harvested and store-bought foods, and various drinking water alternatives thus reduce the overall vulnerability of the community to freshwater systems change.

As not all households are equally exposed to freshwater changes, and not all those exposed have equivalent means to adapt, vulnerability is socially differentiated in Rigolet. This finding is consistent with much of the climate change vulnerability literature, and is highlighted by Adger: "…virtually all climate change differentially affects different groups in society depending on their ability to cope" (2003, 33). As not all residents have equal access to cash in the community, adaptive strategies requiring capital or cash resources are more readily attained by some sectors of the population over others. While the role of social networks, food sharing, and trade in supporting individual and household ability to cope with stresses affecting community food security and livelihoods have been established in the arctic literature (Ford, Smit, and Wandel 2006; Ford et al. 2008; Wenzel 2009; Goldhar and Ford 2010; Pearce et al. 2010), these findings did not emerge within the Rigolet case study[12]. As these practices were not specifically targeted in the study, lack of evidence in this area may reflect the direction of interview questions rather than community practices.

Rigolet residents commonly noted substituting alternative water sources such as tap water and bottled water for preferred sources on the land, and gathering water from new locations in the region. Similar substitutions have been discussed by Wenzel (2009) who

[12] Similar findings did, however, emerge within the Nain case study with regards to water security and are discussed in Goldhar, Bell, and Wolf 2011.

highlights the role of species substitution in supporting Inuit subsistence during historic shifts in animal availability. Wenzel goes on to stress the importance of ensuring institutional and political controls governing the hunt and harvest of wildlife do not inhibit the ability of Inuit to adapt to changing conditions. Unlike wildlife, there are no government regulations restricting the collection of water, though as changes in freshwater ecosystems necessarily impact waterfowl, fish, and other animals of value within the Rigolet food system, species substitution may become an important adaptation in future. Freshwater changes are also occurring in connection with a variety of additional environmental changes (such as changes in weather, animal availability, and the health and abundance of plant species including berries; Communities of Labrador et al. 2005) that affect the general well-being of residents and constitute additional stresses they are simultaneously coping with.

Adaptive strategies currently used to cope with these changes in Rigolet occur at the household and individual scale and were generally reactive, though previous need for adaptive strategies in response to seasonal and long-term trends in water availability have inspired some proactive adaptations in anticipation of future trends. Strategies such as bringing extra provisions on the land (including water, fuel, and hunting supplies) are examples of adaptations that have been used in response to known changes in certain regions surrounding Rigolet, and as precautionary measures when traveling to less familiar areas. Reactive adaptation strategies at the individual and household scale in response to the implications of climate variability and change are prevalent within vulnerability case studies in arctic communities (e.g. Andrachuk and Pearce 2010; Pearce et al. 2010; Wesche and Armitage 2010).

Existing changes in freshwater availability threaten food security, water security, and the viability of subsistence livelihoods in the region, though broadly speaking, Rigolet residents are thriving in the presence of environmental change. The majority of households not only have a strong capacity to adapt to existing exposure-sensitivities, they are successfully utilizing adaptation strategies at present, though this resilience has not come without compromise and sacrifice. This finding is consistent with the reality that northern peoples have experienced a high degree of natural climate variability and environmental change for the last 4,000 years, demonstrating significant adaptability (Brody 1987; Sabo 1991; McGhee 1996; Berkes and Jolly 2002); though it contrasts media depictions of Inuit as vulnerable victims of climate change.

3.5.2. Future vulnerability

The question remains as to whether residents will have the capacity to adapt to future exposure-sensitivities stemming from projected trends in freshwater availability in the Hamilton Inlet watershed, in the context of future climate variability and change. Similar to existing vulnerability, this will depend on the nature of these changes, and the characteristics of resident relationships with and use of freshwater as influenced by lifestyle, livelihoods, and personal preferences. The ability to recognize these trends and establish appropriate adaptive strategies, and the accessibility of these strategies as determined by the socio-economic resources of the community, and the flexibility of government regulations and institutional structures are also important factors shaping future adaptive capacity (Ford, Smit, and Wandel 2006; Wenzel 2009).

Many residents noted an expectation that changes in freshwater availability on the land will continue in future, and that this trend will have negative implications for Rigolet residents and environmental systems in the region.

"I think we're only at the beginning of it now but what's going to happen in another ten years? It's definitely going to disrupt people's lives. Probably make country food harder to get, harder to hunt and fish." -Dan

Others view freshwater changes in the context of additional changes they have observed in climate, animals, berries, and sea- ice, often with a sense of fear regarding the future implications of these changes.

"I told my wife I think I'm going to move further north because it's starting to warm up. [...] We're not getting any really cold weather here now, no snow, and you can see the water receding, no water in the ponds. I think that we're in for a big culture shock because of the temperatures and losing our water, and losing our sea ice." -Tom

"Climate change," or "global warming" was frequently noted to be the cause of these observations, implying these changes are perceived to be local manifestations of global-scale phenomena that Rigolet residents have minimal power to mitigate. Future change is thus regarded as "inevitable" by some, with residents conveying an expectation of future unforeseen changes. This perspective may contribute to the mental preparedness of residents when responding to future exposure-sensitivities, thus strengthening the capacity to adapt and lessening the future vulnerability of the community to risks associated with these changes.

"Everything is changing. Things aren't the way they were even when I was younger. Things are just so different now that I'm sure it's inevitable that everything else will change as well." -Mary

3.6. Conclusion

Residents of Rigolet are currently experiencing variations in freshwater availability that mirror the implications of climate trends observed in the western arctic. These changes are challenging the ability of residents to access preferred drinking water sources, and are exacerbating existing financial barriers restricting the accessibility of hunting, fishing, and spending time on the land. This paper argues that practices shaping resident relations with local freshwater ecosystems contribute to community vulnerability, and must be understood through the lens of local values, preferences, and understandings. While residents may consume a variety of drinking water sources in the community, these sources are each regarded as distinct and many residents have strong opinions concerning the suitability of some of these sources for drinking water purposes. Despite these distinctions, residents are substituting drinking water from sources (such as tap water or bottled water) that they deem to be less desirable as a result of limited access to preferred sources on the land (Goldhar, Bell, and Wolf 2011). The availability of store-bought water and tap water thus offer a valuable alternative when water gathered from the land is difficult to access. Bottled water supports community water security in the context of local freshwater change by providing drinking water sourced outside the immediate watershed.

Similarly, the various modes of production in the community including waged employment and subsistence livelihoods, with many individuals participating in both the waged and subsistence sectors of the economy, helps buffer the economy and strengthens the ability of residents to successfully adapt to observed changes. This is illustrated in Rigolet by the use of additional fuel or bottled water by casual hunters with cash income to adapt to drinking water shortages, and the ability of subsistence hunters to draw on their extensive knowledge of the watershed to locate new geese hunting ponds when water levels in former hunting areas are low.

The flexibility of Rigolet residents, their experienced-based knowledge of freshwater ecosystems, and the diversification of the local economy to include a variety of employment possibilities, sources of food, and drinking water all strengthen the capacity of the community to adapt to changing freshwater regimes. In the context of these sweeping social and environmental processes of change, it is especially important that arctic residents have the power and freedom needed to guide their own adaptation, selecting desirable adaptation strategies and approaches in response to climate variability and change.

Acknowledgements

This research would not have been possible without the generous support and participation of Rigolet residents. Special thanks to Tanya Pottle for her invaluable research assistance, and to staff at the Rigolet Inuit Community Government, and the Nunatsiavut Government. Dr. Ratana Chuenpagdee provided thoughtful feedback on an earlier draft of this paper. Maxine Budgell patiently transcribed the majority of interviews used in this study and Callista Coldwell assisted with the analysis of river discharge records. This project was funded by ArcticNet and the IPY CAVIAR project.

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CHAPTER 4

Conclusion

4.1. Summary

The primary aim of this thesis is to contribute to existing understanding of the relationship between Nunatsiavut residents and freshwater ecosystems through case studies in Rigolet and Nain, situated within the context of freshwater changes experienced in the region. More specifically, this project aims to characterize the vulnerability of residents to changing freshwater ecosystems, drawing on the Community Adaptation and Vulnerability in Arctic Regions (CAVIAR) research methodology (e.g. Smit, Hovelsrud, and Wandel, 2008). The CAVIAR methodology was developed within the human dimensions of climate change field, and emphasizes a "contextual" approach to understanding vulnerability (also termed "second-generation" or "social vulnerability"), and is contrasted with "impacts-driven", "first-generation", or "outcome vulnerability" in the literature (O'Brien et al. 2004, 2007; Eakin and Luers 2006; Füssel and Klein 2006; Ford et al. 2010). As a contextual approach, vulnerability is conceptualized as a dynamic condition that is informed by determinants at multiple spatial and temporal scales including both climatic and non-climatic conditions. As identified in Chapter 1, vulnerability is understood to be a function of one's exposure and sensitivity to a certain stimulus at a certain time (in this case the stimulus in question is freshwater ecosystem changes within Nunatsiavut watersheds), and capacity to adapt to this exposure-sensitivity. In addition to the CAVIAR framework, this study has been influenced by the "values-based" approach to vulnerability described by O'Brien and Wolf (2010), and the thoughtful insights of O'Brien et al. (2004, 6) that convey the general lack of consideration within climate vulnerability studies for "…local perceptions and contexts that define 'quality of life' and well being". In light of these perspectives, this study has attempted to consider vulnerability through a locally-grounded approach that emphasises perceptions and values, highlighting the experiential dimensions of freshwater change.

As a necessary first step to understanding the vulnerability of Nunatsiavut to freshwater changes, the first objective was to describe the Rigolet and Nain drinking water systems, resident drinking water preferences, perceptions, and patterns of consumption. This objective was addressed in Chapter 2. Findings revealed drinking water system attributes, drinking water preferences, perceptions, and general water security characteristics that are constituted by the unique social, physical, and historical geographies of Nain and Rigolet. These outcomes were framed through the conceptual model of the "drinking water system" illustrated in Chapter 2. This conceptualization compliments existing water security approaches that typically emphasize drinking water access, availability, and quality, by introducing the element of desirability. The desirability of drinking water sources is understood to encompass aspects of preference, perception, and value.

The majority of participants in semi-structured household interviews in both Nain and Rigolet expressed a preference for drinking water gathered from sources on the land over tap water or store-bought water available in the community. Findings suggest preferences are shaped by the aesthetic qualities of water (such as colour, taste, smell, and turbidity), risk perceptions, values, norms, and to a lesser extent, convenience.

Access to a sufficient quantity of desirable, clean drinking water was found to be compromised for some residents. In Nain and Rigolet, water security is supported by a variety of dynamic inter-related factors and processes at the individual, household, and community scale. Some of these factors include: the seasonal availability of water within local watersheds, the prevalence of contaminants in drinking water, access to cash or capital such as a vehicle, the physical ability of individuals or households to collect and carry water, and the cost of fuel, municipal taxes, and store-bought water.

The second objective was to identify the ways in which Nunatsiavut residents are affected by and sensitive to changing freshwater conditions. This objective sought to describe the exposure-sensitivity of residents to observed freshwater changes in their watershed. The second objective was addressed through findings from the Rigolet case study presented in Chapter 3. Participants noted decreases in the seasonal availability of freshwater in their watershed, confirming observations noted in previous studies (e.g. Communities of Labrador et al. 2005). These changes are affecting the ability of residents to access preferred drinking water sources during land-based activities outside the community, and are affecting the harvest of geese and other waterfowl. Water levels in ponds that formerly provided habitat for these species have dropped and birds have moved to larger ponds and water bodies located farther inland. As additional time, fuel, and hunting supplies are now needed to locate desirable drinking water sources and successfully hunt waterfowl, these changes have economic consequences that are exacerbating existing financial stresses on subsistence livelihoods. Changes in the seasonal availability of freshwater are affecting water security, food security, and the accessibility and viability of subsistence livelihoods in Rigolet.

The third objective was to determine the ways in which residents are adapting to these changing conditions. Rigolet residents noted consuming less desirable (second-choice) sources of drinking water in response to shortages of water on the land. They described filling buckets with tap water or purchasing large bottles of water from the store in preparation for land-based activities in areas where freshwater supplies have been limited in recent years. Some noted bringing water as a precautionary measure when traveling to new regions, or areas they are less familiar with. Others noted traveling farther (often by boat as most shortages were reported in summer) in search of reliable freshwater sources or new ponds to hunt waterfowl.

Relating closely to the third objective, the fourth objective was to establish what factors enhance or obstruct community adaptability to changing freshwater conditions. Barriers restricting access to adaptive strategies presently used by Rigolet residents relate closely to the costs of each strategy. Supporting the findings of previous vulnerability assessments discussed in the literature (e.g. Adger 2003; Ford et al. 2006, 2008), vulnerability was found to be socially differentiated in Rigolet. As the predominant adaptation strategies used by residents in response to changes in freshwater availability demand time (in search of new waterfowl hunting sites and new sources of drinking water) and money (to purchase fuel, store-bought water, and additional hunting supplies), these options are not available to all residents. The ability of residents to successfully locate new hunting spots or drinking water sources is additionally dependent on fair weather and is supported by knowledge of the surrounding land, animal populations, and freshwater sources. This knowledge is developed through subsistence-based livelihoods, recreational time spent on the land, and wisdom shared by elders and other community members.

Past experience adapting to seasonal changes in freshwater availability further strengthens adaptive capacity. While it seems intuitive that social bonds (relations with family and friends) would support access to these adaptive strategies and build adaptive capacity, there was no explicit discussion of this theme during interviews in Rigolet, and it did not emerge as a significant theme during participant observation in the community. By contrast, social bonds did emerge in findings from Nain where reliance on family and friends was highlighted as a factor supporting water security.

Capacity to adapt to freshwater changes is enhanced by the existence of diverse drinking water alternatives and food sources in the community, as well as the variety of possible livelihoods (characteristic of a "diverse-economy" or a "mixed subsistence-cash economy"). Intimate relations with local freshwater sources and freshwater ecosystems were found to enhance the exposure-sensitivity of households to changing conditions while simultaneously nurturing adaptive capacity. Findings thereby suggest that the existence of a "diverse economy" in Rigolet diminishes vulnerability to freshwater changes (and by extension environmental change).

4.2. Critical reflections, limitations, and emerging questions

4.2.1. Data

Some limitations to this thesis stem from a lack of physical climate data in the region. Precipitation is a very localized phenomenon and the lack of a meteorological station in Rigolet with a record of sufficient length to discern climate normals meant that an explicit discussion of past precipitation trends was not possible. Projected future changes in connection with climate variability and change were not discussed as there are presently no downscaled scenarios available. Finally, as there are no discharge records for any rivers in the Hamilton Inlet watershed, data was used from rivers contributing to the watershed, providing a less certain depiction of local water availability.

Observations of diminishing trends in freshwater availability may have been overestimated by respondents due to the timing of the study. As the most dramatic changes have been observed in late summer, conducting interviews in September while water levels were at their annual minimum may have presented a recall bias, exaggerating resident perceptions of these changes. It is also possible that negative tap water descriptions and relating issues have been overstated due to the existence of the study. Some respondents questioned whether the research was being conducted in response to previously established concerns with their tap water system that they were unaware of.

As no explicit intention was made to reflect community demographic characteristics within the Nain and Rigolet structured interview samples, the gender and age composition of study participants was skewed in some categories. Generally speaking, women were overrepresented in this portion of the study, as were older generations (particularly the forty-five to fifty-nine age grouping). Consequently, no attempt has been made to scale up findings to represent either community as a whole. These considerations are discussed at greater length in Chapter 2.

4.2.2. Methodology

During the research process I was conscious of the degree to which the conceptual framework I was drawing from (the vulnerability framework) was effectively producing the story that was emerging from this work. I am concerned that the lens is overly deterministic and that a less rigid framework drawn from diverse influences (perhaps drawing on multiple bodies of literature or multiple frameworks) may have produced a storyline more intimately grounded within the experiences of freshwater change in Nunatsiavut. Perhaps a storyline would have emerged that challenged the findings of previous case studies in the literature.

In the context of constant change, Inuit are raised to expect the unexpected (Briggs 1991), and yet they have been characterized as "vulnerable" in the face of recent climate variability and change within the climate change discourse. What factors contribute to this characterization of "vulnerability" and to what extent are they produced by the discourse itself? Is it possible to hear local voices through a universal framework embedded in a global discourse? Or as Cruickshank (2009, 47) has contemplated: "are there ways of speaking about global issues such as climate change that accord weight to culturally specific understandings as well as to universalizing frameworks of science?". I have attempted to ameliorate these concerns by drawing on the "values-based" approach to vulnerability discussed earlier, and through a focus on perceptions and preferences of water—though preferences and perceptions are poor substitutes for an understanding of the worlds lived by study participants that may be developed through ethnography and a (slower), longer field season.

Other methodological concerns stem from the "community-based" approach drawn on in this thesis and common in the discourse. While "community-based" approaches are consciously reflective of the power relations embodied in research production, they fail to create adequate space for aboriginal knowledges in practice. Consistent with all research, the assumptions and norms of modern science filter and translate respondent stories, meanings and understandings, effectively constructing knowledge that is communicated. Modern world views (and conceptual frameworks) constitute the ways in which aboriginal knowledge, thoughts and needs are represented in the discourse (e.g. Martello 2008). In an attempt to provide a more direct vehicle for the voices of participants, findings are commonly supported by the heavy use of direct quotes (as I have done in Chapter 2 and Chapter 3), though it is ultimately the writer, research team, and journal editor who decide which quotes effectively support the author's argument, and how best to frame and interpret them. It is the researcher and the broader scientific community who define what is and is not deemed relevant and valid knowledge (Cruickshank 2009; Nadasdy 2009). By labelling this work "community-based", victory is claimed; there is an implied assumption that the research process has been democratized and aboriginal knowledge and science have been integrated. I am not certain whether either of these goals are achievable in an absolute sense and the use of these terms conceals existing limitations and remaining questions.

Concepts and frameworks such as "vulnerability", presently ubiquitous within the human dimensions of climate change literature, presume a need for outsider intervention, expert knowledge, and assistance from government and the scientific community to facilitate community preparedness in the face of global environmental change. The concept of "capacity-building" has become a recent buzz word and efforts to build community "capacity" through economic development projects or public education initiatives render research more desirable to funders. Current ethical norms in northern research contribute to the motivation of these initiatives by emphasizing the importance of "empowering" Inuit in the research process and ensuring arctic residents are directly benefitting from research in their communities. While self-conscious efforts to democratize the research process in the north and open the eyes and ears of researchers to ethical expectations are highly important, the language of development presently framing these directions is disconcerting. The potential harms of exogenous development are well-articulated within the critical development studies literature (e.g. Ferguson 1990; Escobar 1995; Blaser, Feit and McRae 2004), though little discussion has emerged identifying the problematic nature of intentionally shaping arctic research as a tool for development or the paternalism underlying these directions.

4.3. Respondent feedback and recommendations

Many study participants offered suggestions regarding the provision of drinking water in their community and areas in need of future research. These contributions are summarized below.

i. Community residents desired more effective communication strategies on behalf of the Inuit Community Governments of Rigolet and Nain regarding BWAs. Participants asked that notices contain a detailed description of the cause of each BWA, thereby increasing awareness of the general functioning and performance of their MWS, and informing decisions when choosing water treatment methods and selecting water sources. Presently, most postings note the category of BWA (such as "D1: water distribution system undergoing maintenance or repairs"), but do not offer further detail regarding cause.

ii. BWA postings are often unnoticed on crowded billboards, and are missed by residents that do not frequent locations where they are posted or listen to the radio. Residents suggested a variety of new BWA communication strategies including: hiring someone to drop off BWA notices to each household and placing additional notices in the mailboxes of residents, selecting a daily time when community announcements are made on the radio so non-radio listeners know when to turn their radios on, and setting up a phone call network that is used when BWAs are issued. The network may begin with each town counsellor calling a list of ten families, these families then notify ten additional families, and so on. A network like this is presently used by some residents in Nain to communicate BWAs among family. As not all residents have well-developed social networks (particularly in the larger community of Nain), "word-of-mouth" is not a reliable communication strategy. The need to place greater emphasis on direct communication by the Inuit Community Government was emphasized by residents in both communities.

iii. Residents asked that equal care be given to communicating both the beginning and the end of each BWA. A lack of awareness that BWAs are over contributes to the sense that BWAs are "always" in place in the community, lessens trust in the MWS, and diminishes the motivation of residents to adhere to these advisories.

iv. Many residents strongly voiced a preference for non-chlorinated tap water. Alternative means of disinfection (such as ultraviolet) would be preferable to these residents and would likely improve the perceived safety of tap water in the community.

v. Residents of Rigolet requested that the community locate a new tap water source that would diminish the need for large amounts of chlorine, reduce THM concentrations, and minimize unfavourable aesthetic characteristics (such as discolouration). These participants felt locating a new source would also amend fears in the community regarding the potential implications of past uses of Rigolet Pond on tap water safety.

vi. Recognizing that existing water system infrastructure is prone to pipe freezing and leaks, some residents of Nain suggested modifying the design of the municipal water system. Suggestions included: moving water pipes above ground (thereby enhancing the accessibility of the system for maintenance and reducing the vulnerability of piping to the effects of freeze-thaw cycles in years with minimal snow insulation), installing heat tape along the distribution line as is done in other northern communities, and using a water delivery system whereby water is trucked to each household and stored in water tanks.

vii. Given the unfavourable physical qualities of tap water in Rigolet, some participants requested a subsidy that would reduce the cost of filtered tap water presently sold at the store, or coupons that would allow this water to be collected free of cost.

viii. Some participants in Nain discussed the expectation that residents pay for construction costs associated with connecting their home to the water distribution system. In Nain, there are homes without running water due to the inability of residents to afford this payment. Other respondents in Nain described needing support to fix previously frozen water pipes in their homes that are preventing them from using the MWS. These participants requested financial support to assist them with these costs.

ix. Residents of Rigolet voiced concern regarding the implications of the Upper Churchill Dam (constructed in 1971) on water availability within the Hamilton Inlet watershed, biodiversity in the Lake Melville estuary, tides in the Groswater Bay area, and the general ecosystem health of the region. They requested research addressing the biophysical changes that ensued following the construction of the Upper Churchill Dam, and a second project identifying the projected biophysical impacts of the Lower Churchill Dam on the ecosystems in region.

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APPENDIX I

Drinking Water Systems in Nunatsiavut

Hello! My name is Christina Goldhar, I am a student in the Department of Geography at Memorial University.

I am in Nunatsiavut to discuss a research project about drinking water and how changes in the environment and community might affect water resources.

I look forward to meeting with you, hearing your opinions, and working with you.

THANK YOU for hosting me in your community.

Contact Me

416-724-7628

christina.goldhar@mun.ca

ArcticNet

APPENDIX II

Imituinnamik imipviusot Nunatsiavummi

Hello! Atiga My name is Christina Goldhar, Ilinniavunga SuliaKapvingani Geography Memorial University ilinniavitsuangani.

Nunatsiavummivunga uKâlautiKagiattulunga Kaujisannimik Kanuk inuit isumaKammangâta imigiamik imituinnamik, ammalu Kanuk silak asianguvalliamangât attuiniKagajattuk imijauKattajunik nunagijaujunni.

Ilitsinut katimaKataugumavunga, tusâllusi isumagijasi, ammalu suliaKaKatigellusi.

NAKUMMEK tujummititaunginama nunagijanni.

KaujisapvigigunnaKamma maunga
1-416-724-7628
christina.goldhar@mun.ca

ArcticNet
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APPENDIX III

Semi-Structured Interview Guide
Assessing the vulnerability of drinking water systems in Nunatsiavut, Labrador

This study proposes to investigate the current status of drinking water systems in Nunatsiavut communities, focusing specifically on freshwater supply, demand and access. The study will further explore the vulnerability of drinking water systems in Nunatsiavut to socio-economic and environmental changes such as economic development, population growth and climate change. The vulnerability of drinking water systems in all Nunatsiavut communities will be assessed through a review of relevant data and literature while a more in-depth study was conducted in Rigolet, and is proposed for Nain. The following is a draft of a possible interview guide involving a series of voice-recorded, semi-structured interviews with households in the community. As interviews will be semi-structured the questions below are meant to be used as a guide only- topics may be discussed in an alternative order and discussion will follow associations made by the respondent. A single household representative will be asked to respond to structured questions within the "Demographic/Background" section, in addition to fixed choice questions regarding drinking water preferences and risk perceptions.

Themes-

Water preferences
Water consumption
Water on the land
Water sources
Water in the community
Water availability
Water access

A. **DEMOGRAPHIC/BACKGROUND** *-this information will allow an analysis of responses by demographic grouping and an understanding of the context within which the respondent's perspectives and experiences were formed*

1. Can you tell me a little bit about yourself? (ie. occupation, birthplace, children, household members etc., skip questions below as necessary if answers are given here)
2. Gender
3. What year were you born?
4. How long have you lived in this community?
5. If respondent has lived elsewhere: Where have you lived before?

6. How many people are there in your household? How many children/adults?
7. What do you do for a living? (full-time, part-time or seasonal wage work, retired, homekeeper, student, unemployed (seeking waged work), hunter/fisher full-time, hunter-fisher part-time, hunter-fisher casual/weekends, other)
8. Do you ever get out onto the land, hunting, fishing or to a cabin? If yes: How many weeks would you say you are on the land per year?
9. Do you ever spend time outside of the community for other reasons? (ie. travel, visiting family in other communities etc.) If yes: How many weeks per year would you say you spends outside the community for other reasons?

B. DEMAND-*this information will allow an understanding of the quantities of freshwater presently consumed by community residents for various purposes, further assisting in the projection of future water demand.*

1. What do you use water for in a typical day? (list all activities, ie. brushing teeth, cooking, drinking, showers, laundry, dishwasher/dishes)
2. Which three things do you feel you use the most water for?
3. Do you have a washing machine? If yes: How many loads per week does your household do?
4. Do you have a dishwasher? If yes: How many loads per week does your household do?

C. SUPPLY and ACCESS -*this information will allow an understanding of the methods and sources used to access drinking water and drinking water preferences, in addition to gaining a qualitative description of water and any water changes observed on a seasonal basis, and finally identifying any noted long-term changes, projected future changes, and adaptive strategies currently being used by residents*

Preferred water sources

1. What is your favourite source of drinking water?
2. What do you like about this water?
3. How would you describe the colour, taste, and smell of this water?
4. Where/How do you collect this water? I.e. do you use a boat, ATV, money, tools etc.
5. Do you ever bring this water on the land/in the community to drink?
6. Have you ever had difficulty accessing this water? If yes: When was this difficult, what made it difficult, how often is it difficult to access this water? What did you do?

Water accessed in the community

1. What is your primary source of drinking water in the community? Do you use this water for anything other than drinking?
2. If not tap water: Where do you get this water from?
3. Have you ever wanted to access this water and not been able?
4. If yes: Why were you unable? How long was the longest time when you were unable to access this water? What did you do? Did you access a different source of water or beverage instead? If yes: Which one?
5. If no: If this source were unavailable, where would you get your drinking water? /What is your second choice?

Water accessed while on the land

1. What is your primary source of drinking water on the land? Do you use this water for anything other than drinking?
2. Where do you get this water from?
3. Have you ever wanted to access this water and not been able?
4. If yes: Why were you unable? How long was the longest time when you were unable to access this water? What did you do? Did you access a different source of water or beverage instead? If yes: Which one?
5. If no: If this source were unavailable, where would you get your drinking water? /What is your second choice?

Tap Water

1. Do you ever drink tap water? Do you ever use tap water for any other purposes?
2. How would you describe the colour, taste and smell of your tap water?
3. Do these characteristics change at all throughout the year?
4. Have they ever changed in your memory?/Has the tap water changed since the system was installed in the community?
5. Have you ever had difficulty accessing tap water?/Have you ever run short on tap water? If yes: When, What did you do?
6. How would you describe the water pressure in your home?
7. Do you ever treat your tap water before drinking? Ie. boil it, use a filter etc. If yes: What is the main reason you treat it?
8. Do you feel your tap water is safe to drink? (no, yes, sometimes, unsure) What makes you feel your tap water is/isn't safe?
9. What are your thoughts on the boil orders that sometime occur in the town? How many boil orders do you recall in last 12 months? How long was the longest one?
10. How do you find out about boil orders? Have you ever found out about a boil order after it was over?

11. How does a boil order affect you? Do you drink tap water during a boil order?, Do you do anything to your tap water before drinking it during a boil order?
12. Do you expect your tap water to change at all in future? What might change/why? What impact will this have on you and the community?
13. Are you satisfied with your tap water? What would you change about your water if you could change something?
14. Who do you believe is responsible for ensuring your community has satisfactory drinking water?

Refillable Water (store-bought)

1. Do you ever drink refillable water from the store? Do you ever use this water for any other purposes?
2. Who is in charge of buying water in your household?
3. How would you describe the colour, taste and smell of the refillable water?
4. Have you ever had difficulty accessing refillable water from the store? If yes: When, What happened? What did you do?
5. Has the cost of buying refillable water ever prevented you from buying it?
6. Do you feel the refillable water is safe to drink? (no, yes, sometimes, unsure) What makes you feel this water is/isn't safe?

Bottled water (store-bought)

1. Do you ever drink bottled water from the store? Do you ever use this water for any other purposes?
2. Who is in charge of buying water in your household?
3. How would you describe the colour, taste and smell of bottled water?
4. Have you ever had difficulty accessing bottled water from the store? If yes: When, What happened? What did you do?
5. Has the cost of buying bottled water ever prevented you from buying it?
6. Do you feel bottled water is safe to drink? (no, yes, sometimes, unsure) What makes you feel this water is/isn't safe?

Water on the Land

1. Do you ever drink water from the land? Do you ever use water from the land for any other purposes?
2. Who is in charge of collecting water in your household? How is water gathered from the land?

3. What kind of water sources on the land are your favourite? (ie. Do you prefer water from a well, brook, river, lake, pond?)
4. What do you like about these sources?
5. How would you describe the colour, taste and smell of water on the land?
6. Does water on the land change at all throughout the year? (ie. Is the water the same in spring as it is in summer? What changes? How do these changes affect you? Ie. Do you gather water from a different source sometimes etc.)
7. Have you noticed any changes in water on the land over the years?/ Is the water on the land different now than it was when you were younger?
8. If yes: What is different? When did you first start noticing these changes? Why do you think the water on the land is changing in this way? How do these changes affect you? Have you begun doing anything differently as a result of these changes?
9. Have you ever had difficulty accessing water on the land?/Have you ever run short on water while on the land? If yes: When, how often, Why, What did you do? How did this shortage affect you? Did you access water from a different source? Did these changes affect your travel routes on the land? Do these changes affect your ability to hunt/fish/spend time on the land?
10. Do you ever bring water with you from the community when traveling on the land? If yes: why? When did you start doing this?
11. Do you ever bring water back from the land to use in the community? If yes: Why? When did you start doing this?
12. Do you ever treat water on the land before drinking? Ie. boil it, use a filter etc. If yes: What is the main reason you treat it?
13. Do you feel water on the land is safe to drink? (no, yes, sometimes, unsure) What makes you feel water on the land is/isn't safe?
14. Do you expect water on the land to change at all in future? What might change/why? What impact will this have on you and the community?

D. MAP and CONCLUDING REMARKS: *this section offers residents an opportunity to add any additional information not addressed above*

1. I have a map here and I was wondering if you could mark on the map the places where you access water and where you've noticed the changes we discussed earlier?
2. Are there anything else you would like to share about your water?
3. Do you know of anyone in the community that we should talk with regarding water?

Thank you for your time and participation!