Geographic Information Systems as Communication Tools: Environmental Assessment and the Health Impacts of Natural Resource Developments on Circumpolar Indigenous Peoples

by

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Abstract

Introduction.

The industrialization of circumpolar regions confronts a legacy of disproportionate bio-physical, socio-economic, heritage, and health impacts borne by indigenous populations. As natural resource development continues to accelerate in the north, concerns about impacts to the health and well-being of indigenous communities lead many to question whether the benefits of industrialization outweigh the risks. Legally mandated consultation processes to identify and mitigate development impacts are beginning to incorporate provisions for improving health outcomes to maximize the benefits and minimize the risks for indigenous communities. Nevertheless, the complex nature and diversity of evidence involved necessitates new tools to network information across scientific and cultural gradients, and ensure the long-term viability of health impact assessment within decision-making forums. Geographic Information Systems, or GIS, are one tool with the potential to facilitate appropriate public health planning in the context of natural resource development. My thesis research is among the first to engage arctic and subarctic stakeholders on the topic of whether GIS can improve communication and consultations about health impacts in forums focused on environmental assessment of natural resource developments in circumpolar regions.

Methods.

I employed a mixed-methods qualitative approach involving three lines of inquiry. First, I conducted semi-structured interviews with circumpolar experts in policy, research, and practice. This research engaged expert perspectives on whether GIS can improve consultations by leveraging health impacts in the

process of project approvals and regulation, which currently focus on changes in the physical environment. Second, I conducted document review / automated content analysis on the public record for two environmental assessments (the Prairie Creek and Nico mines) in the Northwest Territories (NWT), Canada. This research identified health and socio-economic content, characterized the communication practices of key stakeholder groups, and linked salient features of the environmental assessment processes with public health planning-related outcomes in each case. Third, I conducted semi-structured interviews with stakeholders in the Nico environmental assessment in the Wek'eezhii region of the NWT. This research provided evidence from which I derived an organizational analysis of how GIS can be used to leverage health issues from the community-base, thereby increasing the impetus to establish and sustain health impact assessment within the environmental assessment process.

Results.

My results can be grouped under three main themes. First, self-determination and governance are the critical issues which define circumpolar indigenous communities' relationship with the state, stewardship of resources, and capacity for public health planning. Second, the complexity of health inequities in these indigenous communities requires extensive participation and guidance from community members who articulate their priorities and worldviews to help operationalize appropriate public health planning in the context of circumpolar developments. Third, while GIS may appear advantageous for communicating health inequities in decision-making forums, circumpolar indigenous communities must see its demonstrated utility for their own needs and aspirations, in ways that they define for themselves. Partnerships with

government and academia can help to facilitate “counter mapping” processes in communities that may generate appropriate, relevant, timely, and local-scale data about the socio-ecological parameters of health and well-being.

Conclusion.

My results lead to three recommendations and two implications for future research. My recommendations are (1) Circumpolar nations should establish legal norms that recognize a full range of rights for indigenous populations; (2) Circumpolar jurisdictions should revise environmental assessment frameworks to incorporate equity-based health impact assessment; and (3) Circumpolar researchers and health practitioners working with community-based participatory GIS should publish detailed protocols for knowledge translation. Future research should (1) consider how to support indigenous researchers and research methodologies to examine the socio-ecological pathways or mechanisms by which development impacts circumpolar health and well-being. Additionally, research should (2) evaluate best practices to employ GIS in participatory research with indigenous peoples.

Preface

This thesis is an original work by Jennifer Ann McGetrick. The research project, of which this thesis is a part, received two research ethics approvals from the University of Alberta Research Ethics Board 1 as “Pilot Study: Expert Assessment of Geographic Information Systems (GIS) for Health Impact Assessment of Natural Resource Development in Canada’s North”, No. 31998, on June 29, 2012; and as “Multi-stakeholder Health Impact Communication in Environmental Assessment of Natural Resource Development in Northern Canada”, No. 34519, on January 14, 2013. In addition, the research project, as “Geographic Information Science (GIS) as a Health Communication Tool for Consultation with Stakeholders in Environmental Assessment of the Nico Project in the Tlicho Region of the Northwest Territories” was licenced by the Aurora Research Institute No. 15242 on May 9, 2013, and No. 15409, on February 4, 2014.

Dedication

My thesis is dedicated to Daniel Martin Brown.

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

ANTHC	Alaska Native Tribal Health Consortium
C/BAR	Circumpolar / Boreal Alberta Research
CIHR	Canadian Institutes of Health Research
GIS	Geographic Information System(s)
GPS	Global Positioning System
EA	Environmental Assessment
LEO	Local Environmental Observer
MVEIRB	Mackenzie Valley Environmental Impact Review Board
NLTK	Natural Language Toolkit
NSTP	Northern Scientific Training Program
NWT	Northwest Territories
PHAC	Public Health Agency of Canada
TF*IDF	Term Frequency-Inverse Document Frequency
WLWB	Wek'eezhii Land and Water Board

Chapter One:
"Introduction"

The acceleration of natural resource development in the circumpolar arctic and subarctic creates challenges for remote indigenous communities[1], with significant implications for population health (Chatwood et al, 2012). Historically, development drove much of the expansion of non-indigenous interests into the resource-rich north, resulting in the longstanding and persistent marginalization of northern indigenous populations, who thus face structural as well as logistical barriers to improving their health outcomes (Macintosh, 2012; Nuttall, 2009; O'Neil, 1986; Usher et al, 1992) Since that time, indigenous peoples have presented poorer indicators of health and well-being in circumpolar regions, versus national population averages (Chatwood et al, 2012; King et al, 2009). Research evidences a vicious cycle in relation to circumpolar developments, in which indigenous communities with poorer health status are at greater risk for development to worsen material hardships and increase health inequities (Asselin & Parkins, 2009; Bronson & Noble, 2006; Davison & Hawe, 2012; Kwiatkowski, 2011). Despite many part injustices, today the social license of development is predicated on proponents' sharing of benefits with indigenous communities, and assurances that development will both raise the standard of living and improve quality of life in the north (Fitzpatrick et al, 2011; Wilson & Alcantara, 2012). Public health planning is clearly needed if natural resource development is to realize its commitment to marginalized indigenous peoples, requiring culturally appropriate communication and consultations with these arctic and subarctic residents most affected, and potentially impacted, by natural resource development (Chatwood et al, 2012; Noble & Bronson, 2006).

Environmental assessment (EA) is the process for publically reviewing natural resource developments employed in over 100 countries, with the mandate

[1]In my thesis, I use the term *indigenous* to refer to the native inhabitant peoples of the circumpolar region, and the term *aboriginal* to indicate relevance specifically to the First Nations, Métis, and Inuit indigenous peoples of Canada, as identified under the 1982 *Constitution Act* (Bartlett et al, 2007; R.S.C. 1984, s. 11).

to identify and mitigate potentially negative impacts, emphasizing changes in the bio-physical environment (Kwiatkowski & Ooi, 2003; McCaig, 2005). Health impact assessment and public health planning to identify and mitigate development impacts are two areas of intensifying research in the field of EA scholarship (Birley, 2005; Bronson & Noble, 2006; Potvin et al, 2005; Snyder et al, 2012). In the circumpolar context, health impact assessment has been formally implemented only recently in the Alaskan context; in the remaining arctic jurisdictions, public health planning to mitigate health impacts must be integrated into existing legislative structures for EA (Anderson et al, 2013; Kwiatkowski, 2011; Solodyankina & Koeppel, 2009). Within a typical EA, multi-stakeholder participation is a key feature of decision-making in the impact identification and mitigation process; research shows that greater public involvement leads to participant satisfaction, reduced conflict, and higher quality decision-making (Beierle, 2002; Cundill & Rodela, 2012). Thus, the full participation of circumpolar indigenous peoples in EA processes has much to offer for effective public health planning- recognizing, respecting, and integrating indigenous concepts and priorities in relation to developments (Hanna & Vanclay, 2013; Kryzanowski & McIntyre, 2011).

The evidence involved in identifying and mitigating health impacts for circumpolar indigenous communities is diverse and complex, necessitating new tools to help gather, interpret, and communicate the relevant information (Gibson, 2011; Macintosh, 2012; Paci & Villebrun, 2005). In this light, Geographic Information Systems (GIS) may prove an effective tool for public health planning, within robust structures for public participation in EAs (Brubaker et al, 2011; Eisner et al., 2012; McCarthy et al, 2012; Palmer, 2012; Petheram et al, 2012). My thesis examines the potential role for GIS in review processes, building on the work of indigenous peoples and their collaborators to document health inequities and the socio-ecological parameters of health and well-being in circumpolar communities. In the following sections, I provide an introduction of relevant concepts and information framing my thesis research: 1.1.1 Legal Frameworks for Health Impact Assessment in Canada; 1.1.2 Health Inequities and the Socio-ecological Impacts of Natural Resource Development in Circumpolar Indigenous Communities; and 1.1.3 Geographic Information

Systems (GIS) as a Communication Tool. These topics are those which emerged throughout the investigation of my research question, both in literature review and the collection and analysis of data; I provide further details on specific lines of inquiry in my subsequent chapters. After my introduction, I state my research question and research objectives. Finally, I outline the structure of my thesis which comprises, in addition to this chapter, a methods chapter, three paper-based results chapters for submission to peer-reviewed journals, and a conclusion chapter with recommendations and implications for future research.

1.1 Introduction

1.1.1 Legal Frameworks for Health Impact Assessment in Canada

The process of establishing and sustaining health impact assessment for circumpolar indigenous communities within EAs derives from two legal frameworks: the obligation of states to consult with indigenous peoples on the use of their traditional territories, and the incorporation of human health impacts into EA legislation (Government of Canada, 2011; McCaig, 2005). Indigenous peoples have a range of legal rights that vary widely across the circumpolar nations (Berger, 2010; Fondahl et al, 2001; O'Neil, 1986; Robbins, 2003). Legal frameworks for reviewing and regulating natural resource developments are similarly diverse across arctic and subarctic jurisdictions (Anderson et al, 2013; Kryzanowski & McIntyre, 2011; Solodyankina & Koeppel, 2009). In my thesis, although international experts contributed their insights from the United States, Europe, and Russia, my focus was on the Canadian context. Therefore, I present both the frameworks for consultation and for health impact assessment in terms of the Canadian legislation and policy.

Canadian aboriginal and treaty rights are a vastly complex field of legal scholarship, although a necessarily abridged exposition is important for establishing the context of my research question (Lavoie, 2013; MacIntosh, 2012). Judicially, there is an impressive chain of litigation by native Canadian peoples to establish their aboriginal and treaty rights (MacIntosh, 2012; Nadasdy, 2002; Usher, 1992). The Supreme Court of Canada first recognized aboriginal title in the 1973 Calder decision (Houde, 2007). Although that ruling did not

recognize the aboriginal title of the Nisga'a plaintiffs on the basis of their submission of oral narratives and maps of ancient traditional territories, it ruled that such evidence could be used to prove aboriginal title, as it was in later cases such as Delgamuukw and the Haida Nation versus British Columbia (*Calder v. British Columbia*, 1973, S.C.R. 313; *Delgamuukw v. British Columbia*, 1997, 3 S.C.R. 1010; *Haida Nation v. British Columbia (Minister of Forests)*, 2004, 3 S.C.R. 511). The recognition of oral narratives and maps in aboriginal law was a key step to establish an appropriate basis for consultation (Houde, 2007). Since the Calder ruling, a host of major decisions have broadened the scope of legal norms with respect to the aboriginal peoples of Canada. These judgements include, notably, the right to subsistence harvesting, requirements for meaningful consultation, and the acceptability of evidence in the oral tradition (Government of Canada 2011; Houde, 2007; Notzke, 1995). As a corollary to these judgements, Section 35 of the *Constitution Act* recognized both the aboriginal and treaty rights of First Nations, Métis, and Inuit, as aboriginal peoples of Canada in 1982 (Bartlett et al, 2007; *Constitution* Act, 1982, being Schedule B to the Canada Act 1982 (UK), 1982, c. 11 s-35).

Another key step in the process of establishing appropriate consultation was the Berger Inquiry (1974-1977), which was headed by Thomas Berger, the solicitor for the Calder claimants (*Calder v. British Columbia*, 1973, S.C.R. 313; Gamble, 1978). The Government of Canada commissioned the Berger Inquiry to evaluate the development of a pipeline through the Mackenzie Valley of the NWT, land with asserted but then yet to be established aboriginal title (Nuttall, 2009). The Berger Inquiry consulted extensively with indigenous peoples of the north, finding for a moratorium on development until comprehensive land claim agreements were negotiated and aboriginal title could be legally established (Gamble, 1978). Since the Berger Inquiry, the conclusion of land claims in northern regions such as the Yukon, the NWT, and Nunavut have resulted in the establishment of new self-government structures by aboriginal peoples, many of which prominently feature natural resource management (Auditor General of Canada, 2010; Nuttall, 2009; Usher, 1992). In the NWT, where I conducted the bulk of my field work, the Inuvialuit negotiated a comprehensive land claim in 1984, followed thereafter by the Gwich'in (1992), the Sahtu (1993), and the Tlicho

(2005) (Auditor General of Canada, 2010). By the 1990s, the pace of natural resource developments had accelerated in the NWT and across other northern regions, for which the formal establishment of aboriginal title requires meaningful consultation with aboriginal peoples (Christensen & Grant, 2007).

EA is the primary forum for consultation with aboriginal peoples during the public review of natural resource developments in Canada (Kwiatkowski, 2011; McCaig, 2005). Although EA processes vary slightly between Canadian jurisdictions, its four basic stages are (1) screening; (2) scoping; (3) determining significance, mitigation, and follow-up; and (4) recommendation (McCaig, 2005). Scoping and determining significance, mitigation, and follow-up provide the greatest opportunity for aboriginal community members to have direct input into the EA process (Houde, 2007). In these stages, informal community meetings, baseline research, and formal public hearings are the primary channels through which community members can influence decision-making (Fitzpatrick et al, 2008). Following from the relevant judicial, constitutional, and legislative mandates, EA processes must be accessible, inclusive, iterative, flexible, and comprehensive for meaningful consultation with aboriginal people through public participation (Centre for the North, 2012).

The *Canadian Environmental Assessment Act* supports this engagement of aboriginal peoples in natural resource management by stipulating that EA address impacts to aboriginal peoples, ostensibly including human health (McCaig, 2005). This obligation is part of the Honour of the Crown, which refers to Canada's legal dealings with its aboriginal peoples (MacIntosh, 2012). In the national legislation, impacts are considered with respect to aboriginal peoples' (1) health and socio-economic situation, (2) heritage, (3) traditional land and resource use, and (4) historically significant sites (S.C. 2012, c. 19). In seeking meaningful consultation in EAs, the Honour of the Crown pursues two tasks of reconciliation: (1) re-establishing relationships between the state and aboriginal people, and (2) facilitating relationships between aboriginal people and the rest of society (Government of Canada, 2011). However, the slow incorporation of health impacts into EA practice, which has proved elusive for the benefit of both aboriginal peoples and the public at large, evidences a failure of reconciliation

which the Honour of the Crown must address (Auditor General of Canada, 2010; Galbraith et al, 2007, Kwiatkowski & Ooi, 2003). Impacts to the bio-physical environment have remained the primary focus since the inception of Canadian EA policy in the late 1970s, despite the early articulation of health impacts as a part of these policies (Lavoie, 2013; Noble & Bronson, 2006).

The integration of health impacts in EAs has been hindered by the absence of a theoretical framework, and a lack of resources and participation by health practitioners (Bronson & Noble, 2006; Kryzanowski & McIntyre, 2011; Kwiatkowski, 2011). In the late 1990s, Health Canada participated in a global evaluation of health impact assessment, and the Canadian federal and provincial ministers responsible for health and the environment issued a joint statement recognizing the relationship between economic development and human health (McCaig, 2005). Nevertheless, health impact assessment is unevenly applied in Canada, either as part of mandated EA or as non-mandated review practices (Birley, 2005; McCaig, 2005; Noble & Bronson, 2006). Increasingly, aboriginal communities have worked to assert health impacts during EAs within participatory structures from the community-base (Christensen & Grant, 2007; McCarthy et al, 2012). Thus, in the Canadian arctic and subarctic, health impact assessment for natural resource development has only begun to be incorporated within the bio-physically focused context of EAs, and then only as driven by the aboriginal communities themselves (Bronson & Noble, 2006; Kwiatkowski, 2011; McCaig, 2005).

1.1.2 Health Inequities and the Socio-ecological Impacts of Natural Resource Development in Circumpolar Indigenous Communities

The circumpolar arctic and subarctic regions of Canada, the United States, Russia, Finland, Sweden, Norway, Iceland, and Greenland are home to over thirty indigenous peoples (Kraft Sloan & Hik, 2008). Circumpolar indigenous populations are characterized by robust social support networks, strong connections to the physical environment, and a resilient and supportive culture (Flicker & Worthington, 2012; Wilson, 2003). Circumpolar indigenous settlements are typically remote and isolated, with small populations who participate in a mixed subsistence and wage economy (Usher et al, 2003). For

these communities, water and sanitation, income and employment, education, culturally appropriate health care, social and mental health services, and food security are continual challenges (Brubaker et al, 2011; Ford, 2012; Ford & Beaumier, 2011; Ritter, 2007). As a corollary to such structural and logistical challenges, many northern indigenous people experience disproportionately poorer health status (King et al, 2009; O'Neil, 1986, Usher et al, 1992). Health inequities are manifest as lower life expectancy, increased morbidity and mortality from infectious and chronic diseases, and increased prevalence of social problems like injuries, violence, addictions, and risky sexual behaviours (Birley, 2005; Chatwood et al, 2012; Gracey & King, 2009; Wilson & Young, 2008).

While these health inequities are themselves cause for community-driven public health action, there is additional concern that these communities may be more susceptible to the negative impacts of development (Kwiatkowski, 2011; Noble & Bronson, 2006). Abundant non-renewable and renewable natural resources are to be found throughout arctic and subarctic regions of the circumpolar nations (Johnson & Miyanishi, 2012). Proponents of limited industrialization argue that developing natural resources is a means to increase the standard of living and improve quality of life for northern residents (Birley, 2005; Wilson & Alcantara, 2012). Indeed, the social license of development is largely predicated on alleviating economic inequities through employment and other financial opportunities for northerners (Birley, 2005; Galbraith et al, 2007). Nevertheless, in addition to economic benefits, past developments have produced bio-physical, socio-economic, heritage, and health impacts for indigenous communities (Gamble, 1978; Nuttall, 2009).

Observed impacts of development at the community level include an influx of workers and accompanying stress on infrastructure; income stratification; increased social pathologies, weakening of networks, and loss of language and culture (Asselin & Parkins, 2009; Birley, 2005; Bronson & Noble, 2006; Davison & Hawe, 2012). Environmental impacts include contamination of land and water, wildlife avoidance, habitat fragmentation, traffic, dust, and ambient noise (Bernard & Ostländer, 2008; Robbins, 2003). Development can disrupt subsistence and land-based activities, which form a historic and dynamic basis

for the physical, symbolic, spiritual, and social relations of indigenous peoples (Nadasdy, 2002; Wilson, 2003). On this basis, numerous stakeholders in northern regions have expressed concern about whether the benefits of development outweigh the risks (Hanna & Vanclay, 2013; Ozkan & Schott, 2013).

Public health planning is clearly needed to maximize benefits and minimize the risks to circumpolar indigenous populations, and to ensure that natural resource development makes a net contribution to sustainability in the circumpolar north (Bronson & Noble, 2006; Gibson, 2011; Paci & Villebrun, 2005). Recently, scholars of health impact assessment have begun to argue that the identification and mitigation of health impacts in decision-making forums should focus on linkages between development and changes in the socio-ecological parameters of health and well-being (Bronson & Noble, 2006). Because individual and community health outcomes are influenced by complex interactions between political, economic, social, and environmental factors, more evidence is required to understand how development might produce positive impacts, and avoid exacerbating underlying problems, in remote regions (Marmot et al, 2012; McCaig, 2005). In this respect, indigenous peoples' extensive knowledge of their communities is vital to understanding and improving the standard of living and quality of life in northern settlements (Armitage, 2005; Christensen & Grant, 2007). New tools are needed to gather and interpret the complex evidence required for health impact assessment, integrating indigenous peoples' perspectives on sustainability in relation to development (Kwiatkowski, 2011; Kwiatkowski & Ooi, 2003). Moreover, these tools must be aligned with indigenous peoples' worldviews and priorities, to realize community-driven concepts of health and well-being (Kryzanowski & McIntyre, 2011).

1.1.3 Geographic Information Systems (GIS) as a Communication Tool

One potential tool for the integration and synthesis of complex and diverse health impacts is Geographic Information Systems (GIS) technology (Louis et al, 2012). Although mapping was instrumental to the development of epidemiology in the mid-nineteenth century, geospatial analysis on digital platforms is only beginning to take its place in public health planning (Bailey & Grossardt, 2010;

Brown, 2003; Butz & Torrey, 2006; Winslow, 1920). GIS was developed mainly in North America after the Second World War, is currently used in a variety of contexts throughout the world, and has grown increasingly dynamic with access to the Global Positioning System (GPS) location satellites in the early 2000s (Chapin et al, 2005; Coppock & Rhind, 1991; Homburg & Georgiadou, 2009). GIS consists of the data, hardware, software, and personnel for collecting, storing, retrieving, analyzing, interpreting, and communicating geospatial information (Palmer, 2012). It allows spatial data to be partitioned into layers representing different characteristics of a location, which then can be overlaid and combined in a variety of analyses (Poore & Chrisman, 2006). While these analyses permit investigation of the associations between a potentially unlimited suite of geospatially referenced indicators, the value in using GIS for health impact assessment derives from the level of its acceptability for circumpolar indigenous peoples, as opposed to the extensibility of the technology itself (Chambers et al, 2004).

Indigenous peoples have employed GIS as a tool in negotiating land claims to varying extents throughout North America, and the circumpolar arctic and subarctic (Bartlett et al, 2007; Berger, 2010; Fondahl et al, 2001; Houde, 2007; Palmer, 2012). Mapped evidence outlining the extent of traditional territory over which communities asserted aboriginal title was used in each of the Calder, Delgamuukw, and Haida Nation Supreme Court cases previously mentioned (*Calder v. British Columbia*, 1973, S.C.R. 313; *Delgamuukw v. British Columbia*, 1997, 3 S.C.R. 1010; *Haida Nation v. British Columbia (Minister of Forests)*, 2004, 3 S.C.R. 511). Increasingly, GIS is being used by indigenous communities to document traditional knowledge, as an aid to planning and decision-making, and to facilitate delivery of indigenous government services (Eisner et al, 2012; González et al, 2008; Palmer, 2012; Tripathi & Bhattarya, 2004). Moreover, GIS is capable of representing indigenous people's priorities and worldviews in spatial relation to development on the landscape in a way that is easily understood by non-indigenous interests (Houde, 2007; McCarthy et al, 2012). Its dynamic digital platform permits combining traditional knowledge with scientific evidence, easy updating of information, and networking data between communities (Louis et al, 2012; Wright et al, 2009). However, GIS presents

challenges as well as opportunities for circumpolar indigenous communities. The characteristics of these challenges are beginning to be understood through participatory GIS research in northern regions (Eisner et al, 2012; Stewart et al, 2008).

One concern with GIS adoption by indigenous communities is the potential imposition of a positivistic or technocratic perspective of visualization upon indigenous ontology and epistemology (Wright et al, 2009). Chambers et al (2004) provide an excellent overview of this issue in the adoption of GIS by indigenous peoples in terms of attendant effects on community structure and authority, and interference from government and industry vested interests aligned with certain uses of the technology. Additionally, some researchers question whether GIS is the best communication tool for natural resource development decision-making. In their research on landscape visualization as a communication tool with the Cheam Band in British Columbia, Canada, Lewis and Sheppard (2006) argued that cartographic conventions fail to communicate experiential information critical to aboriginal people's values, precluding meaningful consultation. The authors found that photo-realistic images were more evocative visualizations for their research participants, encouraging more in-depth discussion and more thorough articulation of preferences (Lewis & Sheppard, 2006).

In response to these issues, Louis et al (2012) argue that because GIS is a relatively new tool, positivistic impositions on epistemologies by the technology can be addressed by the evolution of indigenous peoples' practice of "counter-mapping". "Counter mapping" refers to indigenous people, or other marginalized groups, representing their history, needs, and aspirations through the deconstruction of dominant forms of cartography, using GIS (Chapin, 2005; Louis et al, 2012; Palmer, 2012). The "counter mapping" of traditional knowledge is the primary example of such deconstruction at present, through which indigenous peoples place their own priorities and worldviews "on the map". The wide variety of traditional knowledge that has been documented, analysed and communicated with GIS includes spatially referenced land use and occupancy; sacred sites; oral histories and place names; environmental ethics; subsistence

hunting, gathering, fishing and trapping activities; intimate knowledge of fish, wildlife, and plants; travel paths and portages; historical migration; family and kinship organization; patterns of harvest sharing and consumption; seasonal cycles and variations; sea ice and permafrost variations; landscape changes and lake processes; and cosmological and spiritual knowledge (Epp et al, 1991; Houde, 2007; Palmer 2012; Stewart et al, 2008; Wright, 2009). Just as traditional knowledge is vast, it is immediate and relevant to understanding the socio-ecological parameters of health and well-being for indigenous communities (King et al, 2009; MacIntosh, 2012). To the extent that GIS can serve as a communication tool to document, convey, and safeguard these interests, indigenous communities have been willing to explore "counter mapping" processes (Chapin, 2005; Wright et al, 2009). Thus, the general consensus in the literature is that the prospective utility of GIS will be meted in terms of the technology's acceptability for pursuing solutions that matter for indigenous communities themselves (Chambers et al, 2004; Chapin, 2005; Epp et al, 1991; McCarthy, 2012).

Another substantial concern with the adoption and diffusion of GIS has to do with resource constraints and knowledge gaps in circumpolar indigenous communities (Chambers et al, 2004). Literature suggests that GIS technology effects uneven uptake and development, and that data confidentially, stewardship, and resource demands for long term maintenance of a GIS can be problematic for indigenous governments (Palmer, 2012; Wright et al, 2009). In Alaska, Brubaker et al (2011) sought to address GIS resource constraints and knowledge gaps in documenting evidence of climate change in Alaska Native communities. The Alaska Native Tribal Health Consortium (ANTHC) invested personnel, equipment, and infrastructure to establish a network of Local Environmental Observers (LEOs) in the villages across Alaska, hosting local observations of environmental disruption on an Alaska-wide GIS web platform. In partnership with the LEOs, ANTHC facilitates communities' environmental health surveillance research, provides webinars and workshop training, and brokers knowledge exchange between communities, scientists, and policy makers (Brubaker et al, 2011). In Canada, McCarthy et al (2012) discuss how collaboration between the Mushkegowuk Cree First Nations and academic

researchers from the University of Waterloo and Queen's University is helping to adapt GIS applications according to community perspectives in the face of government-imposed land use processes for development in northern subarctic Ontario. Through workshops offering training with a critical approach to the technology, the community and researchers worked together to bridge knowledge gaps and address resource constraints (McCarthy et al, 2012). These two examples from Alaska and Canada serve to illustrate how collaboration between circumpolar indigenous communities and government and academia can facilitate the early stages of "counter mapping".

Given nascent legal frameworks for health impact assessment in Canada, the need to synthesize complex evidence of health inequities and impacts for indigenous populations, and the emerging utility and acceptability of GIS for a variety of indigenous community applications, research is warranted on GIS as a communication tool in circumpolar natural resource development decision-making forums.

1.2 Research Question and Objectives

My research derives from two trends in the natural resource management and public health literature. First, development impacts on the socio-ecological parameters of health and well-being, and public health planning to identify and mitigate those impacts, are emerging as topics for health impact assessment research and EA practice (Kryzanowski & McIntyre, 2011; Kwiatkowski, 2011; Wilson & Young, 2008). Second, participatory research with indigenous peoples using GIS is increasing, with researchers asserting that the technology can facilitate self-determination and self-governance for improved population health in indigenous communities (Brubaker et al, 2011; Eisner et al, 2012; González et al, 2008; Louis et al, 2012; MacIntosh, 2012; McCarthy et al, 2012). My research examines the convergence of these two trends in the circumpolar context, where natural resource development is poised to accelerate (McCarthy et al, 2012; Ozkan & Schott, 2013;).

Thus, my research question is as follows:

> *How can Geographic Information Systems (GIS) improve communication and consultation about health inequities and impacts to indigenous populations in natural resource development decision-making forums for circumpolar regions?*

In addressing this question, I pursued three research objectives which characterize each of my chapters for submission to peer-reviewed journals, respectively.

My first objective was to collate the perspectives of experts in circumpolar indigenous health policy, research, and practice on the barriers and facilitators to implementing GIS in the research context. Given the conceptual and technical complexities involved, I conducted and analysed semi-structured interviews with the experts so that their collective experience, knowledge, and insights could inform my examination of the relevant issues and linkages for GIS, natural resource development decision-making forums, health inequities and impacts, and communication and consultation with circumpolar indigenous communities. Thus, the title of Chapter 3 is "*Can Geographic Information Systems Improve Consultations in Circumpolar Development?"* indicating my assessment of the evidence of expert perspectives on my research question.

My second objective was to present evidence of how health and socio-economic issues are raised by indigenous peoples in natural resource development decision-making forums, given the lack of integration with health impact assessment across arctic and subarctic jurisdictions at present (Anderson et al, 2013; Kwiatkowski, 2011; McCaig et al, 2005). Accordingly, I analysed relevant health and socio-economic content, the communication practices of key stakeholder groups, and linkages between processes and public health planning-related outcomes in two northern Canadian EAs. Using document review / automated content analysis, I compared textual evidence from the public records of two public hearings conducted in the Mackenzie Valley, NWT, Canada- the proposed Prairie Creek and Nico mines. Thus, the title of Chapter 4 is "*How Do Aboriginal Communities Raise Health and Socio-economic Issues in Northern Canadian Environmental Assessment?"* indicating my assessment of the

evidence of how health and socio-economic issues might assume greater prominence as part of the decision-making for natural resource developments.

My third objective was to articulate pathways through which GIS can be integrated into EAs as a communication tool for addressing health inequities and impacts to circumpolar indigenous peoples. Given the lack of theoretical frameworks and resources for health impact assessment of natural resource developments, I gathered evidence on how GIS might be used to leverage indigenous people's concerns, priorities, and worldviews for improved decision-making and public health planning. I conducted and analysed semi-structured interviews with stakeholders in the EA for the proposed Nico mine in the Mackenzie Valley, NWT, Canada. Using my evidence from the stakeholder interviews, I generated an organizational analysis of how GIS can help identify and mitigate impacts on the socio-ecological parameters of health and well-being. Thus, the title of Chapter 5 is "*How Can Geographic Information Systems Support Public Health Planning for Development in Northern Canada?"* indicating how successful innovation using GIS in the Nico EA has improved aboriginal stakeholders' satisfaction with the decision-making process, and increased other stakeholders' willingness to join the dialogue about health inequities and impacts.

1.3 Thesis Outline

My thesis is paper-based, with three chapters formatted for submission to peer-reviewed journals. Following on from the general introduction provided here, I first outline my methods and then present three paper-based chapters. My thesis concludes with a discussion that integrates and reiterates my main findings, leading to recommendations that (1) Circumpolar nations should establish legal norms that recognize a full range of rights for indigenous populations; (2) Circumpolar jurisdictions should revise environmental assessment frameworks to incorporate equity-based health impact assessment; and (3) Circumpolar researchers and health practitioners working with community-based participatory GIS should publish detailed protocols for knowledge translation.

My thesis outline is as follows:

Chapter One: "Introduction" introduces and frames my thesis with discussion of the legal framework for health impact assessment in Canada, health inequities and the socio-ecological impacts of natural resource development in circumpolar indigenous communities, and GIS as a communication tool. I define my research question and three objectives, and provide my thesis outline.

Chapter Two: "Research Methods" presents the justification for my choice and use of research methods. I provide a personal statement and describe my philosophical orientation in conducting the research. For each of the research chapters, I provide detail on my choice of methods, protocol in carrying out the project, and consideration of qualitative rigour.

Chapter Three is titled "*Can Geographic Information Systems Improve Consultations in Circumpolar Development?"* This paper is formatted for the journal *Global Environmental Change*. In this chapter I present the results of my research with circumpolar experts in policy, research, and practice.

Chapter Four is titled "*How Do Aboriginal Communities Raise Health and Socio-economic Issues in Northern Canadian Environmental Assessment?"* It is formatted for the journal *Environmental Policy and Governance*. In this chapter I present the results of my content analysis of text from public record of two EAs in the Mackenzie Valley of the NWT in Canada.

Chapter Five is titled *"How Can Geographic Information Systems Support Public Health Planning for Development in Northern Canada?"* This chapter is formatted for the journal *Arctic*. In this chapter, I present the results of my research with stakeholders in the Nico EA in the Wek'eezhii Region of the NWT in Canada.

Chapter Six: "Conclusion" provides a summary of important themes across my findings in the research chapters, with the implications for future research

and practice. I propose a concise set of recommendations to address my research question.

In addition, I provide my abstract, table of contents, dedication, acknowledgements, preface, list of tables and figures, and list of abbreviations in the front section of my thesis. As required by the School of Public Health, I provide chapter by chapter works cited, as well as a complete thesis bibliography. Appendices with copies of my ethics approvals, research licenses, information and informed consent forms, and interview guides can be found in the final section of my thesis.

1.4 Works Cited

Anderson, P. J., Yoder, S., Fogels, E., Krieger, G. & McLaughlin, J. (2013). The state of Alaska's early experience with institutionalization of health impact assessment. *International Journal of Circumpolar Health*. 72, 1-5.

Armitage, D. R. (2005). Collaborative environmental assessment in the Northwest Territories, Canada. *Environmental Impact Assessment Review*. 25(3), 239-258.

Asselin, J. & Parkins, J. R. (2009). Comparative case study as social impact assessment: Possibilities and limitations for anticipating social change in the far north. *Social Indicators Research*. 94(3), 483-497.

Auditor General of Canada. (2010). Sustaining development in the Northwest Territories. In *The Spring 2010 Report of the Auditor General of Canada* (1-34). Ottawa: Minister of Public Works and Government Services Canada.

Bailey, K., & Grossardt, T. (2010). Toward structured public involvement: Justice, geography and collaborative geospatial/geovisual decision support systems. *Annals of the Association of American Geographers*. 100(1), 57-86.

Beierle, T. C. (2002). The quality of stakeholder-based decisions. *Risk Analysis*. 22(4), 739-749.

Berger, T. (2010). Land use planning: Land claims and Canada's north. In *Canada's north: What's the plan?* (pp 7-35). Ottawa: Conference Board of Canada.

Bernard, L., & Ostländer, N. (2008). Assessing climate change vulnerability in the arctic using Geographic Information Services in Spatial Data Infrastructures. *Climatic Change*. 87(1-2), 263-281.

Birley, M. (2005). Health impact assessment in multinationals: A case study of the Royal Dutch/Shell Group. *Environmental Impact Assessment Review*. 25(7-8), 702-713.

Bronson, J., & Noble, B. F. (2006). Health determinants in Canadian northern environmental impact assessment. *Polar Record*. *42*(4), 315-324.

Brown, P. (2003). Qualitative methods in environmental health research. *Environmental Health Perspectives*. 111(14), 1789-1798.

Brubaker, M. Y., Bell, J. N., Berner, J. E., & Warren, J. A. (2011). Climate change health assessment: A novel approach for Alaska Native communities. *International Journal of Circumpolar Health*. 70(3), 266-273.

Butz, W. P., & Torrey, B. B. (2006). Some frontiers in social science. *Science*. *312*(5782), 1898-1900.

Calder v. British Columbia (Attorney General). 1973, Supreme Court Report 313. Retrieved from the Judgements of the Supreme Court of Canada website http://scc-csc.lexum.com/scc-csc/scc-csc/en/item/5113/index.do

Canadian Environmental Assessment Act, Consolidated Statutes of Canada. (2012, c. 19, s. 52). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/C-15.21.pdf

Centre for the North. (2012). *Getting it right: Assessing and building resilience in Canada's north*. Ottawa, ON: Conference Board of Canada.

Chatwood, S., Bjerregaard, P., & Kue Young, T. (2012). Global health - a circumpolar perspective. *American Journal of Public Health*. 102(7), 1246-1249.

Christensen, J., & Grant, M. (2007). How political change paved the way for indigenous knowledge: The Mackenzie Valley Resource Management Act. *Arctic*. 60(2), 115-123.

Constitution Act, Consolidated Statutes of Canada. (1982, being Schedule B to the Canada Act 1982 (UK), 1982, c 11). Retrieved from the Canadian Legal Information Institute website http://www.canlii.org/en/ca/laws/stat/schedule-b-to-the-canada-act-1982-uk-1982-c-11/latest/schedule-b-to-the-canada-act-1982-uk-1982-c-11.html

Conference Board of Canada. (2013). *The future of mining in Canada's north: Economic performance and trends*. Ottawa: M. Caron-Vuotari & G. Rheaume.

Coppock, J. T., & Rhind, D. W. (1991). The history of GIS. In P. A. Longley, M. F. Goodchild, D. J. Maguire & D. W. Rhind (Eds.), *Geographic Information Systems*. New York: Wiley.

Cundill, G., & Rodela, R. (2012). A review of assertions about the processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*. 113, 7-14.

Davison, C. M., & Hawe, P. (2012). All that glitters: Diamond mining and Tåîchô youth in Behchokö, Northwest Territories. *Arctic*. 65(2), 214-228.

Delgamuukw v. British Columbia. 1977, 3 Supreme Court Report 1010. Retrieved from the Judgements of the Supreme Court of Canada website http://scc-csc.lexum.com/scc-csc/scc-csc/en/item/1569/index.do

Eisner, W. R., Jelacic, J., Cuomo, C. J., Kim, C., Hinkel, K. M., & Del Alba, D. (2012). Producing an indigenous knowledge web GIS for arctic Alaska Communities: Challenges, successes, and lessons learned. *Transactions in GIS*. 16(1), 17-37.

Epp, H., Rigby, B., & Bruce, B. (1991). Remote sensing and Geographic Information System training requirements in arctic Canada. *Arctic*. 44(Suppl. 1), 11-14.

Fitzpatrick, P., Sinclair, A. J., & Mitchell, B. (2008). Environmental impact assessment under the Mackenzie Valley Resource Management Act: Deliberative democracy in Canada's north? *Environmental Management*. 42(1), 1-18.

Fondahl, G., Lazebnik, O., Poelzer, G., & Robbek, V. (2001). Native 'land claims', Russian style. *Canadian Geographer*. 45(4), 545-561.

Galbraith, L., Bradshaw, B., & Rutherford, M. B. (2007). Towards a new supraregulatory approach to environmental assessment in northern Canada. *Impact Assessment and Project Appraisal*. 25(1), 27-41.

Gamble, D. J. (1978). The Berger Inquiry: An impact assessment process. *Science,* 199(4332), 946-952.

Gibson, R. B. (2011). Application of a contribution to sustainability test by the Joint Review Panel for the Canadian Mackenzie Gas Project. *Impact Assessment and Project Appraisal*. 29(3), 231-244.

González, A., Gilmer, A., Foley, R., Sweeney, J., & Fry, J. (2008). Technology-aided participative methods in environmental assessment: An international perspective. *Computers, Environment and Urban Systems*. 32(4), 303-316.

Government of Canada. (2011). *Aboriginal Consultation and Accommodation: Updated Guidelines for Federal Officials to Fulfill the Duty to Consult*. Ottawa: Aboriginal Affairs and Northern Development Canada.

Haida Nation v. British Columbia (Minister of Forests). 2004, 3 Supreme Court Report 511. Retrieved from the Judgements of the Supreme Court of Canada website http://scc-csc.lexum.com/scc-csc/scc-csc/en/item/2189/index.do

Hanna, P., & Vanclay, F. (2013). Human rights, indigenous peoples and the concept of Free, Prior and Informed Consent. *Impact Assessment and Project Appraisal*. 31(2), 146-157.
Homburg, V., & Georgiadou, Y. (2009). A Tale of two trajectories: How spatial data infrastructures travel in time and space. *Information Society*. 25(5), 303-314.
Houde, N. (2007). The six faces of traditional ecological knowledge: Challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 12(2).
Johnson, E. A., & Miyanishi, K. (2012). The boreal forest as a cultural landscape. *Annals of the New York Academy of Sciences*. 1249, 151-165.
King, M., Smith, A., & Gracey, M. (2009). Indigenous health part 2: The underlying causes of the health gap. *Lancet*. 374(9683), 76-85.
Kryzanowski, J. A., & McIntyre, L. (2011). A holistic model for the selection of environmental assessment indicators to assess the impact of industrialization on indigenous health. *Canadian Journal of Public Health*. 102(2), 112-117.
Kwiatkowski, R. E. (2011). Indigenous community based participatory research and health impact assessment: A Canadian example. *Environmental Impact Assessment Review*. 31(4), 445-450.
Kwiatkowski, R. E., & Ooi, M. (2003). Integrated environmental impact assessment: A Canadian example. *Bulletin of the World Health Organization*. 81(6), 434-438.
Lavoie, J. G. (2013). Policy silences: Why Canada needs a national First Nations, Inuit and Métis health policy. *International Journal of Circumpolar Health*. 72, 1-7.
Leszczynski, A. (2009). Poststructuralism and GIS: Is there a 'disconnect'? *Environment and Planning D: Society and Space*. 27(4), 581 – 602.
Lewis, J. L., & Sheppard, S. R. J. (2006). Culture and communication: Can landscape visualization improve forest management consultation with indigenous communities? *Landscape and Urban Planning*. 77(3), 291-313.
Louis, R. P., Johnson, J. T., & Pramono, A. H. (2012). Introduction: Indigenous cartographies and counter-mapping. *Cartographica*. 47(2), 77-79.
Macintosh, C. (2012). Relational theory and indigenous health: Insights for law reform and policy development. In J. Downie & J. Llewellyn (Eds.), *Being Relational: Reflections on Relational Theory and Health Law and Policy* (230-254). Vancouver: University of British Columbia Press.
Mackenzie Valley Resource Management Act. Consolidated Statutes of Canada. (1998, c. 25). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/M-0.2.pdf
Marmot, M., Allen, J., Bell, R., & Goldblatt, P. (2012). Building of the global movement for health equity: From Santiago to Rio and beyond. *The Lancet*. 379(9811), 181-188.
McCaig, K. (2005). Canadian insights: The challenges of an integrated environmental assessment framework. *Environmental Impact Assessment Review*. 25(7-8), 737-746.
McCarthy, D. D. P., Whitelaw, G. S., Anderson, S., Cowan, D., McGarry, F., Robins, A., Gardner, H. L., Barbeau, C. D., Charania, N. A., General, Z., Liedtke, J., Sutherland, C., Alencar, P. & Tsuji, L. J. S. (2012). Collaborative geomatics and the Mushkegowuk Cree First Nations: Fostering adaptive

capacity for community-based sub-arctic natural resource management. *Geoforum*. 43(2), 305-314.
Nadasdy, P. (2002). "Property" and aboriginal land claims in the Canadian subarctic: Some theoretical considerations. *American Anthropologist*. 104(1), 247-261.
Noble, B., & Bronson, J. (2006). Practitioner survey of the state of health integration in environmental assessment: The case of northern Canada. *Environmental Impact Assessment Review*. 26(4), 410-424.
Notzke, C. (1995). A new perspective in aboriginal natural resource management: Co-management. *Geoforum*. 26(2), 187-209.
Nuttall, M. (2009). Energy development and aboriginal rights in northern Canada. In A. Dey-Nuttall & M. Nuttall (Eds.), *Canada's and Europe's northern dimensions* (71-84). Oulu: University of Oulu Press.
O'Neil, J. D. (1986). The politics of health in the fourth world: A northern Canadian example. *Human Organization*. 45(2), 119-128.
Ozkan, U. R., & Schott, S. (2013). Sustainable development and capabilities for the polar region. *Social Indicators Research*. 114(3), 1259-1283.
Paci, C., & Villebrun, N. (2005). Mining Denendeh: A Dene Nation perspective on community health impacts of mining. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health*. 3(1), 71-86.
Palmer, M. (2012). Theorizing indigital geographic information networks. *Cartographica*. 47(2), 80-91.
Petheram, L., Stacey, N., Campbell, B. M., & High, C. (2012). Using visual products derived from community research to inform natural resource management policy. *Land Use Policy*. 29(1), 1-10.
Poore, B. S., & Chrisman, N. R. (2006). Order from noise: Toward a social theory of geographic information. *Annals of the Association of American Geographers*. 96(3), 508-523.
Potvin, L., Gendron, S., Bilodeau, A., & Chabot, P. (2005). Integrating social theory into public health practice. *American Journal of Public Health*. 95(4), 591-595.
Robbins, P. (2003). Beyond ground truth: GIS and the environmental knowledge of herders, professional foresters, and other traditional communities. *Human Ecology*. 31(2), 233-254.
Snyder, J., Wagler, M., Lkhagvasuren, O., Laing, L., Davison, C., & Janes, C. (2012). An equity tool for health impact assessments: Reflections from Mongolia. *Environmental Impact Assessment Review*. 34, 83-91.
Solodyankina, S., & Koeppel, J. (2009). The environmental impact assessment process for oil and gas extraction projects in the Russian Federation: Possibilities for improvement. *Impact Assessment and Project Appraisal*. 27(1), 77-83.
Stewart, E. J., Jacobson, D., & Draper, D. (2008). Public participation Geographic Information Systems (PPGIS): Challenges of implementation in Churchill, Manitoba. *Canadian Geographer*. 52(3), 351-366.
Tripathi, N., & Bhattarya, S. (2004). Integrating indigenous knowledge and GIS for participatory natural resource management: State of the practice. *The Electronic Journal of Information Systems in Developing Countries*. 17(3), 1-13.
Usher, P. J., Duhaime, G., & Searles, E. (2003). The household as an economic unit in arctic aboriginal communities, and its measurement by means of a comprehensive survey. *Social Indicators Research*. 61(2), 175-202.

Usher, P. J., Tough, F. J., & Galois, R. M. (1992). Reclaiming the land: Aboriginal title, treaty rights and land claims in Canada. *Applied Geography*. 12(2), 109-132.
Wilson, G. N., & Alcantara, C. (2012). Mixing politics and business in the Canadian arctic: Inuit corporate governance in Nunavik and the Inuvialuit settlement region. *Canadian Journal of Political Science*. 45(4), 781-804.
Wilson, K., & Young, T. K. (2008). An overview of aboriginal health research in the social sciences: Current trends and future directions. *International Journal of Circumpolar Health*. 67(2-3), 179-189.
Wilson, K. (2003). Therapeutic landscapes and First Nations peoples: An exploration of culture, health and place. *Health & Place*. 9(2), 83-93.
Winslow, C. E. A. (1920). The untilled fields of public health. *Science*. 51(1306), 23-33.
Wright, D. J., Duncan, S. L., & Lach, D. (2009). Social power and GIS technology: A review and assessment of approaches for natural resource management. *Annals of the Association of American Geographers*. 99(2), 254-272.

Chapter Two:
"Research Methods"

2.1 Introduction

In this chapter I describe my use of research methods to address my research question:

> *How can Geographic Information Systems (GIS) improve communication and consultation about health inequities and impacts to indigenous populations in natural resource development decision-making forums for circumpolar regions?*

I provide a personal statement about my choice to employ qualitative methods as a public health researcher, and outline the philosophical considerations of ontology, epistemology, and methods underpinning my work (Carter & Little, 2007; Mayan, 2009). I explain and justify the methods I adopted in each of Chapters 3, 4, and 5, and my research protocols in terms of ethics and funding, sampling and recruitment, and data collection and analysis. Additionally, I discuss the methodological rigor in my research (Caelli et al, 2003; Getty, 2010; Malterud, 2001).

2.2 Personal Statement on Philosophical Considerations

2.2.1 Position as a Public Health Researcher

Researchers' sensitivities differ, shape the patterns of their reasoning, and alert them to different facts (Charmaz, 2004). I regard public health as an academically and practically challenging and rewarding field of inquiry, bridging many of my diverse research interests. My background is interdisciplinary, with a focus on governance and policy issues. Prior to enrolling in the Master of Science Global Health specialization at the University of Alberta School of Public Health, I completed a Bachelor's degree in Human Geography and Economics, a social science course of study focused on environmental planning within the limits of economic growth (Brown et al, 2011; Pop et al, 2013; Spangenberg, 2010). In my program, I studied geographic and geospatial analysis, economic theory and

measurement, and environmental philosophy and systems of management. As a corollary to those broader studies, I became attentive to the question of how Geographic Information Systems (GIS) could serve as a platform for integrating evidence from these diverse fields of research (Butz & Torrey, 2006). My Master of Science thesis research thus proceeded from my position that GIS can improve public health planning to identify and mitigate the socio-ecological[2] impacts of natural resource development (Bailey & Grossardt, 2010; Wright et al, 2009). However, I required evidence from stakeholders as to how GIS is used currently, and the nature of the challenges facing circumpolar indigenous peoples in practice (Caine et al, 2007; Chambers et al, 2004). I feel that a qualitative approach was appropriate to this research, which examines social practices and processes relevant to the uptake and diffusion of a novel technology for communication and consultations (Scammell, 2010). Concerning potential bias, I endorse GIS technology as an aid to decision-making, and I believe we should prioritize socio-ecological health over economic growth. However, in my thesis I attempted to account for these biases by selecting interviewees and data representative of all stakeholders in development, as well as by presenting evidence of contrasting perspectives (Polkinghorne, 2006). In remaining reflexive about my inherent biases, and in enhancing the rigour of my qualitative analysis through measures of inter-coder reliability, I believe the research represents an objective assessment of views of the key stakeholders (Charmaz, 2004). In addition, one chapter relies on quantitative analyses of statements on the record, which decreases the potential for investigator bias.

2.2.2 Ontology, Epistemology, and Methodology of Qualitative Research

Various ontological, epistemological, and method choices were embedded in my qualitative research, which I articulate here (Caelli et al, 2003; Mayan, 2009). The ontological orientation of my research was social practice theory; my epistemology was social constructivism; and my methods were semi-structured interviews and document review/automated content analysis (Brinkmann, 2007; Dinkins, 2005; Reckwitz, 2002). Although my methods do not represent a pure

[2] Socio-ecological theory posits that individuals are embedded within social contexts that positively and negatively influence health outcomes (Potvin et al, 2005).

interpretation of any one qualitative methodology, I was most influenced by grounded theory, based on my goal of understanding decision-making processes, and an iterative approach to data collection (Dew, 2007).

Social practice theory is gaining traction in public health, organizational learning, community health, economic behaviour, and intercultural research (Erden et al, In Press; Kelly, 2014; Nolas, 2014; Potvin et al, 2005; Sahakian & Wilhite, 2014). Social practice theory suggests that the meaning of experience and behaviours is socialized in a variety of contexts, and that social transformation is a precursor to innovation and institutional change (Macintosh, 2012; Potvin et al, 2005). For example, the recent emergence of "counter-mapping" by indigenous peoples as a means to assert their ancestral territories and dynamic culture may precursor a shift in the dominant social practices of cartography (Louis et al, 2012; Palmer, 2012). As another example, northern Canadian co-management institutions, mandating extensive community consultation and the participation of aboriginal decision-makers, may provide impetus to shift social practices for natural resource management involving indigenous peoples in other parts of the world (Christensen & Grant, 2007; González et al, 2008; Houde, 2007). Social practice theory resonates with both my natural and social scientific inclinations. From a natural science perspective, I argue that sound empirical knowledge, scientific construction of theory, and the recognition of uncertainty are necessary for appropriate decision-making as a social practice (Cundill & Rodela, 2012; Rodela et al, 2012; Rodela, 2013). Social scientifically, I also argue that the inclusion, respectful engagement, and empowerment of stakeholders with diverse viewpoints can improve decision-making by expanding social practice horizons (Beierle, 2002).

Regarding epistemology, social constructivism suggests that we understand (construct) experience and learn to motivate our behaviours based on the communicative aspects of social practice (Reckwitz, 2002; Starks & Trinidad, 2007). Employing this epistemology, I gathered multi-stakeholder perspectives on GIS applications in public health planning for circumpolar development (Carter & Little, 2007). Social constructivism does not imply that objective facts can change, but that we can adapt and strengthen our claim to knowledge of the

issues we are researching by engaging with multiple perspectives (Charmaz, 2004). Polkinghorne (2006) states that in dealing with multiple forms of evidence and manifold perspectives, qualitative researchers should cultivate the "epistemic virtues". These virtues include honesty, integrity, caution, and adaptability, as being open to criticism and unattached to prior attitudes and beliefs (Polkinghorne, 2006). Brown (2003) characterizes these virtues more simply as empathy and a flexible worldview, and Givens and Saumure (2008) term them "trustworthiness". Through open communication with research participants, documentation of my process, memo-ing of ideas, and debriefing with my research collaborators and colleagues, I cultivated the aforementioned epistemic virtues, throughout my research process (Onwuegbuzie & Leech, 2007; Peters & Wester, 2007).

My method was semi-structured interviews and document review/automated content analysis (Brinkmann, 2007; Dinkins, 2005; Grimmer & Stewart, 2013). These methods were appropriate to my research question, by providing multi-stakeholder data on this interdisciplinary topic, for thematic analysis. In my thesis, I did not employ a pure methodological approach in my choice of methods and approach to data collection, as these were tailored to the specific objectives underpinning my research question. However, the goals and principles informing my research design were most aligned with the grounded theory methodology. Rather than beginning with a hypothesis, grounded theory begins with data collection, and through data analysis, theory is generated (Dew, 2007). This methodology reflects both social practice ontology and social constructivist epistemology, because it involves the researcher's continual interpretation and collation of multiple social meanings (Starks & Trinidad, 2007). It is also consistent with the methods I used; for instance, semi-structured interviews require active involvement from the interviewer, who administers a standard interview guide to interviewees with the flexibility to pursue additional lines of questioning (Brinkmann, 2007). Using a semi-structured interview format, I was able to address certain issues across interview participants, while choosing to delve more deeply into areas where interviewees exhibited greater experience or expertise (Brinkmann, 2007).

Further, my use of automated content analysis employed computer processing to rapidly review and characterize extant texts and to understand processes in the data according to specific parameters I set as the researcher (Benoit et al, 2009; Hopkins & King, 2010). Using document review/automated content analysis, I worked with elements of grounded theory methodology by creating text models highlighting key social constructions in the extensive public record of northern Canadian environmental assessments (EA) (Grimmer & Stewart, 2013). In both methods, I framed my findings within a thorough review of the research literature, with a view to increasing the transferability of my research as relevant to the emergence of health impact assessment research and processes in EA jurisdictions across the circumpolar arctic and subarctic (Malterud, 2001).

2.3 Chapter Three: "Can Geographic Information Systems Improve Consultations in Circumpolar Development?"

My first research paper, "Can Geographic Information Systems Improve Consultations in Circumpolar Development" is formatted for the journal *Global Environmental Change*. In this chapter, I present my findings on how circumpolar experts in policy, research, and practice regard GIS as a tool for improving communication and consultations about health inequities and impacts in circumpolar indigenous communities.

2.3.1 Ethics and Funding

The University of Alberta Health Research Ethics Board 1 reviewed and gave ethics approval to my research protocol, recruitment process, letter of invitation, information and informed consent form, and interview guide on June 29, 2012, with renewed approval extending to June 18, 2014 (#31998; Appendix A). The content of my submission for review was guided by Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (2010), which requires adherence to the principles of informed consent, fairness and equity in research participation, and privacy and confidentiality for research participants' personal and research data (Canadian Institutes of Health Research [CIHR] et al, 2010).

I selected individuals for recruitment based on my understanding of their demonstrated knowledge and expertise on a wide spectrum of topics related to my research question, and not according to any other discriminating factors (Caine et al, 2007). Everyone who I contacted about the research (including people who declined to participate) were treated with equal courtesy and respect, during recruitment and throughout the research process. I provided all of the interviewees with the research materials (the letter of invitation, information and informed consent form, and interview guide) for review, ahead of the interviews (Brinkmann, 2007). Interviewees were given the opportunity to ask me questions about the research before providing written consent for their participation (Starks & Trinidad, 2007). Prior to commencing the interview, I assured the interviewees that they need not answer any uncomfortable questions, and could stop the interview at any time, for unspecified reasons (Rogers & Lange, 2013).

Following the interviews, I returned an electronic version of the interview transcript to the participants for verification and revision. If the interviewee changed their interview transcript, only that version was analysed, and the previous version was discarded. Furthermore, I informed the participants that they could withdraw from the research within four weeks of my emailing them their transcript, and all records of their participation would be destroyed. The interview materials were de-identified retained on a password protected computer network, and further anonymized in my research papers (CIHR, 2010). The research assistant who worked on this section of the thesis signed and adhered to a confidentiality agreement.

My research was funded by the Northern Scientific Training Program (NSTP), the Circumpolar/Boreal Alberta Research (C/BAR) Grant, the ArcticNet Network of Centres of Excellence of Canada, the University of Alberta Shell Canada Enhanced Learning Fund (SELF), and the School of Public Health Travel Award. Although application proposals were required for NSTP, C/BAR, and SELF, none of the funders had direct input into the research protocol or dissemination. I declare no conflict of interest in my research protocol, or dissemination of results.

2.3.2 Sampling and Recruitment

Recruitment was an iterative component of my study design, allowing me to expand the scope of my inquiry as interviewees addressed and emphasized different topics relevant to this line of inquiry. I recruited 30 circumpolar stakeholders, who were purposively sampled as having demonstrated expertise in arctic and subarctic policy, research, and practice. My participants were drawn from different jurisdictions of the arctic including Canada (n=9), the United States (n=18), Europe (n=2), and Russia (n=1); five interviewees self-identified as indigenous. Expertise which met my inclusion criteria for recruitment spanned GIS, natural resource development, and circumpolar indigenous health. A complete breakdown of interviewee expertise is provided in Chapter 3 (Table 3-1). I mainly recruited interviewees by email and onsite, at the 2012 International Congress on Circumpolar Health (n=15), as well as through snowball sampling by which interviewees recommended other experts for interviews (n=10). In addition, I interviewed authors of academic literature (n=5) to bridge identified gaps in the research sample. As mentioned in my ethics and funding section, all of the research participants received a letter of invitation, the information and informed consent form (Appendix B), and the interview guide (Appendix C), and provided written consent to participate, prior to the interview.

2.3.3 Data Collection and Analysis

I used a semi-structured interview guide with each interviewee, tailoring my questions to their area of expertise. I provide a list of the interview questions in Chapter 3 (Table 3-2), and the interview guide that was approved by Health Research Ethics Board 1 in the appendices (Appendix C). My interview guide was informed by a literature review and input from my thesis committee members, who provided expertise to improve the depth and breadth of my questions on arctic science policy, intellectual property law, health impact assessment, and risk communication. I conducted 29 semi-structured interviews with 30 interviewees, either in person (n=14) or by telephone (n=16) between July and October 2012. Although the collection of data both in-person and by telephone may have some implications for validity within certain research designs (particularly in phenomenological research), I feel that my data collection strategy was

appropriate to ensure the broadest representation of experts. Without the use of telephone interviews, I would not have had the resources to consult as broadly with experts in a variety of jurisdictions. Moreover, because I was conducting interviews with experts, the content of their responses to interview questions was informed by their professional work, and thus less susceptible to social influences in the interview setting. Therefore, I am confident that the use of both in-person and telephone interviews was an appropriate data collection strategy. During the interviews, I provided ample opportunity for the participants to express their perspectives, beyond those solicited by the interview questions. Each interview was approximately 20-30 minutes in length, based on the recommendation of one of my committee members, who recognized that time constraints would otherwise limit my pool of expert interviewees.

I digitally recorded and took notes during the interviews, as well as jotting down my reflections afterward. A professional transcriptionist working under the confidentiality requirements of the Law and Risk Communication in Health (LaRCH) research group transcribed the interviews, which I then verified for accuracy. I returned the interview transcripts to interviewees for their review and revision, providing an opportunity for participants to alter their responses, and withdraw from the research, if necessary. None of the interviewees withdrew participation, although there were minor revisions to the transcripts. Any revisions to the transcripts were incorporated into my dataset for analysis, and previous versions discarded.

My data analysis employed the constant comparison method, which is the process of denoting discrete units of meaning in the data ("coding"), organizing those patterns into an analytic frame ("categorizing"), and interpreting that analytical frame to produce findings that address the research question ("themes")(Leech & Onwuegbuzie, 2011; Peters & Wester, 2007). I reviewed each of the transcripts using NVivo version 10 software, sorting the transcripts with "codes" and recording the meaning of my coding in a preliminary codebook (Leech & Onwuegbuzie, 2011; QSR International 2013). After reading and coding all the transcripts a first time, I returned to earlier transcripts and re-coded them with the appropriate codes that had emerged in later transcripts (Peters &

Wester, 2007). Throughout this coding process, I kept extensive documentation of my analysis, known as "memo-ing", to increase the reflexivity and rigour of my research (Caelli et al, 2003).

Once all of the transcripts had been reviewed and no new codes emerged, I consolidated my codebook. Based on literature review and my knowledge of the data, I organized what I considered to be key codes into categories that would help to address my research question. I removed the other codes from my analysis, retaining them for future research purposes (Polkinghorne, 2006). Returning to my codebook, I defined each key code, providing keywords and several examples from the transcripts (Onwuegbuzie & Leech, 2007). An expert member of my research committee reviewed my codebook. After this preliminary codebook had been finalized, I trained a second coder to return to the dataset and code all of the transcripts (Burnard et al, 2008). We then used the coding comparison functionality of NVivo to identify transcripts with less than 0.7 kappa coefficients, above the 0.6 threshold indicating substantial agreement in the methodology literature (Landis & Koch, 1977; QSR International, 2014). We resolved any discrepancies in coding through discussion to reach consensus on the definition and application of the final codes and final categories. In our final iteration, we developed a codebook with six main categories and 22 codes. The relevant categories and codes for my research paper are presented in Chapter 3 (Table 3-3). With reference to my final codebook, my interview notes, my reflections, my memos, and my literature review, I interpreted themes in the data, and reported these findings, using interviewee quotes in support of my analysis.

2.4 Chapter Four: "How Do Aboriginal Communities Raise Health and Socio-economic Issues in Northern Canadian Environmental Assessment?"

My second research paper, "How Do Aboriginal Communities Raise Health and Socio-economic Issues in Northern Canadian Environmental Assessment?" is formatted for the journal *Environmental Policy and Governance*. In this chapter, I present my findings from conducting document review and automated content analysis on the reports of environmental assessment (EA) and public hearing

transcripts from the public record of the Prairie Creek and Nico natural resource developments proposed in the Mackenzie Valley of the Northwest Territories (NWT) of Canada.

2.4.1 Ethics and Funding

No ethics approvals were required for this research, which employed data obtained from the public registry of the Mackenzie Valley Environmental Impact Review Board. I did, however, travel to the NWT to discuss relevant issues to frame the analysis with EA practitioners and attend public hearings in March and October 2012. My travel in this instance comprised preliminary field work both for this research paper, and for my research as detailed in Chapter 5. As part of that research paper, I obtained both a 2013 and 2014 Research License through the Aurora Research Institute, as required by the *Scientists Act* (R.S.N.W.T. 1988, c. S-4). I describe that licensing process in my Chapter 5 ethics and funding section.

2.4.2 Sampling and Preparation of Data

In this research paper, I examined the health socio-economic content, communication practices of stakeholder groups, and linkages between process and public health planning outcomes in two public hearing transcripts and reports of EA in the Mackenzie Valley, the Prairie Creek lead-silver-zinc mine (EA0809-002) (Figure 2-1) and the Nico gold-copper-cobalt-bismuth mine (EA0809-004) (Figure 2-2).

Figure 2-1. Location of the Prairie Creek mine in the Dehcho region of the NWT (MVEIRB, 2014a).

I selected these two mines after consulting with EA practitioners in the NWT in March 2012, who explained there were potential health impacts to aboriginal communities involved in those EA deliberations (Caine et al, 2009). As part of preliminary fieldwork for this and subsequent research, I attended two of six days of Nico public hearings held in Behchoko, NWT during October 2012. Therefore, as scholars have stated is important to both qualitative and northern research, I was to a certain extent engaged with events "on-the-ground", in addition to performing a desktop analysis (Caine et al, 2007; Charmaz, 2004).

Figure 2-2. Location of the Nico mine in the Tlicho region of the NWT (MVEIRB, 2014b).

I obtained the reports and public hearing transcripts as downloads from the public registry of Mackenzie Valley EA documents (www.reviewboard.ca) (Mackenzie Valley Environmental Impact Review Board [MVEIRB], 2011; MVEIRB, 2013). While I analysed the reports of EA as they were formatted for downloading, the public hearing transcripts required additional preparation prior to analysis. A research assistant parsed the transcripts into two sets of smaller text files, one for each of the individual participants in either the Prairie Creek or Nico public hearings (Prairie Creek =66, and Nico = 144). I assigned each participant to one of five stakeholder groups, consisting of the proponent, aboriginal communities, the territorial government, the federal government, and regulators. As scholars indicate should be stated in the reporting of qualitative research results, the primary unit of analysis for this research paper consisted of those stakeholder groups (Tong et al, 2007).

2.4.3 Data Collection and Analysis

My research employed both document review and automated content analysis to develop text models characterizing the content, communication practices, and linkages in the Prairie Creek and Nico EAs. While document review is researcher-driven, automated content analysis applies computational processing to textual data (Grimmer & Stewart, 2013). I employed five analysis techniques to characterize these two EAs, each of which I present, in turn.

Document review of projects and the health and socio-economic mitigations.

I conducted a document review of the Prairie Creek and Nico reports of EA, comprising two separate parts. First, I read the complete reports, distinguishing the two EAs with a brief narrative summary of the salient features of each mine (Grimmer & Stewart, 2013). Next, informed by literature review, I examined the mitigations listed in the appendices of the reports, discarding those which did not deal with health and socio-economic impacts, and grouping the remainder into categories, informed by literature review. I provide a summary of the health and socio-economic mitigations grouped my category in Chapter 4 (Table 4-1).

Sentiment analysis.

Sentiment analysis is a form of automated content analysis which aims to distinguish the emotive content of text according to parameters established by the researcher (Mohammad & Turney, 2013). For this analysis, I used Wordstat software to identify the 100 most frequent terms in each of the Prairie Creek and Nico transcripts (Budge & Pennings, 2007; Provalis, 2014). The most frequent terms were those used most widely by public hearing participants, versus terms with the highest usage overall. I discarded stopwords (like pronouns and conjunctions) and terms with purely procedural content (like "please", "yes", or "no"), resulting in a set of 38 terms for Prairie Creek, and 54 terms for Nico. Using Wordstat, I conducted a keyword-in-context examination for each of the two lists, reviewing hundreds of sentences to determine the context of each term in the sense that it was used (Leech & Onwuegbuzie, 2011; Provalis, 2014). To complete the sentiment analysis, I grouped the terms into categories, characterizing their overall use in the transcripts, based on the keyword-in-context analysis and my literature review (Peters & Wester, 2007). I present the terms and categories in Chapter 4 (Table 4-2).

Term frequency-inverse document frequency analysis.

Term frequency-inverse document frequency (TF*IDF) provides a measure of the strength of an n-gram in characterizing a document or set of documents (Robertson, 2004). An n-gram consists of one or more words, allowing greater flexibility in automated content analysis for presenting multiple term concepts (such as "traditional knowledge" or "environmental assessment") (Grimmer & Stewart, 2013). I provide the calculation used for TF*IDF in Chapter 4. Using Wordstat, I computed the 10 most frequent n-grams in each of the two transcripts, and report the number and percent of participants who used the n-gram in either public hearing (Table 4-3).

Stakeholder group grade level and proportions analysis.

Using the Python programming language Natural Language Toolkit (NLTK) module, I wrote a number of simple programs to perform calculations on the two public hearing transcripts (Python NLTK, 2014). I calculated the average grade level of communication used by each stakeholder group using the Flesch-Kincaid

Grade Level test, for which I provide the formula in Chapter 4 (Hopkins & King, 2010). I also calculated the total length of all the transcripts in each stakeholder group, and the proportion of the total transcript occupied by each group. Finally, separate from the previous analyses (which were conducted on the complete transcripts) I lemmatized the transcripts by removing inflected forms from root terms, so that only the root would be included in my analysis (Grimmer & Stewart, 2013). For example, "processed" or "processing" would both be lemmatized as "process", and counted as only one unique word. From this lemmatization, I calculated the number of unique vocabulary items in each transcript, and the proportion of the vocabulary used by each stakeholder group. I report the grade level of communication by stakeholder group; length and proportion of total and stakeholder groups' transcripts; and extent and proportion of total and stakeholder groups' vocabulary in Chapter 4 (Table 4-4).

Correspondence plotting analysis.

In automated content analysis, correspondence plotting is used to show in a two-dimensional graph how different categories of text within a document correspond to each other (Beh, 1998). Using Wordstat, I generated a correspondence plot of how the different stakeholder groups as categories corresponded with each other in each of the Prairie Creek and Nico transcripts (Laver & Garry, 2000; Lowe et al, 2011; Provalis, 2014). I present and interpret the correspondence plots in Chapter 4 (Figure 4-2 and Figure 4-3).

2.5 Chapter Five: How Can Geographic Information Systems Support Public Health Planning for Development in Northern Canada?

My third research paper, "How Can Geographic Information Systems Support Public Health Planning for Development in Northern Canada?" is formatted for the journal *Arctic*. In this chapter, I present my findings on how stakeholders in a northern Canadian EA view the utility of GIS for communication and consultations about the social determinants of health, using a theoretical framework derived from organizational analysis (Scott & Davis, 2007).

2.5.1 Ethics and Funding

The University of Alberta Health Research Ethics Board 1 reviewed and gave ethical approval to my research protocol, recruitment process, letter of invitation, information and informed consent form, and interview guide on January 14, 2013, with renewed approval extending to January 12, 2015 (#34519)(Appendix D). Under the Northwest Territories *Scientists Act*, the Aurora Research Institute licensed me to conduct my research with a 2013 Scientific Research License (#15242)(Appendix E), and a renewed 2014 Scientific Research License (#15409)(Appendix F)(R.S.N.W.T. 1988, c S-4). The Aurora Research Institute issued its license based on both the approval of the University of Alberta Health Research Ethics Board 1, and their own process of consulting with regional interests in the Northwest Territories about the acceptability of my research proposal.

The content of my submission for this ethical review and licensing was guided by Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (2010), involving the same principles of informed consent, fairness and equity, and privacy and confidentiality, which I discussed with respect to my research for Chapter 3 (CIHR et al, 2010). In addition, since I was working in the context of legal structures and policies directly affecting aboriginal peoples, my submission was informed by Tri-Council principles of respect for aboriginal government and customary structures, meaningful engagement with aboriginal communities, and the opportunity for participants to review findings prior to dissemination (CIHR et al, 2010). In considering and preparing my applications, I recognized aboriginal peoples' distinct perspectives on research, the complexity of negotiating community consent, and the importance of relationship building (Flicker & Worthington, 2012).

I participated in preliminary consultations with the Mackenzie Valley Environmental Impact Review Board (MVEIRB), the Wek'eezhii Land and Water Board (WLWB), and members of the Tlicho Government, establishing research relationships prior to the development of my research protocol and ethics applications (Caine et al, 2009). I selected research participants based on a clearly defined inclusion criterion of their having participated in the Nico EA

representing a stakeholder group (Starks & Trinidad, 2007; Tong et al, 2007). Each individual who I contacted was given equal consideration and respect, whether or not they decided to participate (Polkinghorne, 2006). As in my Chapter 3 protocol, I provided all of the interviewees with the research materials, including a letter of invitation, the information and informed consent form (Appendix G), and the interview guide (Appendix H), prior to conducting an interview (Brinkmann, 2007). I encouraged the interviewees to ask me about the research, assuring them they need not answer any uncomfortable questions, and could stop the interview and withdraw from the research, if necessary. None of the research participants withdrew their participation from the research.

As the informed consent processes can run counter to cultural traditions within indigenous populations, who may prefer a collective decision on whether or not to participate, informed consent was obtained both in writing, and through a series of multi-participant discussions with members of the Tlicho Government (CIHR, 2010; Flicker & Worthington, 2012; Rogers & Lange, 2013). As in my previous protocol, I returned the transcripts to interviewees by email for verification and revision. I incorporated any revisions into my analysis, discarding previous versions. I de-identified all of my research materials and research papers, and retained the information on a password protected computer network (CIHR, 2010). The research assistant, who had access to interview transcripts, signed and adhered to a confidentiality agreement.

My research received funding from the Northern Scientific Training Program (NSTP), the Circumpolar/Boreal Alberta Research (C/BAR) Grant, and the ArcticNet Network of Centres of Excellence of Canada. Although application proposals were required for NSTP and C/BAR, funding influenced neither my research protocol nor my dissemination. I declare that I had no conflict of interest in either of my research protocol of dissemination of results.

2.5.2 Sampling and Recruitment

My research focused on stakeholders in the EA for the Nico gold-cobalt-copper-bismuth mine proposed in the Wek'eezhii region of the NWT by Fortune Minerals Limited in 2009 (Nico EA0809-004)(MVEIRB, 2013). During initial

fieldwork consultations, the staff of the MVEIRB, the WLWB, and the Tlicho Government all identified Nico as an appropriate case study for my research because the Nico EA employed GIS in a novel capacity and aboriginal community health and well-being was a prominent concern (Caine et al, 2009). Indeed, the proposed Nico mine will be located only 50 kilometers from the Tlicho community of Whati (population 509), and would be proximal to Behchoko (population 2064), Gameti (population 311), and Wekweeti (population 145) (Government of the Northwest Territories Bureau of Statistics, 2011). To gain a better understanding of the Nico EA process, I attended two out of six public hearing dates for the mine in October 2012, in Behchoko, NWT.

I recruited 13 interviewees from the Nico EA, purposively sampling to engage all of the key regional groups working with GIS or in an implementation capacity to mitigate impacts of development on Tlicho communities. These interviewees comprised representatives from the territorial government, regional regulatory agencies, the aboriginal government and its consultants, and the proponents and its consultants. I recruited interviewees by sampling directly from the public record of EA (n=1), from my networking at the public hearings (n=3), from the participants in my preliminary fieldwork (n=4), and by snowball sampling based on the recommendations of interviewees and other experts (n=5) (Tong et al, 2007). I present the specific affiliations of my interviewees in Chapter 5 (Table 5-1). All of the interviewees received a letter of invitation, the information and informed consent form, and the interview guide, providing their consent prior to the interviews.

2.5.3 Data Collection and Analysis

As detailed above in the data collection and analysis section of this chapter, I used a semi-structured interview guide in my data collection for this research paper. My interview guide was informed by literature review and by my two previous thesis research projects, and probed for confirmations, refutations, and examples of how GIS contributed or could be used in public health planning for development impacts (Charmaz, 2004). My thesis committee reviewed and revised my interview guide for depth and breadth of coverage. In Chapter 5, I provide a list of my interview questions (Table 5-2). A copy of the interview guide

approved by Health Research Ethics Board 1 can be found in my appendices (Appendix H).

I conducted the semi-structured interviews in-person in Yellowknife or Behchoko in the NWT (n=11), and by telephone from Edmonton, Alberta (n=2) between June and October 2013. Again, although the use of both in-person and telephone interviews can impact research validity in some research designs, I felt my approach to data collection was appropriate. While the majority of the interviews were conducted in the NWT where the EA took place, interviewees who participated by telephone resided outside of the NWT or the greater Edmonton area. However, those two stakeholders brought key perspectives to the research, based on their unique contribution to the Nico EA. Moreover, as with my expert interviews in Chapter 3, participants were involved in my research within their professional capacities, and so were less influenced in their interviews by the social context. Therefore, I feel that it was appropriate to use both in-person and telephone interviews in my approach to data collection. I digitally recorded the interviews, which ranged from 40 minutes to over an hour in length. I transcribed the interviews verbatim, made a few slight edits for syntactical clarity (removing "so" and "and" to separate long passages into separate sentences, for example). I then returned the transcripts to the interviewees for their review and revision, incorporating any changes they made into my analysis and discarding previous versions. This kind of verification can improve the accuracy of qualitative analysis, contributing to the rigour of the research (Onwuegbuzie & Leech, 2007). To assist my later interpretation of the dataset, I took notes during the interviews, recorded my reflections afterward, and documented my ideas, theories, and methods as I transcribed (Polkinghorne, 2006).

As detailed above in the previous data collection and analysis section for this chapter, I employed the constant comparison method for my data analysis. In brief, using NVivo software, I applied a complete set of "codes" to all of the transcripts, organized these codes into "categories", and then interpreted "themes" from this organization of my data (Leech & Onwuegbuzie, 2011; Peters & Wester, 2007; QSR International, 2014). I documented my choices using

"memos", and compared my interpretations with the notes and reflections I had documented from the interviews and transcription process (Caelli et al, 2003). Although my constant comparison codes were inductively interpreted from the data, I also referred to the memos from my research in Chapter 3, to increase my efficiency (Polkinghorne, 2006).

From my initial coding and categorization of the transcripts, I created a codebook including my categories, codes, definitions, keywords, and examples from the texts. I trained a research assistant to use the codebook to code 61.5% of the transcripts. Using NVivo, we calculated the kappa coefficients for the dataset, discussing and clarifying all codes with kappa scores of less than 0.8, a cut-off above the 0.6 substantial inter-coder agreement value in the methodological literature (Landis & Koch, 1977; QSR International, 2014). After resolving conflicting interpretations, we recalculated kappa scores, and all were above 0.8, indicating excellent agreement (McHugh, 2012). The eight final codes that I used and the categories into which I grouped them are presented in Chapter 5 (Table 5-3). To interpret my analysis and present emergent themes in the data, I adapted an organizational analysis framework to assign its key variables (Objective, Process, Social Practice, and Technology) to my categories and coding scheme (Scott & Davis, 2007). By presenting the results of my research in this manner, I aimed both to collate my relevant interview data and generate a content analysis for my research participants to use, and also to increase the transferability of my results to jurisdictions outside the Mackenzie Valley (Moran-Ellis et al, 2006).

2.6 Methodological Rigour

Rigor is a theoretical versus technical issue; in qualitative research, researchers must be able to articulate their approach to rigour as philosophically and methodologically appropriate to their research (Caelli et al, 2003). In my personal statement on philosophical considerations at the outset of this chapter, I described how my ontological, epistemological, and method choices suit the nature of my research question (Hallberg, 2006). From these philosophical foundations, I consider that the rigour of my qualitative research should be

assessed in a manner broadly invoking the precepts of post-normal science (Aslaksenet et al, 2013). My approach to rigour derives from both the literature of natural resource management, which is practice-oriented, and a debate in the qualitative literature about quality of research (Rodela, 2012; Morse et al, 2002). In the 1980s, qualitative researchers Guba and Lincoln seminally argued that rigour should include four aspects: credibility, transferability, dependability, and confirmability, each of which could be enhanced through the use of reflexive techniques in the research process, such as an audit trail, memo-ing, debriefing, and member checking (Morse et al, 2002). Since then, other researchers have suggested that more appropriate criteria for rigorous qualitative inquiry would be based on its instrumental value, including "overall significance, relevance, impact, and the utility of completed research" (Caelli et al 2003; Morse et al, 2002, p. 3). Rather than subscribing to either perspective alone, my thesis adapts constructs from both sides of the debate under the paradigm of post-normal science, which is increasingly being applied to problems in natural resource management (Aslaksenet et al, 2013).

Post-normal science is a paradigm from environmental philosophy, which emphasizes problem-oriented research, the production of knowledge by increasing community involvement, and the capacity for iterative actions in the face of urgent but uncertain situations (Turnpenny et al, 2011). In a post-normal science context, both qualitative and quantitative approaches are appropriate; the value of either form of research is judged by its applicability to solving problems in the real world context (Kueffer et al, 2012). In the qualitative methodology literature, Mays and Pope (1998) were among the first to suggest that the rigour of both quantitative and qualitative research should be judged in broadly similar terms, specifically on relevance and validity (reflecting both Guba and Lincoln's process-oriented and more instrumental approaches) (Malterud, 2001; Morse et al, 2002). These criteria correspond with a post-normal science perspective, in that various ontological, epistemological, and methodological choices in a qualitative (or quantitative) research protocol can be tailored in relevance and validity to solving real world problems (Polkinghorne, 2006). To these two measures of rigour, I add reflexivity, as recognition of researchers' framing of issues, and credibility, as a measure of the acceptability of the research design,

process, and outcomes for other stakeholders addressing a problem (Caelli et al., 2003; Flicker & Worthington, 2012; Starks and Trinidad, 2007; Tong et al, 2007). In the following sections, I outline my consideration of relevance, validity, reflexivity, and credibility in my thesis research.

Relevance.

Relevance is a measure of the extent to which research effectively addresses a problem in terms of contextual needs, constraints, and uncertainties (Mays & Pope, 1998). In a northern research context, indigenous peoples are increasingly articulating the problem of sustainability, with attendant concern for community health and well-being (Caine et al., 2009). To ensure the relevance of my thesis research, I approached my research question from three perspectives. First, I consulted with experts in policy, research, and practice (Chapter 3). Next, I constructed text models evincing the centrality of health and socio-economic concerns in the public records of natural resource development reviews (Chapter 4). Finally, I consulted with stakeholders in the review of the Nico project in the Mackenzie Valley, NWT (Chapter 5). I feel that this trifold approach, in conjunction with my other measures of rigour, ensured that I understood the needs, constraints, and uncertainties of using GIS in communication and consultations to address the socio-ecological parameters of health and well-being relative to circumpolar development (Charmaz, 2004; Moran-Ellis et al, 2006).

Validity.

Validity is a measure of internal and external consistency, and is necessary for understanding the applicability of research findings to addressing a problem (Onwuegbuzie & Leech, 2007). Qualitative research validity is affected by its research protocol, requiring the proper conduct of ethics and funding; sampling and recruitment; and data collection and analysis. I extensively detail my research protocols in this chapter, in each of the research papers, and in the appendices of my thesis. I justify my choices at each stage, arguing that my work is consistent both with itself and with the real world context of the research (conveyed through the data and substantial literature review). By establishing a high degree of validity in my work, my goal was to increase the applicability and

transferability of my research findings to the real world circumpolar setting (Kueffer et al, 2012).

Reflexivity.

Reflexivity is a measure of the degree to which the researcher engages with their own perspective, recognizing that it influences all aspects of qualitative research (Starks & Trinidad, 2007). My practices to increase the reflexivity of my thesis research include extensively memo-ing at each stage of the research process; consulting with collaborators, colleagues, and mentors; participating in conferences and workshops in relevant topic areas; and exchanging email correspondence with research participants (Caelli et al, 2003; Peters & Wester, 2007). Through this self-reflective process, I feel that I was able to develop some of the aforementioned "epistemic virtues" of honesty, integrity, caution, adaptability, empathy, openness to criticism, and a flexible worldview, bracketing my biases (although a phenomenological term, still relevant to my research approach) to become a more competent qualitative researcher (Brown, 2003; Malterud, 2001; Polkinghorne, 2006; Scammell, 2010).

Credibility.

Credibility is a measure of the demonstrability of evidence in the research, as well as how the research and researchers are accepted in the broader context of a problem and its stakeholders (Starks & Trinidad, 2007). I provide extensive examples of the evidence that I used to reach my conclusions throughout my research papers. Ethical review, licensing, and funding of my project, as described in the ethics and funding sections of this chapter, involved an evaluation of the credibility of my research by external reviewing parties (CIHR, 2010; Flicker & Worthington, 2012). Additionally, I was able to establish that my research is viewed as credible through my participation and presentation of preliminary results at major academic meetings, such as the International Congress of Circumpolar Health in August 2012, Arctic Science Summit Week in April 2013, and the ArcticNet Annual Scientific Meeting in December 2013. I look forward to presenting my final thesis chapters to my research participants for their feedback, and moving forward from understanding how they perceive the

relevance, validity, reflexivity, and credibility of my work in relation to my research question.

2.7 Works Cited

Aslaksen, I., Glomsrød, S., & Myhr, A. I. (2013). Post-normal science and ecological economics: Strategies for precautionary approaches and sustainable development. *International Journal of Sustainable Development*. 16(1-2), 107-126.

Bailey, K., & Grossardt, T. (2010). Toward structured public involvement: Justice, geography and collaborative geospatial/geovisual decision support systems. *Annals of the Association of American Geographers*. 100(1), 57-86.

Bartlett, J. G., Madariaga-Vignudo, L., O'Neil, J. D., & Kuhnlein, H. V. (2007). Identifying indigenous peoples for health research in a global context: A review of perspectives and challenges. *International Journal of Circumpolar Health*. 66(4), 287-307.

Beh, E. J. (1998). A comparative study of scores for correspondence analysis with ordered categories. *Biometrical Journal*. 40(4), 413-429.

Beierle, T. C. (2002). The quality of stakeholder-based decisions. *Risk Analysis*. 22(4), 739-749.

Benoit, K., Laver, M., & Mikhaylov, S. (2009). Treating words as data with error: Uncertainty in text statements of policy positions. *American Journal of Political Science*. 53(2), 495-513.

Brinkmann, S. (2007). Could interviews be epistemic?: An alternative to qualitative opinion polling. *Qualitative Inquiry*. 13(8), 1116-1138.

Brown, J. H., Burnside, W. R., Davidson, A. D., Delong, J. R., Dunn, W. C., Hamilton, M. J., Zuo, W. (2011). Energetic limits to economic growth. *BioScience*. 61(1), 19-26.

Brown, P. (2003). Qualitative methods in environmental health research. *Environmental Health Perspectives*. 111(14), 1789-1798.

Budge, I., & Pennings, P. (2007). Do they work? Validating computerised word frequency estimates against policy series. *Electoral Studies*. 26(1), 121-129.

Burnard, P., Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Analysing and presenting qualitative data. *British Dental Journal*. 204(8), 429-432.

Butz, W. P., & Torrey, B. B. (2006). Some frontiers in social science. *Science*. 312(5782), 1898-1900.

Caelli, K., Ray, L., & Mill, J. (2003). 'Clear as mud': Toward greater clarity in generic qualitative research. *International Journal of Qualitative Methods*. 2(2).

Caine, K. J., Davison, C. M., & Stewart, E. J. (2009). Preliminary field-work: Methodological reflections from northern Canadian research. *Qualitative Research*. 9(4), 489-513.

Caine, K. J., Salomons, M. J., & Simmons, D. (2007). Partnerships for social change in the Canadian North: Revisiting the insider-outsider dialectic. *Development and Change*. 38(3), 447-471.

Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and Humanities Research Council of Canada (2010). *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*. Retrieved from http://www.pre.ethics.gc.ca/pdf/eng/tcps2/TCPS_2_FINAL_Web.pdf

Carter, S. M., & Little, M. (2007). Justifying knowledge, justifying method, taking action: Epistemologies, methodologies, and methods in qualitative research. *Qualitative Health Research*. 17(10), 1316-1328.

Chambers, K. J., Corbett, J., Keller, C. P., & Wood, C. J. B. (2004). Indigenous knowledge, mapping, and GIS: A diffusion of innovation perspective. *Cartographica*. 39(3), 19-31.
Charmaz, K. (2004). Premises, principles, and practices in qualitative research: Revisiting the foundations. *Qualitative Health Research*. 14(7), 976-993.
Christensen, J., & Grant, M. (2007). How political change paved the way for indigenous knowledge: The Mackenzie Valley Resource Management Act. *Arctic*. 60(2), 115-123.
Cundill, G., & Rodela, R. (2012). A review of assertions about the processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*. 113, 7-14.
Derry, R. (2012). Reclaiming marginalized stakeholders. *Journal of Business Ethics*. 111(2), 253-264.
Dew, K. (2007). A health researcher's guide to qualitative methodologies. *Australian and New Zealand Journal of Public Health*. 31(5), 433-437.
Dinkins, S. C. (2005). Shared inquiry: Socratic hermeneutic interpre-viewing. In P. Ironside & N. Diekelmann (Eds.), *Beyond Method: Philosophical Conversations in Healthcare Research and Scholarship* (111-147). Madison: University of Wisconsin Press.
Erden, Z., Schneider, A., & von Krogh, G. (In Press). The multifaceted nature of social practices: A review of the perspectives on practice-based theory building about organizations. *European Management Journal*. DOI: 10.1016/j.emj.2014.01.005
Flicker, S., & Worthington, C. A. (2012). Public health research involving aboriginal peoples: Research ethics board stakeholders' reflections on ethics principles and research processes. *Canadian Journal of Public Health*. 103(1), 19-22.
Getty, G. A. (2010). The journey between western and indigenous research paradigms. *Journal of Transcultural Nursing*. 21(1), 5-14.
Givens, L. M. & Saumure, K. (2008). Trustworthiness. In L. M. Given (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods* (896-897). Thousand Oaks: SAGE Publications.
González, A., Gilmer, A., Foley, R., Sweeney, J., & Fry, J. (2008). Technology-aided participative methods in environmental assessment: An international perspective. *Computers, Environment and Urban Systems*. 32(4), 303-316.
Government of Northwest Territories Bureau of Statistics. (2011). *Population Projections*. http://www.statsnwt.ca/population/community-projections/ [Last accessed on April 27, 2014]
Grimmer, J., & Stewart, B. M. (2013). Text as data: The promise and pitfalls of automatic content analysis methods for political texts. *Political Analysis*. 21(3), 267-297.
Hallberg, L. R. M. (2006). The "core category" of grounded theory: Making constant comparisons. *International Journal of Qualitative Studies on Health and Well-being*. 1(3), 141-148.
Hopkins, D. J., & King, G. (2010). A method of automated nonparametric content analysis for social science. *American Journal of Political Science*. 54(1), 229-247.
Houde, N. (2007). The six faces of traditional ecological knowledge: Challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 12(2).

Kelly, P. (2014). Intercultural comparative research: rethinking insider and outsider perspectives. *Oxford Review of Education*. 40(2), 246-265.
Kueffer, C., Underwood, E., Hadorn, G. H., Holderegger, R., Lehning, M., Pohl, C., Schirmer, M., Schwarzenbach, R., Stauffacher, M., Wuelser, G. & Edwards, P. (2012). Enabling effective problem-oriented research for sustainable development. *Ecology and Society*. 17(4).
Laver, M., & Garry, J. (2000). Estimating policy positions from political texts. *American Journal of Political Science*. 44(3), 619-634.
Leech, N. L., & Onwuegbuzie, A. J. (2011). Beyond constant comparison qualitative data analysis: Using NVivo. *School Psychology Quarterly*. 26(1), 70-84.
Louis, R. P., Johnson, J. T., & Pramono, A. H. (2012). Introduction: Indigenous cartographies and counter-mapping. *Cartographica*. 47(2), 77-79.
Lowe, W., Benoit, K., Slava, M., & Laver, M. (2011). Scaling policy preferences from coded political texts. *Legislative Studies Quarterly*. 36(1), 123-155.
Mackenzie Valley Environmental Impact Review Board [MVEIRB]. (2014a). Canadian Zinc Corporation - Prairie Creek Mine - EA0809-002 [2008]. Retrieved from the MVEIRB Public Registry http://www.reviewboard.ca/registry/project.php?project_id=70 [Last accessed on May 7, 2014]
Mackenzie Valley Environmental Impact Review Board [MVEIRB]. (2014b). Fortune Minerals Ltd. - Nico Project - EA0809-004. Retrieved from the MVEIRB Public Registry [2009] http://www.reviewboard.ca/registry/project.php?project_id=72 [Last accessed on May 7, 2014]
Mackenzie Valley Environmental Impact Review Board [MVEIRB]. (2013). Report of environmental assessment and reasons for decision: EA 0809-004 Fortune Minerals Limited Nico Project. Retrieved from the MVEIRB Public Registry http://www.reviewboard.ca/upload/project_document/EA0809-004_NICO_Report_of_EA_and_Reasons_for_Decision.PDF
Mackenzie Valley Environmental Impact Review Boad [MVEIRB]. (2011). Report of environmental assessment and reasons for decision: EA0809-002: Canadian Zinc Corporation Prairie Creek Mine. Retrieved from the MVEIRB Public Registry. http://reviewboard.ca/upload/project_document/EA0809-002_Report_of_Environmental_Assessment_and_Reasons_for_Decision_1328709638.PDF
Malterud, K. (2001). Qualitative research: Standards, challenges, and guidelines. *Lancet*. 358(9280), 483-488.
Mayan, M. J. (2009). *Essentials of Qualitative Inquiry*. Walnut Creek, CA: Left Coast Press.
Mays, N., & Pope, C. (1995). Rigour and qualitative research. *British Medical Journal*. 311(6997), 109-112.
Mohammad, S. M., & Turney, P. D. (2013). Crowdsourcing a word-emotion association lexicon. *Computational Intelligence*. 29(3), 436-465.
Moran-Ellis, J., Alexander, V. D., Cronin, A., Dickinson, M., Fielding, J., Sleney, J., & Thomas, H. (2006). Triangulation and integration: Processes, claims and implications. *Qualitative Research*. 6(1), 45-59.

Morse, J. M., Barrett, M., Mayan, M., Olson, K., & Spiers, J. (2002). Verification strategies for establishing reliability and validity in qualitative research. *International Journal of Qualitative Methods*. 1(2), 1-19.
Nolas, S. M. (2014). Towards a new theory of practice for community health psychology. *Journal of Health Psychology*. 19(1), 126-136.
Onwuegbuzie, A. J., & Leech, N. L. (2007). Validity and qualitative research: An oxymoron? *Quality and Quantity*. 41(2), 233-249.
Palmer, M. (2012). Theorizing indigital geographic information networks. *Cartographica*. 47(2), 80-91.
Peters, V., & Wester, F. (2007). How qualitative data analysis software may support the qualitative analysis process. *Quality and Quantity*. 41(5), 635-659.
Polkinghorne, D. E. (2006). An agenda for the second generation of qualitative studies. *International Journal of Qualitative Studies on Health and Well-being*. 1(2), 68-77.
Pop, I. A., van Ingen, E., & van Oorschot, W. (2013). Inequality, wealth and health: Is decreasing income inequality the key to create healthier societies? *Social Indicators Research*. 113(3), 1025-1043.
Potvin, L., Gendron, S., Bilodeau, A., & Chabot, P. (2005). Integrating social theory into public health practice. *American Journal of Public Health*. 95(4), 591-595.
Provalis. (2014). Wordstat Software.
QSR International. (2014). NVivo Version 10 Software.
Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *European Journal of Social Theory*. 5(2), 243-263.
Robertson, S. (2004). Understanding inverse document frequency: On theoretical arguments for IDF. *Journal of Documentation*. 60(5), 503-520.
Rodela, R. (2013). The social learning discourse: Trends, themes and interdisciplinary influences in current research. *Environmental Science and Policy*. 25, 157-166.
Rodela, R., Cundill, G., & Wals, A. E. J. (2012). An analysis of the methodological underpinnings of social learning research in natural resource management. *Ecological Economics*. 77, 16-26.
Rogers, W., & Lange, M. M. (2013). Rethinking the vulnerability of minority populations in research. *American Journal of Public Health*. 103(12), 2141-2146.
Sahakian, M., & Wilhite, H. (2014). Making practice theory practicable: Towards more sustainable forms of consumption. *Journal of Consumer Culture*. 14(1), 25-44.
Scammell, M. K. (2010). Qualitative environmental health research: An analysis of the literature, 1991-2008. *Environmental Health Perspectives*. 118(8), 1146-1154.
Scientists Act, Revised Statutes of the Northwest Territories. (1988, c. S-4). Retrieved from the Canadian Legal Information Institute website http://www.canlii.org/en/nt/laws/stat/rsnwt-1988-c-s-4/latest/rsnwt-1988-c-s-4.html
Scott, R., W., & Davis, G., F. (2007). The subject is organizations; The verb is organizing. In *Organizations and Organizing: Rational, Natural, and Open System Perspectives* (1-34). New Jersey: Pearson Prentice Hall.

Spangenberg, J. H. (2010). The growth discourse, growth policy and sustainable development: Two thought experiments. *Journal of Cleaner Production*. 18(6), 561-566.
Starks, H., & Trinidad, S. B. (2007). Choose your method: A comparison of phenomenology, discourse analysis, and grounded theory. *Qualitative Health Research*. 17(10), 1372-1380.
Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 19(6), 349-357.
Turnpenny, J., Jones, M., & Lorenzoni, I. (2011). Where now for post-normal science?: A critical review of its development, definitions, and uses. *Science Technology and Human Values*. 36(3), 287-306.
Wilson, K., & Young, T. K. (2008). An overview of aboriginal health research in the social sciences: Current trends and future directions. *International Journal of Circumpolar Health*. 67(2-3), 179-189.
Winiecki, D. J. (2010). Rational, natural, and open: Organizational system typologies and their relevance for performance improvement professionals. *Performance Improvement*. 49(5), 35-41.
Wright, D. J., Duncan, S. L., & Lach, D. (2009). Social power and GIS technology: A review and assessment of approaches for natural resource management. *Annals of the Association of American Geographers*. 99(2), 254-272.

Chapter Three:

"Can Geographic Information Systems Improve Consultations in Circumpolar Development?"

3.1 Introduction

The circumpolar region is the homeland of over thirty indigenous peoples (Kraft Sloan & Hik, 2008). Spanning eight arctic countries, this vast land area has an abundance of non-renewable and renewable natural resources (Johnson & Miyanishi, 2012). Industry, government, and many indigenous groups promote natural resource development to improve the arctic economy (Wilson & Alcantara, 2012). Yet research shows that unsustainable development can worsen material hardships, social pathologies, and health inequities (Asselin & Parkins, 2009; Davison & Hawe, 2012; Noble & Bronson, 2006).

Indigenous peoples have poorer health indicators than the general population in the circumpolar nations, and face added barriers to improving their health status (King et al, 2009). Overall, they experience lower socio-economic standing, higher morbidity, higher mortality, and shorter life-expectancy (Gracey & King, 2009). Because of the remoteness of the communities, healthcare access, social and mental health services, water and sanitation, and food security are challenges (Brubaker et al, 2011; Ford, 2012; Ford & Beaumier, 2011; Ritter, 2007). Moreover, the colonial legacy faced by indigenous peoples is one of political, legal, economic, and cultural marginalization from the state and its resources (Hall, 2013; Macintosh, 2012). Indigenous peoples are therefore the arctic and subarctic residents most affected, and potentially impacted, by natural resource developments (Chatwood et al, 2012).

To mitigate negative impacts and ensure indigenous peoples share in benefits for sustainable natural resource development, mechanisms and tools are needed to ensure full participation in decision-making (Kwiatkowski, 2011; Kwiatkowski & Ooi, 2003). One potential tool is the use of Geographic Information Systems (GIS) to aid in communication and consultations on arctic natural resource management (McCarthy et al, 2012). This study is one of the first to engage circumpolar stakeholders on the utility of GIS as a decision-making platform inclusive of environmental, social, and health impacts (González et al, 2008). The main forum in which GIS may be employed is environmental assessment (EA), which takes various forms in circumpolar Canada, the United States, Russia, and

Europe (González et al, 2008; Solodyankina & Koeppel, 2009). My research findings focus on the northern Canadian context, although the recommendations may be relevant to other parts of the arctic.

In Canada, EA is a forum where government, industry, and community members meet to approve or reject proposed developments (Hanna & Vanclay, 2013; Kwiatkowski, 2011). Research shows that this public process benefits both participants and the quality of decision-making (Beierle, 2002; Fitzpatrick et al, 2008). EA follows four basic phases of screening, scoping, evaluating impacts, and recommendation (McCaig, 2005). Each of these phases informs of the nature of the proposal, understanding of baseline conditions, and potential impacts of development (Noble & Birk, 2011). Legislative and judicial mandates direct EA; the government of Canada is legally obligated to consult and accommodate indigenous peoples as affected, and potentially impacted, parties (Galbraith et al, 2007).

While EA routinely involves participation by indigenous peoples, health impacts are often overlooked (Bronson & Noble, 2006). Potential health impacts of natural resource development include interference with subsistence harvesting practices, loss of language and culture, decreased social cohesion, income disparity, mental health problems, violence, addictions, and social stratification (Asselin & Parkins, 2009; Birley, 2005; Davison & Hawe, 2012). Identifying and mitigating these health impacts requires both institutional capacity and flexibility in EA. Further, institutional capacity is necessary to collect, analyse, and interpret information about indigenous peoples' health inequities (Armitage et al, 2008). Institutional flexibility and the use of GIS would improve communication about identified issues during EA, and help to focus mitigations on the health and well-being of communities (Christensen & Grant, 2007).

New applications of GIS are at the frontier of social sciences (Butz & Torrey, 2006). GIS has the flexibility and capacity to examine a multitude of geospatial variables at once, and facilitates the networking of science across many social gradients (Bailey & Grossardt, 2010). In brief, GIS consists of technologies, systems, and personnel for the collection, storage, retrieval, and manipulation of geospatial data (Palmer, 2012). It allows greater dimensionality of analyses by integrating diverse data sets in a “real world” context (Chapin et al, 2005). Thus, GIS is a tool to examine associations between seemingly

disparate data sources that are nevertheless linked in time and space. The network science aspect of GIS is that it allows the partitioning of information into layers. Layers can be reused and recombined for sophisticated analyses, and many collaborators can assemble the data for layers in a single map (Poore & Chrisman, 2006). Moreover, GIS visualizations can simplify the communication of highly complex geospatial concepts (Lewis & Sheppard, 2006) (Figure 3-1).

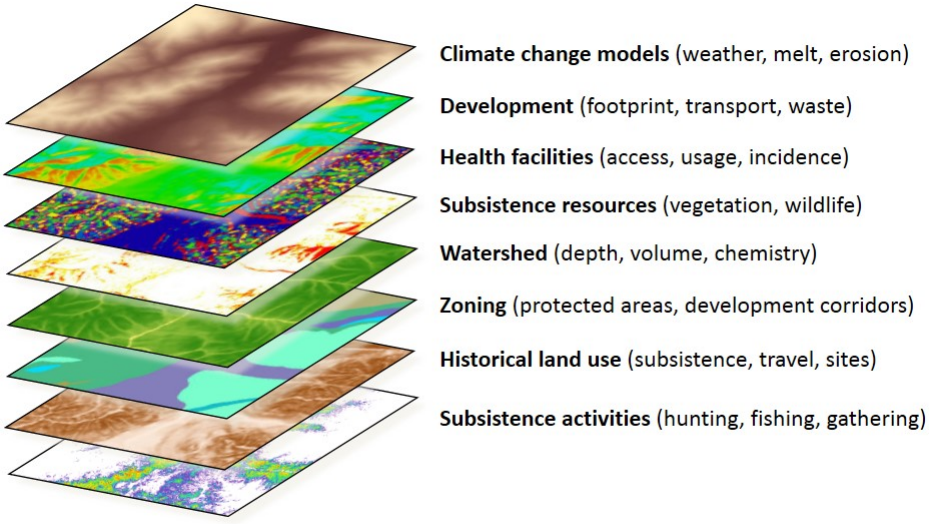

Figure 3-1. Visualizing the layers of a Geographic Information System (GIS).

GIS is becoming more widely used in many forms of participatory decision-making (González et al, 2008). It is especially relevant to indigenous communities for two reasons. First, as a collaborative technology, GIS reflects the diversity, and yet consistent relevance, of indigenous people's knowledge to its land base (Houde, 2007; Nadasdy, 2002). Indigenous communities can also protect confidentiality and preserve their system of access to this information in a GIS (Chambers et al, 2004). Second, the GIS platform has been instrumental to land claims and self-governance processes in northern regions (Eisner et al, 2012; Houde, 2007). Some researchers argue that the most effective contribution to securing land, natural, and cultural resources for indigenous communities has been work of digital cartographers (Louis et al, 2012).

My qualitative study based on expert interviews investigates the use of GIS as a tool to improve communication and consultations on health inequities and the impacts of

arctic and subarctic development on indigenous peoples. In the tradition of natural resource development research, my study is practice oriented, as opposed to theory generating (Rodela, 2013). I examined how GIS applications demonstrate associations between development and changing health and socio-economic conditions in circumpolar regions (Bartlett et al, 2007; González et al, 2008). Further, I examined how decision-making to mitigate identified health impacts could proceed through using GIS in communication and consultations as part of EA. Specifically, my research had three aims: (1) to relate circumpolar development to changing parameters of socio-ecological health and well-being; (2) to highlight mechanisms for circumpolar communities to use GIS; and (3) to identity applications of GIS for communication and consultations during EAs.

3.2 Materials and Methods

3.2.1 Participants

I interviewed 30 circumpolar stakeholders with expertise in policy, research, and practice. I selected stakeholders through purposive sampling from the 2012 International Congress on Circumpolar Health (n=15) and authors of academic literature (n=5). I interviewed additional experts (n=10) as recommended by individuals in the purposive sample (snowball sampling). Inclusion criteria for the sample included relevant expertise in GIS, natural resource development, and circumpolar indigenous health (Table 3-1).

Table 3-1. Expert interviewees' disciplinary affiliations.

Category	Interviewee alias
Policy makers advising at regional, national, or international levels	*Public health official*
	Indigenous political representative
	Public servant
	Arctic research expert
	Indigenous health systems expert
	Arctic health expert
Researchers affiliated with academic institutions	*Indigenous health historian*
	Indigenous law expert
	Food systems anthropologist
	Human ecologist
	Medical geographer
	Environmental sociologist
	Remote sensing specialist
	Population health investigator
	Indigenous health researcher
	Environmental assessment expert
	Health geomatics specialist
Practitioners affiliated with community, regional, and national organizations	*Regional epidemiologist*
	Surveillance data analyst
	Subsistence researcher
	GIS industry professional
	Health system director
	Water systems scientist
	Regional program director
	Family health expert
	Community activist
	Health system administrator
	Regional planner
	Indigenous government negotiator
	Health impact assessment practitioner

I recruited participants by email and in person at the Congress; I provided participants with an information and informed consent form and interview guide prior to the interviews.

3.2.2 Data Collection

I digitally recorded 29 semi-structured interviews with 30 participants in person (n=14) or by telephone (n=16) between July and October 2012. One interview was with two stakeholders. Each interview was approximately 30 minutes in length. I also took notes during the interviews and noted my reflections following each stakeholder interview. My literature review of research in GIS, natural resource development, and circumpolar indigenous health informed the interview guide. My thesis committee members, with expertise in public health, arctic science policy, intellectual property law, health impact assessment, and risk communication, reviewed the interview guide for depth and breadth of coverage (Table 3-2).

Table 3-2. Experts in policy, research, and practice interview guide.

1. *Can you please tell me about your background as a policy maker/researcher/public health practitioner with remote communities in Canada's northern territories/ Alaska/arctic Europe/arctic Russia?*
2. *Can you please describe your involvement in community consultations about health and/or natural resource development in those regions?*
3. *Do you think that natural resource developments have health impacts for remote communities? Who is impacted, and how?*
4. *In your experience, how do environmental assessments consider the health impacts of natural resource developments?*
5. *Can you provide any ideas of how consultation with communities during environmental assessments might better address the potential health impacts of natural resource developments?*
6. *Can you please comment on how Geographic Information Systems (GIS) are used in relation to environmental assessments or other processes?*
7. *How do you think GIS information can be presented to communities?*
8. *In your opinion, do you think there are any ethical concerns to using GIS with indigenous communities?*
9. *Is there anything else you would like to add?*

The Health Research Ethics Board 1 at the University of Alberta approved the interview guide, study design, information and informed consent form, and invitation letter to participants in June, 2012.

3.2.3 Data Analysis

The philosophical orientation of data analysis was social practice theory, which recognizes a dynamic of social construction in political institutions and behaviours (Potvin et al, 2005; Reckwitz, 2002). This perspective is useful for understanding indigenous peoples' relationship with the state and its resources (Macintosh, 2012), and the adoption and utilization of GIS technology (Chambers et al, 2004; Homburg & Georgiadou, 2009).

I reviewed each of the transcripts using NVivo version 10 software to record themes in the interviews ("codes"), employing the constant comparison method (Leech & Onwuegbuzie, 2011; QSR International 2013). After reading and recording the themes in each interview as codes in a codebook, previous interviews were reviewed and coded for the occurrence of themes that had emerged in subsequent transcripts (Peters & Wester, 2007). After reviewing all of the transcripts and once no further themes emerged, I consolidated my codebook into two sections. The first section identified all of the circumpolar actors and institutions mentioned in the interviews, which is beyond the scope of the current research. The second section of the codebook identified main themes and subthemes, defining each, in turn, with definitions and example from the text (Onwuegbuzie & Leech, 2007). The two codebooks were reviewed by an expert member of my research committee. The relevant main themes and sub-themes from this data analysis are presented below (Table 3-3).

Table 3-3. Experts in policy, research, and practice interview coding frame.

Main Theme	Sub-theme
Natural Resource Development	*Problems with Development*
	Benefits of Development
Health Impact Vectors	*Environmental*
	Socio-economic
Community Dynamics	*Historical Conditions*
	Self-government
	Capacity Building
	Indigenous Knowledge
	Subsistence
Environmental Assessment	*Scoping*
	Baselines
	Public Hearings
	Monitoring and Surveillance
Roles and Responsibilities	*Communities*
	Regulators
	Government
	Academics
	Industry

Once the codebook was complete, I trained a second coder to use it to code the entire dataset. I used the coding comparison functionality of NVivo to identify transcripts with less than 0.7 kappa coefficients, above the 0.6 threshold for substantial agreement (Landis & Koch, 1977). Together, the second coder and I discussed each of those transcripts to resolve a consensus on the definition and application of the codes. In the final iteration, we developed a codebook comprised of six main themes and 22 sub-themes.

3.2.4 Study Limitations

As is common in qualitative research, my study is most limited by the nature of the sample (Flicker & Worthington, 2012). My study focused on expert opinion rather the perspectives of indigenous peoples. Five participants self-identified as indigenous, but nevertheless brought an expert rather than a lay perspective. Further, while the participants represented different arctic countries/regions (Canada: 9, United States: 18, Europe: 2, and Russia: 1), I viewed these perspectives through a Canadian lens. Finally, I did not interview industry representatives because the research focus here was on policy, academic, and practice perspectives on GIS.

3.3 Results and Discussion

3.3.1 Circumpolar Development in the Production of Health Inequities and Impacts

Laws, legal frameworks, and policies.

Natural resource development has fuelled the expansion into circumpolar regions by non-indigenous interests (Conference Board of Canada, 2013; Nuttall, 2009). Some laws, legal frameworks, and policies have been developed to govern this expansion, which, in principal, but not necessarily in practice, promote the equitable participation of indigenous peoples in decision-making (Christensen & Grant, 2007; Macintosh, 2012). In a historical context, interviewees blamed the force of law in early development for the disenfranchisement of indigenous peoples in North America and in the Russian arctic (Fondahl et al, 2001; O'Neil, 1986). This absence of protection for indigenous rights is long standing and persistent.

> *Getting settlers in, and selling mineral rights … an awful lot of conflict of interest that goes on … in terms of protecting the rights of the [indigenous peoples] versus selling off those rights for the government's benefit (Researcher 001)*

> *Not everything was lost, but because of the impact of colonial legal history and policy … the result in indigenous communities was suppression of tradition and identity (Researcher 002)*

> *Representation in the Soviet Union for the indigenous people was almost nil, and the situation hasn't changed since Perestroika … there is no law that protects them (Researcher 003)*

In contrast to the colonial history of development, interviewees highlighted the Berger Inquiry[3] as a touchstone for equitable and appropriate natural resource management (Gamble, 1978). The hallmarks of the Berger Inquiry were equity and respectful dialogue, supporting indigenous peoples' participation in decision-making for sustainable development (Berger, 2010; Houde, 2007). Since the Berger inquiry, there has been a growing body of international law that has transformed indigenous peoples' relationship with the resource economy (Fidler & Hitch, 2007; MacIntosh, 2013). Inasmuch as those principles have informed international precepts for indigenous rights (and environmental justice), stakeholders spoke of law, legal frameworks, and policies empowering indigenous peoples by connecting their local experiences to the international context (Hanna & Vanclay, 2013).

> *The significance of the Berger Inquiry was that people recognized that there was a different way of being consulted … whether it was in the frame of stories, or it was personal experiences, or what the future might hold as a result of that development (Researcher 004)*

> *[The] United Nations Declaration on the Rights of Indigenous Peoples … if we respected that document … consultations and review processes are done more effectively, are more inclusive of what communities want, [and] their right to make these decisions are reviewed with them in the first place (Practitioner 001)*

Laws, legal frameworks, and policies for natural resource development can help fulfill the state's obligation toward indigenous peoples and contribute to sustainability for arctic and subarctic communities (Gibson, 2011). Since the Berger Inquiry and through international mechanisms, it has become obvious that sustainable development requires the state and its resources to recognize, affirm, and protect indigenous communities' rights and role in arctic development (Hanna & Vanclay, 2013). Over the last decade, Canadian leadership in natural resource management has extended the legislative mandate of EAs to consider health and socio-economic impacts (McCaig, 2005). In remote northern communities, this mandate provides opportunities for indigenous peoples to address the SDH though public health planning, as part of decision-making for development (Kwiatkowski, 2011).

[3] The Berger Inquiry (1974-1977) was commissioned by the Government of Canada to evaluate the environmental and socio-economic impacts of a proposed gas pipeline from fields near the arctic ocean to facilities in southern Canada; it recommended that any development be delayed for ten years while land claim agreements were established (Gamble, 1978).

Dynamics of cultural revitalization and resilience.

To address the SDH for indigenous communities relative to arctic developments, it is imperative to understand the reciprocal dynamics of cultural revitalization and resilience (Marks et al, 2007). Cultural revitalization entails how indigenous knowledge can be generated and maintained within a socio-ecological system, and is protected by the indigenous community's resilience (Brown-Leonardi, 2012; Kirmayer et al, 2011). Resilience encompasses the resources and capacity to adapt to stressors, and is fostered by cultural revitalization (Brown-Leonardi, 2012; Kirmayer et al, 2011; McCarthy et al, 2012). Interviewees described this reciprocal dynamic between resilience and cultural revitalization in terms of indigenous peoples' shared connection to the environment. However, they recognised the tension between tradition and development (Bone et al, 2011).

> *Well, the environment is a part of Natives … mentally and physically, spiritually and emotionally … I saw that in Siberia, and all the circumpolar countries (Policy maker 001)*

> *For us, it's really to keep that balance between the worlds that we have to live in, the economic activity and the experience of our ancestors (Policy-maker 002)*

Stakeholders described ways that development could support cultural revitalization and resilience, primarily through income, employment, working conditions, and other financial means (Birley, 2005; Fitzpatrick et al, 2011; Galbraith et al, 2007).

> *[Indigenous communities] applied the property tax to [development], they've put money into schools, they've put money into utilities, and they've done a lot of really wonderful things to improve their lifestyle (Policy-maker 003)*

> *[Employees] receiving free counselling services on how to manage their money, how to set up a bank account [and] cultural sensitivity training in the workforce… it's a means to provide local communities with money for fuel, money for food, money to engage in traditional activities (Researcher 005)*

However, interviewees indicated confluent problems for cultural revitalization and resilience with the influx of people and infrastructure into remote indigenous communities (Bone et al, 2011). This influx also has negative health impacts (chronic diseases, income disparities, and social pathologies) for which government and industry are loathe to assume responsibility, even though indigenous people commonly raise these issues during EAs (Armitage, 2005; Notzke, 1995).

> *[C]hange from a subsistence economy, which emphasizes the use of local food resources, and which is a major source of physical activity, to one more passive, where with cash availability, there will be more use of the general store, and availability of high caloric foods (Practitioner 002)*
>
> *[M]assive relocation of crews, with limited living space, and intense working hours, that are being isolated from their family and social supports. High amounts of money, self-medicating going on, frankly, in terms of substance abuse rates increase, violence rates increase. That's just a reality (Practitioner 003)*

Cultural revitalization and resilience is also challenged by evident and perceived development impacts on the environment (Usher, 2003). Stakeholders indicated threats to subsistence harvesting, increasing pollution and contamination rates, and elevated risk perceptions in communities (Ford, 2012; Horwitz & Finlayson, 2011). The complexity of cumulative impacts in these areas is only beginning to be addressed in EAs (Racher et al, 2011).

> *[T]he aquifer in those towns is low. Putting in a giant mine there is not going to help that aquifer replenish itself. It's going to put even more of a strain on it (Practitioner 004)*
>
> *The road from the mine to the port site has some disruptive effects on caribou migrations, pollutants in the river, a loss of air quality, and road dust covering berries and other heavily used plant resources (Researcher 006)*
>
> *We don't know. I'm sure there're some models and theories out there, but we don't know what'll happen if there is a major oil spill. Or even a small one. When they drill for oil, there're always a lot of contaminants that go through the water and the ground (Practitioner 005)*

Circumpolar development changes the dynamics of cultural revitalization and resilience, which has implications for the socio-ecological parameters of health and well-being for indigenous communities (Johnson & Miyanishi, 2012). EAs must identify and mitigate these impacts. Decision-making processes must be re-designed to address socio-cultural, health and environmental impacts to ensure development is a net benefit; such processes must respect and integrate indigenous knowledge (Bronson & Noble, 2006; Gibson, 2011; (Houde, 2007).

3.3.2 Geographic Information Systems (GIS) in Circumpolar Communities

Self-determination and capacity building.

Capacity for GIS is relative to the ability of indigenous communities to adopt and leverage the technology (Chambers et al, 2004; Chapin et al, 2005). Interviewees recognized GIS as a tool for the collection, analysis, interpretation, and communication of both scientific and indigenous knowledge, providing a shared platform for decision-making to address positive and negative impacts (Lewis & Sheppard, 2006; Wright et al, 2009). Historically, mapping was necessary to negotiate indigenous people's political inclusion and stewardship of traditional lands (Usher et al, 1992). In the past 40 years, GIS has played a pivotal role in litigation, land claims, and increasingly EAs (McCarthy et al, 2012; Nadasdy, 2002; Usher, 2003).

> *It was post-Delgamuukw[4], which was a big court case around trying to prove title … people weren't sure about exactly how some of the "adaawk", or the traditional stories… related to use on the land. I was part of a group that was using GIS to actually track some of that (Practitioner 006)*

> *GIS is one way to really look at the footprint or the nature of [a] project's activities' … are there river systems, or water supplies, where you have, let's say, regular fishing spots, regular cabins, that are connected somehow to a project site? Is there a potential vector for health impact? (Researcher 005)*

Many interviewees reflected on the utility of GIS for addressing issues of self-determination in the current context of governance and planning. They discussed how GIS might be used for management of infrastructure and services for the maintenance of healthy communities, requiring appropriate respect for indigenous land use values (Chambers et al, 2004; Wright et al, 2009). Although limited by the authority that individual communities have over health, interviewees also considered GIS as extensible to policies and health system conceptualization and planning (Lavoie, 2013).

> *We deal everyday with individual residents, villages, [government] agencies, national and multinational interests … land use planning, permitting, and zoning … to negotiate, and avoid potential conflicts … it's within that context that [the] mapping project becomes a decision support tool to assist our land use planners … to protect subsistence (Practitioner 007)*

[4] Delgamuukw versus British Columbia [1997] 3 S.C.R. 1010 was a case litigated by Gitxsan and the Wet'suwet'en peoples in which the Supreme Court of Canada ruled, in part, that indigenous oral histories should have the same evidentiary weight as written testimony in determining occupancy, a requirement for land claims (Houde, 2007).

> *This is a tool to help [indigenous peoples] become more efficient and effective in governing. Not only their people, but their lands, and the different activities that take place on those lands. Whether it's … planning, or managing their natural resources … rural housing … the emergency 911 system. GIS can be used for all those different things (Practitioner 008)*
>
> *[Indigenous people] can arrange their own health system [with] their definitions of health and healing, which might be very different from the biomedical, [and] come up with their own models to improve the overall health situation … they create maps, for example, for preventative health interventions in the community (Researcher 006)*

While political access (as the legal right for consultation) is a prerequisite to decision-making that employs GIS in consultation with indigenous communities, a substantial knowledge gap also exists in most cases between interest in GIS and the capacity for stewardship of the technology (Bailey & Grossardt, 2010; Chambers et al, 2004; Chapin et al, 2005). Stakeholders acknowledged that leadership, education, collaboration, training, and resources are needed to establish community-based GIS (Epp et al, 1991).

> *I know from talking to people [that] they are interested in GIS [as] tools that they can actually use themselves, on their boats and snowmachines, and being able to provide that information … there is a lot of room to do really interesting and creative things (Researcher 007)*
>
> *[U]niversities, federal agencies, local [communities], some consortium that would put together workshops and training sessions, that would probably be most effective … a collaboration of efforts really does need to take place (Policy-maker 002)*

As a decision-making platform, GIS is already being used by arctic and subarctic indigenous communities in various governance and planning contexts (Palmer, 2012; Wright et al, 2009). Although many indigenous communities confront a knowledge gap, interest in adopting and leveraging the technology is fostering collaboration and networking between communities, and with partners in government and academia (Chambers et al, 2004; Eisner et al, 2012; Stewart et al, 2008).

Community-based research by government and academia.

There are government and academic collaborations that already use GIS with indigenous communities (Eisner et al, 2012; Stewart et al, 2008). GIS allows land-based data collection, assembling indigenous knowledge as multi-media, and visual decision-making (Petheram et al, 2012; Pfeiffer et al, 2008). Stakeholders stressed community-

based participatory principles in any GIS research that addresses the SDH in indigenous communities (Flicker & Worthington, 2012). Key features of engagement included community advisory structures and long-term involvement (Caine et al, 2009; Flicker & Worthington, 2012). Key features of methodology included community-driven and replicable research protocols, with the goal of co-creation of knowledge (Caine et al, 2007; Lewis & Sheppard, 2006; McCarthy et al, 2012).

> *[H]ealth problems in the arctic are quite significant, quite extraordinary, and quite different in many ways … it's a difficult place to do research. It has to be community-based (Policy-maker 004)*

> *[C]onnecting the dots between that motivation, and that interest, and the ability to actually do it … working with partnerships over a long time … that really helps to build the capacity at the community level (Researcher 008)*

Without the participation of indigenous peoples with knowledge of their communities, the knowledge of health and socio-economic impacts of development is necessarily inadequate (Bronson & Noble, 2006; Usher et al, 2003). Desired products of the community-based research process are relevant, timely, local-scale geospatial data to support public health decision-making in communities and in forums such as EAs (Bailey & Grossardt, 2010; Palmer, 2012). Interviewees noted the importance of providing accessibility to data, facilitating analysis of research questions that interest communities, and ensuring community ownership and stewardship to empower indigenous peoples within research relationships (Caine et al, 2007; Chapin et al, 2005).

> *[Our] database [is] a key research tool for us, and a key communication tool for us. It's how we can summarize, in an accessible way, the information that we collect, which is extremely fine grained, and detailed, and extensive (Practitioner 009)*

> *[I]f they ask a question, and you give them the answer, that's probably more important than them actually having the data in their memory stick … it is a major ethical concern, data ownership and access in a group (Researcher 009)*

> *[T]he Saami, … to prevent a gold mine from occurring on their traditional reindeer herding lands, they used the data, directly, themselves, and then … informed us that they had done that already. It is the community that utilizes it (Researcher 010)*

Currently, GIS applications present a knowledge gap for many indigenous communities, in utilizing the technological equipment, facilities, and expertise (Chambers et al, 2004). Leveraging GIS to address health inequities and impacts in decision-making forums can

find support in community-based health and well-being research by government and academia. Certainly, the process of collaboration must be community-focused, timely, produce local-scale knowledge, and support data stewardship by indigenous communities (Hall, 2013; Wright et al, 2009).

3.3.3 Geographic Information Systems (GIS) in Environment Assessment

Scoping and baselines for sustainable development.

Scoping and baselines are the earliest components in EA where communication and consultations can inform circumpolar development about health inequities and impacts in indigenous communities (Kryzanowski & McIntyre, 2011; McCaig, 2005). Scoping establishes an overall framework to evaluate impacts, and baselines help to establish significance thresholds for any impacts that are identified (Kwiatkowski, 2011; Racher et al, 2011). Interviewees were critical of the narrow breadth of current scoping as lacking consideration of ecosystem effects, cumulative events, and health impacts related to indigenous peoples' connection with the landscape (Gibson, 2011; Houde, 2007; Johnson & Miyanishi, 2012).

> *Government and industry like to look at things in a really isolated context … No one steps back and says, maybe we should legislate and regulate this stuff looking at everything as a whole and not on a piecemeal basis (Practitioner 001)*

> *Although there may be some places that are more significant than others in terms of their ongoing utility, impact on one region can have a significant impact on another (Researcher 002)*

Interviewees were less critical of baseline assessments, indicating their importance in the later stages of EA for monitoring and follow-up. However, they indicated difficulties locating accurate sources for health data (Cundill & Rodela, 2012; Noble & Birk, 2011).

> *(O)ne of the reasons we really try to get the best baseline we can is that, at a future time, if there is a concern that arises, we have some good starting point, for as many indicators as we can think of, to examine and explore the validity of the claim (Practitioner 010)*

> *One of the real struggles that we found in trying to develop baselines, and understand impacts, was having to create a baseline from scratch. Having to go to the local clinics, counseling services, community members, and schools, and collect what we could, in terms of data that would allow us to have complete [picture of] the determinants framework (Researcher 005)*

Interviewees were largely in consensus that GIS could serve as a platform for more complex scoping and the integration of baseline data sources (Epp et al, 1991; Wright et al, 2009). Moreover, the visual aspect of the technology was cited as informing communication and consultations by representing indigenous knowledge and socio-ecological relationships (Lewis & Sheppard, 2006).

> *GIS is very visual as a tool to express concerns about a project, or the possible implications of a project [especially] maps [showing] the aboriginal name, the traditional name, for that place … people want to talk about the stories that are associated with the area that might be impacted (Researcher 004)*

> *[T]here is tremendous potential in using GIS systems to combine the information and data, in ways that create a picture view for people to understand, not only cumulative impacts, but the relationship between the natural systems, water availability, species that people rely on for subsistence, and the location of certain developments. It's one thing to read that in a text, it's another thing to be able to visualize it (Policy-maker 005)*

Thus, interviewees agreed that GIS can facilitate complex scoping of developments, and manage the extensive and diverse baseline data sets available across circumpolar regions (González et al, 2008). In addition, GIS can simplify the presentation of this information without sacrificing its accuracy and precision, potentially improving decision-making (Bailey & Grossardt, 2010).

Monitoring and surveillance to mitigate health impacts.

In later and post-approval phases of EAs, GIS may contribute to monitoring and surveillance (Noble & Birk, 2011). GIS platforms can both document and analyse changes associated with development on the landscape (Racher et al, 2011). Interviewees expressed dissatisfaction with monitoring driven by industry and surveillance of human health impacts in the Canadian context (Chatwood et al, 2012; Kryzanowski & McIntyre, 2011). Some lauded the growth of independent observation networks across the arctic, and indicated the need to support those programs. Such community-based monitoring initiatives contribute relevant, local-scale environmental and socio-economic data, and network indigenous communities (Eisner et al, 2012; National Snow and Ice Data Center, 2014). Health and socio-economic data was a priority for many interviewees, who described the growth of those networks in collaboration with government and academia (Brubaker et al, 2011).

Monitoring and follow-up? Terrible … When you actually prove impacts, and illustrate that there's problems with services, the [government] writes themselves out of it. They never take any authority, or any responsibility. They do nothing, absolutely nothing, with the data. Even when direct impact is linked back to mining (Practitioner 011)

A network of observers … can they make you aware of something that is going on [and] they can also participate in a surveillance project … By doing so, it becomes not just an individual community issue. It becomes a broader issue. And sometimes, that's helpful in getting attention, resources, and response (Practitioner 012)

Because of the number of variables, it can be tedious to get through. It is maybe not making the strongest public health message, as far as motivating local people. But that will be one of the changes in response to comments coming back from rural and community users. Which variables would [they] like to see an emphasis on? We have responded to that … at least we're giving some indications to the community of what's happening locally (Practitioner 002)

Some stakeholders described the difficulty in accessing health outcome data in the arctic (Bernard & Ostländer, 2008). In regions with available data, they found differences in scale, temporality, and extent between environmental and public health data sets (Kraft Sloan & Hik, 2008).

[In] explanatory mapping… any explanation that you can come up with, for that, you have to have health data. We haven't been able to get good quality health data, or info on the health data at all, because it is collected in a very haphazard way (Researcher 005)

Whether it's for the natural environment or health, sometimes the data don't always overlap in the best way …. It's hard to make spatial associations between environmental and health outcome data, if you have it (Researcher 011)

Stakeholders approached the issue of data aggregation in monitoring and surveillance in two ways. First, the data should be relevant at the local-scale, while preserving confidentiality (Marks et al, 2007). Second, the data should be geographically as opposed to jurisdictionally aggregated across the circumpolar arctic (Bjerregaard, 2011).

When [data] is aggregated into a large group, people might not feel it's as relevant to them, to their region. Each region has its own uniquenesses. Being as local as possible and yet still protecting the individual communities, in terms of identifying communities is kind of the balance (Practitioner 013)

We track infectious diseases by region, and even down to the village level … across seven of the eight arctic countries … We're able to look at it across regions that are actually very similar, and have similar issues and problems (Policy-maker 006)

Reorientation of monitoring and surveillance may be needed for EAs to address the human health impacts of arctic development. GIS can support scalable community-based networks to understand socio-ecological changes in indigenous communities at the regional scale (Brubaker et al, 2011). GIS can also support collaboration with a broader range of parties to EAs (including government and academic researchers) to improve the relevance of monitoring and surveillance to indigenous communities (McCarthy et al, 2012).

3.4 Conclusions and Recommendations

The circumpolar arctic faces rapid environmental, economic, social, and political transformation, driven by development, and amplified by climate change (Kraft Sloan & Hik, 2008). Indigenous peoples are the subarctic and arctic residents most potentially impacted by development (Chatwood et al, 2012). In Canada, EAs are important forums in which to consider health inequities and impacts, although health impact assessment only beginning to emerge in these forums (Noble & Bronson, 2006). Communication and consultations can both fulfill government obligations to indigenous peoples and support decision-making for public health planning (Ozkan & Schott, 2013). Tools are needed that provide the flexibility and capacity to address indigenous peoples' socio-ecological parameters of health and well-being during EAs (Bailey & Grossardt, 2010; Kwiatkowski, 2011). As part of indigenous peoples' access and full participation for decision-making, GIS may be an important tool to improve communication and consultations about health inequities and the health impacts of circumpolar development (Palmer, 2012).

This is one of the first studies to consult with circumpolar stakeholders about the utility of GIS for health impact assessment in decision-making forum such as EA (González et al, 2008). As such, the results lead to a number of recommendations. First, it is important to address historical disenfranchisement with laws, legal frameworks, and policies to promote equity of access and full participation for indigenous peoples in decision-making about arctic natural resource development (Gamble, 1978; MacIntosh, 2012). Beyond sharing economic benefits, EAs must identify and mitigate socio-cultural and environmental impacts to the dynamic of cultural revitalization and resilience for indigenous communities (Wilson, 2003). GIS initiatives and applications for governance and planning in indigenous communities should be integrated with communication and

consultations for circumpolar development (Eisner, 2012). Support and collaboration should be community-focused and address the GIS knowledge gap in partnerships that provide timely, relevant, local-scale data to empower indigenous peoples in decision-making forums (Flicker & Worthington, 2012).

EAs can use GIS to collect and integrate baseline data for more complex scoping of ecosystem effects, cumulative events, and health impacts associated with indigenous people's connection to the landscape (Wright, 2009). Finally, GIS can link community-based monitoring networks and integrate additional data (such as health outcomes) for monitoring and surveillance at various scales of aggregation (Brubaker et al, 2012). By improving communication and consultations relative to arctic and subarctic natural resource developments, GIS is a tool with the potential to facilitate better decision-making to support the health and well-being of circumpolar indigenous communities.

3.5 Works Cited

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change*. 18(1), 86-98.

Armitage, D. R. (2005). Collaborative environmental assessment in the Northwest Territories, Canada. *Environmental Impact Assessment Review*. 25(3), 239-258.

Asselin, J., & Parkins, J. R. (2009). Comparative case study as social impact assessment: Possibilities and limitations for anticipating social change in the far north. *Social Indicators Research*. 94(3), 483-497.

Bailey, K., & Grossardt, T. (2010). Toward structured public involvement: Justice, geography and collaborative geospatial/geovisual decision support systems. *Annals of the Association of American Geographers*. 100(1), 57-86.

Bartlett, J. G., Madariaga-Vignudo, L., O'Neil, J. D., & Kuhnlein, H. V. (2007). Identifying indigenous peoples for health research in a global context: a review of perspectives and challenges. *International Journal of Circumpolar Health*. 66(4), 287-307.

Beierle, T. C. (2002). The quality of stakeholder-based decisions. *Risk Analysis*. 22(4), 739-749.

Berger, T. (2010). Land use planning: Land claims and Canada's north. In *Canada's north: What's the plan?* (pp 7-35). Ottawa: Conference Board of Canada.

Bernard, L., & Ostländer, N. (2008). Assessing climate change vulnerability in the arctic using geographic information services in spatial data infrastructures. *Climatic Change*. 87(1-2), 263-281.

Birley, M. (2005). Health impact assessment in multinationals: A case study of the Royal Dutch/Shell Group. *Environmental Impact Assessment Review*. 25(7-8), 702-713.

Bjerregaard, P. (2011). The Arctic Health Declaration. *International Journal of Circumpolar Health*. 70(1), 101-102.

Bone, C., Alessa, L., Altaweel, M., Kliskey, A., & Lammers, R. (2011). Assessing the impacts of local knowledge and technology on climate change vulnerability in remote communities. *International Journal of Environmental Research and Public Health*. 8(3), 733-761.

Bronson, J., & Noble, B. F. (2006). Health determinants in Canadian northern environmental impact assessment. *Polar Record*. 42(4), 315-324.

Brown-Leonardi, C. J. (2012). Notions of property: Traditional land use and boundaries in the Deh Cho region. *Polar Record*. 48(3), 249-254.

Brubaker, M. Y., Bell, J. N., Berner, J. E., & Warren, J. A. (2011). Climate change health assessment: A novel approach for Alaska Native communities. *International Journal of Circumpolar Health*. 70(3), 266-273.

Butz, W. P., & Torrey, B. B. (2006). Some frontiers in social science. *Science*. 312(5782), 1898-1900.

Caine, K. J., Davison, C. M., & Stewart, E. J. (2009). Preliminary field-work: Methodological reflections from northern Canadian research. *Qualitative Research*. 9(4), 489-513.

Caine, K. J., Salomons, M. J., & Simmons, D. (2007). Partnerships for social change in the Canadian north: Revisiting the insider-outsider dialectic. *Development and Change*. 38(3), 447-471.

Chambers, K. J., Corbett, J., Keller, C. P., & Wood, C. J. B. (2004). Indigenous knowledge, mapping, and GIS: A diffusion of innovation perspective. *Cartographica*. 39(3), 19-31.

Chapin, M., Lamb, Z., & Threlkeld, B. (2005) Mapping indigenous lands. *Annual Review of Anthropology*. 34, 619-638.

Chatwood, S., Bjerregaard, P., & Kue Young, T. (2012). Global health - A circumpolar perspective. *American Journal of Public Health*. 102(7), 1246-1249.
Christensen, J., & Grant, M. (2007). How political change paved the way for indigenous knowledge: The Mackenzie Valley Resource Management Act. *Arctic*. 60(2), 115-123.
Conference Board of Canada. (2013). *The future of mining in Canada's north: Economic performance and trends*. Ottawa: M. Caron-Vuotari & G. Rheaume.
Cundill, G., & Rodela, R. (2012). A review of assertions about the processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*. 113, 7-14.
Davison, C. M., & Hawe, P. (2012). All that glitters: Diamond mining and Tåîchô youth in Behchokö, Northwest Territories. *Arctic*. 65(2), 214-228.
Eisner, W. R., Jelacic, J., Cuomo, C. J., Kim, C., Hinkel, K. M., & Del Alba, D. (2012). Producing an indigenous knowledge web GIS for Arctic Alaska communities: Challenges, successes, and lessons learned. *Transactions in GIS*. 16(1), 17-37.
Epp, H., Rigby, B., & Bruce, B. (1991). Remote sensing and Geographic Information System training requirements in arctic Canada. *Arctic*. 44(Suppl. 1), 11-14.
Fidler, C., & Hitch, M. (2007). Impact and Benefit Agreements: A contentious issue for environmental and aboriginal justice. *Environments*. 35(2), 49-69.
Fitzpatrick, P., Fonseca, A., & McAllister, M. L. (2011). From the Whitehorse Mining Initiative towards sustainable mining: Lessons learned. *Journal of Cleaner Production*. 19(4), 376-384.
Fitzpatrick, P., Sinclair, A. J., & Mitchell, B. (2008). Environmental impact assessment under the Mackenzie Valley Resource Management Act: Deliberative democracy in Canada's north? *Environmental Management*. 42(1), 1-18.
Flicker, S., & Worthington, C. A. (2012). Public health research involving aboriginal peoples: Research ethics board stakeholders' reflections on ethics principles and research processes. *Canadian Journal of Public Health*. 103(1), 19-22.
Fondahl, G., Lazebnik, O., Poelzer, G., & Robbek, V. (2001). Native 'land claims', Russian style. *Canadian Geographer*. 45(4), 545-561.
Ford, J. D. (2012). Indigenous health and climate change. *American Journal of Public Health*. 102(7), 1260-1266.
Ford, J. D., & Beaumier, M. (2011). Feeding the family during times of stress: Experience and determinants of food insecurity in an Inuit community. *Geographical Journal*. 177(1), 44-61.
Galbraith, L., Bradshaw, B., & Rutherford, M. B. (2007). Towards a new supraregulatory approach to environmental assessment in northern Canada. *Impact Assessment and Project Appraisal*. 25(1), 27-41.
Gamble, D. J. (1978). The Berger Inquiry: An impact assessment process. *Science*. 199(4332), 946-952.
Gibson, R. B. (2011). Application of a contribution to sustainability test by the Joint Review Panel for the Canadian Mackenzie Gas Project. *Impact Assessment and Project Appraisal*. 29(3), 231-244.
González, A., Gilmer, A., Foley, R., Sweeney, J., & Fry, J. (2008). Technology-aided participative methods in environmental assessment: An international perspective. *Computers, Environment and Urban Systems*. 32(4), 303-316.
Gracey, M., & King, M. (2009). Indigenous health part 1: Determinants and disease patterns. *Lancet*. 374(9683), 65-75.
Hall, R. (2013). Diamond mining in Canada's Northwest Territories: A colonial continuity. *Antipode*. 45(2), 376-393.

Hanna, P., & Vanclay, F. (2013). Human rights, indigenous peoples and the concept of Free, Prior and Informed Consent. *Impact Assessment and Project Appraisal*. 31(2), 146-157.
Homburg, V., & Georgiadou, Y. (2009). A tale of two trajectories: How Spatial Data Infrastructures travel in time and space. *Information Society*. 25(5), 303-314.
Horwitz, P., & Finlayson, C. M. (2011). Wetlands as settings for human health: Incorporating ecosystem services and health impact assessment into water resource management. *BioScience*. 61(9), 678-688.
Houde, N. (2007). The six faces of traditional ecological knowledge: Challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 12(2).
Johnson, E. A., & Miyanishi, K. (2012). The boreal forest as a cultural landscape. *Annals of the New York Academy of Sciences*. 1249, 151-165.
King, M., Smith, A., & Gracey, M. (2009). Indigenous health part 2: The underlying causes of the health gap. *Lancet*. 374(9683), 76-85.
Kirmayer, L. J., Dandeneau, S., Marshall, E., Phillips, M. K., & Williamson, K. J. (2011). Rethinking resilience from indigenous perspectives. *Canadian Journal of Psychiatry*. 56(2), 84-91.
Kraft Sloan, K., & Hik, D. (2008). International Polar Year as a catalyst for sustaining arctic research. *Sustainable Development Law & Policy*. 8(1), 4-7.
Kryzanowski, J. A., & McIntyre, L. (2011). A holistic model for the selection of environmental assessment indicators to assess the impact of industrialization on indigenous health. *Canadian Journal of Public Health*. 102(2), 112-117.
Kwiatkowski, R. E. (2011). Indigenous community based participatory research and health impact assessment: A Canadian example. *Environmental Impact Assessment Review*. 31(4), 445-450.
Kwiatkowski, R. E., & Ooi, M. (2003). Integrated environmental impact assessment: A Canadian example. *Bulletin of the World Health Organization*. 81(6), 434-438.
Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*. 33(1), 159-174.
Lavoie, J. G. (2013). Policy silences: Why Canada needs a national First Nations, Inuit and Metis health policy. *International Journal of Circumpolar Health*. 72, 1-7.
Leech, N. L., & Onwuegbuzie, A. J. (2011). Beyond constant comparison qualitative data analysis: Using NVivo. *School Psychology Quarterly*. 26(1), 70-84.
Lewis, J. L., & Sheppard, S. R. J. (2006). Culture and communication: Can landscape visualization improve forest management consultation with indigenous communities? *Landscape and Urban Planning*. 77(3), 291-313.
Louis, R. P., Johnson, J. T., & Pramono, A. H. (2012). Introduction: Indigenous cartographies and counter-mapping. *Cartographica*. 47(2), 77-79.
MacIntosh, C. (2013). The role of law in ameliorating global inequalities in indigenous peoples' health. *Journal of Law Medicine & Ethics*. 41(1), 74-88.
Macintosh, C. (2012). Relational theory and indigenous health: Insights for law reform and policy development. In J. Downie & J. Llewellyn (Eds.), *Being Relational: Reflections on Relational Theory and Health Law and Policy* (230-254). Vancouver: University of British Columbia Press.
Marks, E., Cargo, M. D., & Daniel, M. (2007). Constructing a health and social indicator framework for indigenous community health research. *Social Indicators Research*. 82(1), 93-110.
McCaig, K. (2005). Canadian insights: The challenges of an integrated environmental assessment framework. *Environmental Impact Assessment Review*. 25(7-8), 737-746.

McCarthy, D. D. P., Whitelaw, G. S., Anderson, S., Cowan, D., McGarry, F., Robins, A., Gardner, H. L., Barbeau, C. D., Charania, N. A., General, Z., Liedtke, J., Sutherland, C., Alencar, P. & Tsuji, L. J. S. (2012). Collaborative geomatics and the Mushkegowuk Cree First Nations: Fostering adaptive capacity for community-based sub-arctic natural resource management. *Geoforum*. 43(2), 305-314.
Nadasdy, P. (2002). "Property" and aboriginal land claims in the Canadian subarctic: Some theoretical considerations. *American Anthropologist*. 104(1), 247-261.
National Snow and Ice Data Center. (2014). Exchange for Local Observations and Knowledge of the Arctic [ELOKA]. http://eloka-arctic.org/ [Last accessed on April 27, 2014].
Noble, B., & Birk, J. (2011). Comfort monitoring? Environmental assessment follow-up under community-industry negotiated environmental agreements. *Environmental Impact Assessment Review*. 31(1), 17-24.
Noble, B., & Bronson, J. (2006). Practitioner survey of the state of health integration in environmental assessment: The case of northern Canada. *Environmental Impact Assessment Review*. 26(4), 410-424.
Notzke, C. (1995). A new perspective in aboriginal natural resource management: Co-management. *Geoforum*. 26(2), 187-209.
Nuttall, M. (2009). Energy development and aboriginal rights in northern Canada. In A. Dey-Nuttall & M. Nuttall (Eds.), *Canada's and Europe's northern dimensions* (71-84). Oulu: University of Oulu Press.
O'Neil, J. D. (1986). The politics of health in the fourth world: A northern Canadian example. *Human Organization*. 45(2), 119-128.
Onwuegbuzie, A. J., & Leech, N. L. (2007). Validity and qualitative research: An oxymoron? *Quality and Quantity*. 41(2), 233-249.
Ozkan, U. R., & Schott, S. (2013). Sustainable development and capabilities for the polar region. *Social Indicators Research*. 114(3), 1259-1283.
Palmer, M. (2012). Theorizing indigital geographic information networks. *Cartographica*. 47(2), 80-91.
Peters, V., & Wester, F. (2007). How qualitative data analysis software may support the qualitative analysis process. *Quality and Quantity*. 41(5), 635-659.
Petheram, L., Stacey, N., Campbell, B. M., & High, C. (2012). Using visual products derived from community research to inform natural resource management policy. *Land Use Policy*. 29(1), 1-10.
Pfeiffer, C., Glaser, S., Vencatesan, J., Schliermann-Kraus, E., Drescher, A., & Glaser, R. (2008). Facilitating participatory multilevel decision-making by using interactive mental maps. *Geospatial Health*. 3(1), 103-112.
Poore, B. S., & Chrisman, N. R. (2006). Order from noise: Toward a social theory of geographic information. *Annals of the Association of American Geographers*. 96(3), 508-523.
Potvin, L., Gendron, S., Bilodeau, A., & Chabot, P. (2005). Integrating social theory into public health practice. *American Journal of Public Health*. 95(4), 591-595.
QSR International. (2014). NVivo Version 10 Software.
Racher, K. I., Hutchinson, N., Hart, D., Fraser, B., Clark, B., Fequet, R., Ewaschuk, P. & Cliffe-Phillips, M. (2011). Linking environmental assessment to environmental regulation through adaptive management. *Integrated Environmental Assessment and Management*. 7(2), 301-302.
Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *European Journal of Social Theory*. 5(2), 243-263.

Ritter, T. L. (2007). Sharing environmental health practice in the North American arctic: A focus on water and wastewater service. *Journal of Environmental Health*. 69(8), 50-55.
Rodela, R. (2013). The social learning discourse: Trends, themes and interdisciplinary influences in current research. *Environmental Science and Policy*. 25, 157-166.
Solodyankina, S., & Koeppel, J. (2009). The environmental impact assessment process for oil and gas extraction projects in the Russian Federation: Possibilities for improvement. *Impact Assessment and Project Appraisal*. 27(1), 77-83.
Stewart, E. J., Jacobson, D., & Draper, D. (2008). Public Participation Geographic Information Systems (PPGIS): Challenges of implementation in Churchill, Manitoba. *Canadian Geographer*. 52(3), 351-366.
Tripathi, N., & Bhattarya, S. (2004). Integrating indigenous knowledge and GIS for participatory natural resource management: State of the practice. *The Electronic Journal of Information Systems in Developing Countries*. 17(3), 1-13.
Usher, P. J. (2003). Environment, race and nation reconsidered: Reflections on aboriginal land claims in Canada. *Canadian Geographer*. 47(4), 365-382.
Usher, P. J., Duhaime, G., & Searles, E. (2003). The household as an economic unit in arctic aboriginal communities, and its measurement by means of a comprehensive survey. *Social Indicators Research*. 61(2), 175-202.
Usher, P. J., Tough, F. J., & Galois, R. M. (1992). Reclaiming the land: Aboriginal title, treaty rights and land claims in Canada. *Applied Geography*. 12(2), 109-132.
Wilson, G. N., & Alcantara, C. (2012). Mixing politics and business in the Canadian arctic: Inuit corporate governance in Nunavik and the Inuvialuit settlement region. Canadian Journal of Political Science, 45(4), 781-804.
Wright, D. J., Duncan, S. L., & Lach, D. (2009). Social power and GIS technology: A review and assessment of approaches for natural resource management. *Annals of the Association of American Geographers*. 99(2), 254-272.

Chapter Four:

"How Do Aboriginal Communities Raise Health and Socio-economic Issues in Northern Canadian Environmental Assessment?"

4.1 Introduction

4.1.1 Natural Resource Developments and Health Impacts

Non-renewable natural resource exploration and development is accelerating in the Northwest Territories (NWT) of Canada (Auditor General of Canada, 2010). The Canadian mining industry and its proponents argue that development will be sustainable and produce a positive legacy for the north and its communities (Fitzpatrick et al, 2011; Wilson & Alcantara, 2012). Participation in resource development can provide reliable income, employment, and financial opportunities for northerners (Birley, 2005; Galbraith et al, 2007). On the other hand, detractors question whether the development will be sustainable. Unsustainable development may increase health inequities for remote populations in circumpolar regions, with disproportionate negative impacts on arctic and subarctic aboriginal peoples (Chatwood et al, 2012; Kryzanowski & McIntyre, 2011).

Development can disrupt land and land-based cultural activities, which form a historic and dynamic basis for the physical, symbolic, spiritual, and social relations in northern aboriginal communities, exacerbating ecological and socio-economic sensitivities and leading to poorer health outcomes (Nadasdy, 2002; Johnson & Miyanishi, 2012; Wilson, 2003). Consequently, Canada and the NWT are beginning to require proponents of development to consider and contribute to the health and well-being of remote communities (Kwiatkowski, 2011). To realize a positive legacy in the NWT from sustainable development, considerations of health impacts cannot be marginal, but must be central to planning processes from a community-focused perspective (Centre for the North, 2012; Conference Board of Canada, 2013; Gibson, 2011; Potvin et al, 2005).

4.1.2 Environmental Assessment

Environmental assessment (EA) is a key process for evaluating how natural resource developments contribute to or detract from health and well-being. EA is practiced in over 100 countries, under various legislative mandates and jurisdictional constraints (Kwiatkowski & Ooi, 2003). Canadian EA legislation includes health and socio-economic impacts. Its four basic phases are: (1) screening; (2) scoping; (3) determining significance, mitigation, and follow-up; and (4) recommendation (McCaig, 2005). The two preliminary phases, screening and scoping, determine the parameters for an EA, based on legal requirements and levels of public concern (Kwiatkowski, 2011). Recommendation furnishes the decision to approve, reject, or further review a development, based on the evidence produced by stakeholders in the EA process (Cundill & Rodela, 2012).

During the stage of determining significance, mitigation, and follow-up, processes for participation, such as public hearings, allow stakeholders a relatively informal channel to influence decision-making in EA (Onkila, 2011). Research shows that stakeholder participation produces higher quality management of developments, helping to minimize risks and maximize benefits, specific to each case (Beierle, 2002; Fitzpatrick et al, 2008). However, northern researchers are calling for additional attention to positive and negative impacts on population health, in an effort to leverage development to improve health status in northern regions (Bronson & Noble, 2006; Gibson, 2011). My research analyses the evidence of stakeholder participation during EAs in the Mackenzie Valley, NWT. The analysis supports a community-focused, health-focused approach to development in the NWT, and in other arctic and subarctic jurisdictions.

4.1.3 Co-management in the Mackenzie Valley, Northwest Territories

In the NWT, the Inuvialuit Settlement Region in the north and the Mackenzie Valley in the south regulate EA by co-management within their respective jurisdictions (Auditor General of Canada, 2010). Co-management involves sharing responsibility between governments and aboriginal peoples (Armitage et al, 2008). In the Mackenzie Valley, the Mackenzie Valley Environmental Impact Review Board (MVEIRB) conducts EA and renders its recommendation to the federal Minister of Aboriginal Affairs and Northern Development (Armitage, 2005; Fitzpatrick et al, 2008). Members of the MVEIRB are appointed; legislation requires 50% of board members to be selected by aboriginal

communities, tied to land claims and self-government negotiations in the NWT (Christensen & Grant, 2007; Gamble, 1978). Moreover, MVEIRB has an established mandate for ongoing community consultation during EAs (Gibson & Klinck, 2005). Thus, Mackenzie Valley EAs present access and opportunity for direct participation and decision-making by aboriginal community members, enabling processes that are closer to the values and worldviews of aboriginal peoples (Houde, 2007; Noble & Birk, 2011). Furthermore, an extensive public record of the EAs conducted by MVEIRB, available for download on the worldwide web, permits a careful examination of these processes (www.reviewboard.ca). I used the Mackenzie Valley public record to identify health and socio-economic issues of concern in aboriginal communities, and to provide insight on how to incorporate these issues into EAs, emphasizing the community focus of the consultation process (Grimmer & Stewart, 2013).

4.1.4 Health Inequities in Northern Remote Communities

Communications and consultations around health and socio-economic status, impacts, and aspirations must address underlying health inequities in circumpolar regions (Marmot et al, 2012). In remote aboriginal communities, access to the factors known to improve health (such as healthcare, education, housing, sanitation, and nutritious diets) is impeded by logistic and systemic constraints (Hanna & Vanclay, 2013; O'Neil, 1986; Ritter, 2007). Aboriginal communities experience many health inequities, including higher rates of infectious and chronic diseases, injury and violence, smoking and substance use, social pathologies, poorer infrastructure, and food insecurity (King et al, 2009).

Development which is confluent with structural barriers to realizing the positive health outcomes can contribute to these health inequities and worsen population health status (Chatwood et al, 2012; Davison & Hawe, 2012; Hall, 2013). Observed impacts of subarctic and arctic development include stress on infrastructure; interference with subsistence practices; loss of social cohesion, language, and culture; income stratification; and increases in social pathologies like addictions, violence, and risky sexual behaviour (Asselin & Parkins, 2009; Birley, 2005; Bronson & Noble, 2006; Davison & Hawe, 2012). The health problems in northern aboriginal communities are decidedly complex. Understanding how development interfaces with health and well-being can only be understood with input into EAs of the relevant knowledge and experiences of aboriginal peoples (Houde, 2007; Kryzanowski & McIntyre, 2011; McCaig, 2005). In addition, the

communication practices of stakeholders, as well as linkages between process and outcomes, are also key factors for ensuring that natural resource management adequately considers mechanisms to improve health status (Armitage et al, 2008; Onkila, 2011).

4.1.5 Study Objective and Unique Contribution

This research is among the first to use automated techniques to perform content analysis on the extensive text data sets available in regulatory documents for development in subarctic and arctic Canada. I employed this method to identify and analyse content, positions, and linkages relevant to health and socio-economic issues in the public record from two recent northern Canadian EAs. Specifically, I modeled the content in two public hearing transcripts from EAs in the Mackenzie Valley, the Prairie Creek lead-silver-zinc mine (EA0809-002) and the Nico gold-copper-cobalt-bismuth mine (EA0809-004), using document review and automated content analysis.

My research had three aims. First, by focusing on the health and socio-economic content of public hearing transcripts, I provide evidence that improving health and well-being is a central concern for aboriginal peoples facing development in the NWT. Moreover, a broader approach of improving health is warranted, in light of complex health inequities, and ecological and socio-economic sensitivities, in aboriginal communities (Asselin & Parkins, 2009; Bronson & Noble, 2006). Second, I aim to characterize the relative communication practices of the federal and territorial governments, industry, regulators, and aboriginal stakeholder groups in the public hearing transcripts (Ballard & Banks, 2003). In decision-making forums, knowledge exchange between heterogeneous groups is often where communication and consultations break down (Pfeiffer et al, 2008). Therefore, by examining their relative alignment, I indicate possibilities for collaboration and coordination between these five stakeholder groups to address health and socio-economic issues (Duhaime et al, 2004; Onkila, 2011). Third, by examining linkages between process and outcomes in EA, I argue that project-specific versus regional-scale EA approaches limit consideration of the socio-ecological parameters of health and well-being. A positive legacy for development in the NWT, in which health is central instead of marginal, will require addressing impacts by focusing on community rather than project metrics (Bronson & Noble, 2006; Gibson, 2011).

4.2 Methods

4.2.1 Sampling and Preparation of Data

My document sample was from Prairie Creek EA0809-002 (2008-2011) and Nico EA0809-004 (2009-2013), consisting of the two final reports of EA, and the two public hearing transcripts. By sampling two recent EAs in the Mackenzie Valley, I could distinguish certain contextual factors underlying the content, communication practices, and linkages I modeled, facilitating greater transferability of my findings (Polkinghorne, 2006). I selected the Prairie Creek and Nico mines for this analysis after preliminary fieldwork consultations with EA practitioners in the NWT, who indicated these recent projects as having potential health impacts for aboriginal communities (Caine et al, 2009). In addition, I attended two of six public hearings dates for the Nico EA in Behchoko, NWT during October 2012 (Flicker & Worthington, 2012). Thus, despite working with extant text as my data for analysis, I practiced reflexivity by immersing myself to a greater extent in the EA context (Charmaz, 2004).

To prepare the data for analysis, I obtained the reports and public hearing transcripts as downloads from the MVEIRB public registry (MVEIRB, 2013, MVEIRB, 2011). Using computer language programming, my research assistant parsed the transcripts into two sets of smaller text files, with each file containing all of the testimony given by an individual participant during either the Prairie Creek or Nico public hearings (Prairie Creek =66, and Nico = 144). By referring to the list of participants in each public hearing, I assigned each person to one of five stakeholder groups: (1) proponent, (2) aboriginal communities, (3) territorial government, (4) federal government, and (5) regulator. My research concerned these stakeholder groups as my primary unit of analysis (Tong et al, 2007).

4.2.2 Document Review and Automated Content Analysis

Whereas document review involves researcher-driven assessment, automated content analysis employs computer processing to rapidly review and characterize texts (Benoit et al, 2009). I used both of these techniques to conduct five analyses on the Prairie Creek and Nico EA samples. These analyses comprised one analysis of the reports of EA and four analyses of the public hearing transcripts. Descriptions follow for the (1) document review of health and socio-economic mitigations (in the reports); and (2) sentiment analysis, (3) term frequency-inverse document frequency analysis, (4) stakeholder group grade level and proportions analysis, and (5) correspondence plotting analysis (of the public hearing transcripts).

Document review of projects and the health and socio-economic mitigations

I conducted a two part document review on the reports of EA for both the Prairie Creek and Nico projects. First, I carefully read the reports and composed a brief description of the project infrastructure, the human geography of each region, and the decision by MVEIRB, to distinguish the two developments. Second, I reviewed the health and socio-economic mitigations stated in the appendices of the reports and recorded my reflections on these mitigations by memo-ing (Peters & Wester, 2007). Once potential health and socio-economic impacts are identified through an EA process, mitigations are actions required of the developer to ensure those impacts do not occur (McCaig, 2005; Kryzanowski & McIntyre, 2011; Kwiatkowski, 2011). I considered whether each mitigation in the two reports specifically involved health and socio-economic impacts, discarding those which did not. Examining the remaining mitigations, I grouped them into categories based on knowledge gained from literature review, and noted where both the Prairie Creek and Nico proponents were required to conduct the same mitigation. I provide the results of my two part document review of the reports of EA in both narrative and tabular formats.

Sentiment analysis of the public hearings transcripts

Sentiment analysis is often used to characterize agency or perspectives in a text or document set (Mohammad & Turney, 2013). In marketing, where sentiment analysis is most commonly used, sentiment categories provide an index gauging text relative to marketers' research aims (Grimmer & Stewart, 2013). Sentiment categories can range

from “positive” versus “negative”, to more complex representation of language, such as “religious” versus “scientific”.

I adapted sentiment analysis to characterize sentiment categories in the public hearings. Using Wordstat software, I identified the 100 most frequent terms in each public hearing transcript by participant occurrence (Provalis, 2014). This means that the identified terms were used by the greatest proportion of participants, as opposed to the greatest number of times by any number of participants. I discarded terms which did not indicate the content of participants’ testimony, such as stop words (personal pronouns and conjunctions) and procedural words (“question”, “chair”, or “presentation”). I manually examined the list of terms that my process had generated for Prairie Creek and Nico, using the keyword-in-context functionality of the software to review the several hundred sentences in which each term occurred (Leech & Onwuegbuzie, 2011). While conducting the keyword-in-context analysis, I recorded memos noting similarities and inconsistencies in the use of the terms, and any differences that I noticed between stakeholder groups. To complete the sentiment analysis, I manually grouped the terms into inductive categories of sentiments which, based on my key-word-in-context analysis, I considered were characteristic of the overall usage of the terms throughout the public hearing transcript. In my results, I report all of the most frequent terms, grouped according to my sentiment categories.

Term frequency-inverse document frequency analysis of the public hearings transcripts

Term frequency-inverse document frequency (TF*IDF)[5] is a highly robust measure of the relative importance of terms in a collection of documents, provided that all of the documents play a similar role in the data set (such as participant transcripts) (Robertson, 2004). TF*IDF is used, for example, to weight text for internet searches. In simplest terms, higher TF*IDF term scores increase the probability of retrieving a document containing that term (Peng et al, 2014). Using Wordstat software, I calculated TF*IDF scores for all of the n-grams in the public hearing transcripts. N-grams consist of meaningful units of text, one term or more terms in length (Grimmer & Stewart, 2013). I report the 10 n-grams with

[5] TF-IDF is commonly calculated as the frequency of a term in a document (t_i) multiplied by the log of the total number of documents (N) divided by the number of documents with the term TF*IDF = t_i* log(N/n_i) (Robertson, 2004).

the highest TF*IDF scores for the Prairie Creek and Nico public hearing transcripts, and the TF*IDF scores, case occurrence, and percent case occurrence for each.

Stakeholder group grade level and proportions analysis of the public hearings transcripts

Using simple programs that I wrote with the Python Natural Language Toolkit (NLTK), I conducted a number of analysis to represent the two transcripts by stakeholder group grade level and proportions (Hopkins & King, 2010; Python NLTK, 2014). First, using the Flesch-Kincaid Grade Level test[6], I assessed the reading level for each participant transcript and reported the average for each stakeholder group (Grimmer & Stewart, 2013). Second, dividing the length of transcripts in each stakeholder group by the total length of the appropriate transcript, I assessed what proportion of the public hearings was dedicated to each stakeholder group. Third, I lemmatized all of the terms in the public hearing transcripts to identify the number of unique vocabulary items present. Lemmatization removes the inflection from terms and groups them linguistically, so that terms such as "operate", "operation", and "operating" are counted as one unique word (Grimmer & Stewart, 2013). Dividing the unique words used in each stakeholder group by the total number of unique words, I assessed the proportion of the public hearing vocabulary used by each stakeholder group.

Correspondence plotting analysis of the public hearings transcripts.

Using Wordstat, I generated a two-dimensional correspondence plot to represent the scaling of stakeholder groups by the statistical similarity of terms in their transcripts (Grimmer & Stewart, 2013). My correspondence analysis used the complete text of each public hearing, accounting for which stakeholder group employed which terms (Provalis, 2014). Within the correspondence plot, the relative position of the stakeholder groups indicates their respective similarity to one another. Correspondence plot axes labels represent the amount of variability depicted in the diagram in that dimension, and eigenvalues indicate the relative compression (or aspect ratio) of each axis (Beh, 1998).

[6] The Flesch-Kincaid Grade Level test was calculated as (0.39 x [average sentence length]) + (11.8 x [average number of syllables per word]) – 15.59 (Grimmer & Stewart, 2013).

4.2.3 Limitations of the Study

Automated content analysis is rapid, replicable, and extensive; however, it is rarely as detailed or reliable as hand coding (Budge & Pennings, 2007; Lowe et al, 2011). Nonetheless, automated methods can increase the accessibility of long texts and facilitate comparisons between large collections of texts, where hand coding may not be feasible (Laver & Garry, 2000). It should be noted that automated methods to model text are never exhaustive; unlike methods to determine causality, automatic content analyses are not improved by more extensive coverage of the dataset, reducing assumptions, or greater sophistication of analyses (Grimmer & Stewart, 2013). Rather, the generated text models comprehensively highlight features in the dataset that reflect the research aims. Another consideration is that as the public hearings were conducted in the English, North Slavey, and Tlicho languages, I therefore relied on the translators for the EAs, who conveyed the community members' perspectives in English to the MVEIRB. As well, my sampling of two Mackenzie Valley EAs, while intended for comparison purposes, provided only a glimpse of the range of regulatory document sets. Nevertheless, while the EAs are highly contextual, this content analysis remains informative because of the breadth and nature of the issues. This research is among the first to appraise the sizable volume of text produced in a regulatory context using automated methods, demonstrating the potential utility of this form of analysis.

4.3 Results

4.3.1 Document Review of Projects and the Health and Socio-economic Mitigations

Canadian Zinc and Fortune Minerals proposed the Prairie Creek and Nico mining developments in the Dehcho and Tlicho regions of the Mackenzie Valley, respectively (MVEIRB 2011; MVEIRB, 2013) (Figure 4-1).

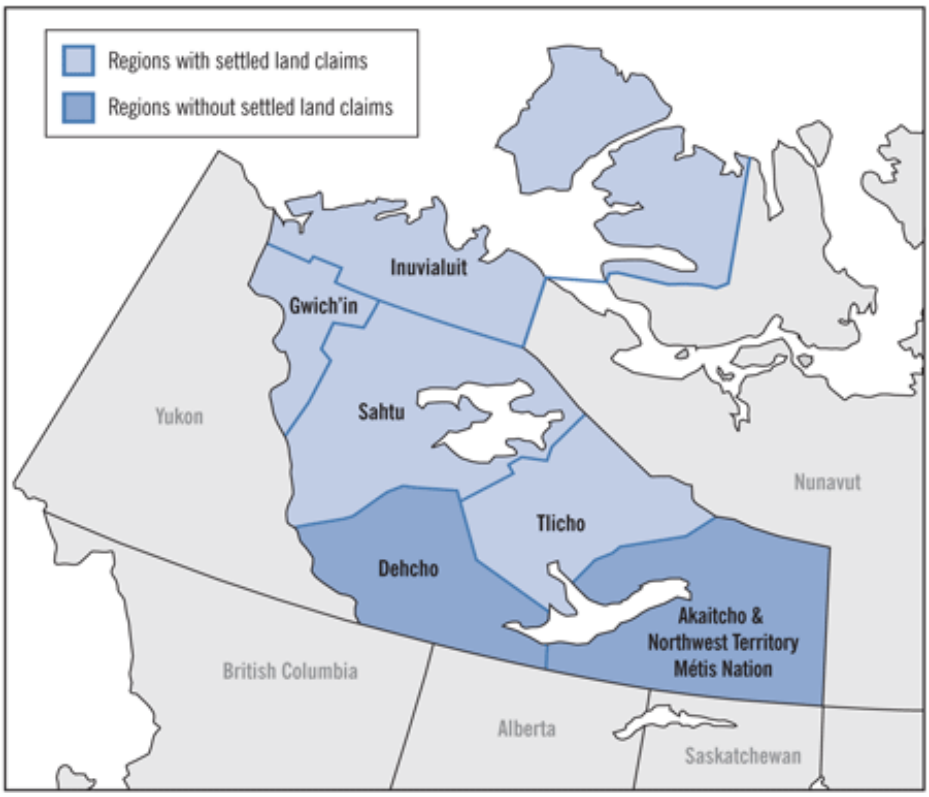

Figure 4-1. The regions of the Northwest Territories, Canada, including the Dehcho and Tlicho (Auditor General of Canada, 2010).

MVEIRB issued its report of EA recommendations for Prairie Creek (EA0809-02) and Nico (EA0809-04) in December 2011 and January 2013. MVEIRB recommended both projects for approval, and referred them to regulatory licensing, with relevant mitigations detailed below.

Prairie Creek EA0809-02.

In 2008, Canadian Zinc proposed Prairie Creek as an underground lead, zinc, and silver mine, with onsite water treatment, paste backfill, dense media separation plants, a waste rock pile, water storage ponds, and worker infrastructure (MVEIRB, 2011). The proponent sought both to upgrade existing facilities and to establish new ones on a previously abandoned site within the Nahanni Nature Park Reserve in the Dehcho region of the NWT. The Government of Canada designated the Nahanni Nature Park Reserve as part of the Canadian national park system, but not yet a national park, while they continued to negotiate comprehensive land claims agreements with aboriginal groups in

the Dehcho (Notzke, 1995). Aboriginal groups in the Dehcho region include the Nahanni Butte Dene Band and the Liidlii Kue First Nation.

MVEIRB held three days of public hearings for the Prairie Creek EA with 66 participants, 23 of whom represented aboriginal communities. Over the course of the EA, the proponent submitted an unprecedented 25 pages of commitments to mitigate impacts by modifying the nature and scale of the development. According to MVEIRB:

> [A]s described in this Report of Environmental Assessment, including the list of commitments made by the developer during proceedings, [Prairie Creek] is not likely to have significant adverse impacts on the environment or be a cause for significant public concern (MVEIRB, 2011, p. iii).

However, two MVEIRB members offered dissenting opinions (contained within the report) from the board majority that the EA:

> [G]ave insufficient weight to the evidence, including traditional knowledge, shared by participants in the Nahanni Butte community hearing and by the Dehcho First Nations through its Grand Chief (MVEIRB, 2011, p. 72).

The complete summary of health and socio-economic mitigations by Canadian Zinc through the EA were provided in the appendices of the Prairie Creek report of EA (Table 1). Canada's Minister of Aboriginal Affairs and Northern Development approved the Prairie Creek EA in 2011 (MVEIRB, 2011).

Nico EA0809-04.

Fortune Minerals proposed Nico in 2009 as an open pit cobalt, gold, bismuth, and copper mine with onsite tailings and mine rock disposal, water treatment, concentrate production, effluent and sewage treatment, and worker infrastructure (MVEIRB, 2013). The proponent sought to establish mining facilities on a grandfathered land lease within the Tlicho settlement region, requiring eventual construction of a 27 km access road through Tlicho lands by a yet undetermined party. MVEIRB consulted the Tlicho beneficiaries of Behchoko, Gameti, Whati, and Wekweeti as affected aboriginal communities.

MVEIRB held six days of public hearings for the Nico EA with 144 participants, 87 of whom represented aboriginal communities. MVEIRB considered Nico:

> [L]ikely to cause significant adverse impacts to the environment, including water, wildlife, and the cultural environment (MVEIRB 2013, p. iv).

MVEIRB required a slate of health and socio-economic mitigations from Fortune Minerals that were detailed in the Nico report of EA (Table 1). Both the Tlicho Government and Canada's Minister of Aboriginal Affairs and Northern Development approved the mine with MVEIRB's mitigations in 2013 (MVEIRB, 2013).

Health and socio-economic mitigations in Prairie Creek and Nico.

My analysis of the health and socio-economic mitigations produced the categories of (1) hiring policies and practices, (2) working conditions and benefits, (3) employee health and well-being, (4) community relations and outreach, (5) community-based monitoring, and (6) financial arrangements with communities (Table 4-1). The majority of health and socio-economic mitigations in Prairie Creek and Nico relate to on site measures for employees, and to relations with individual communities affected by proximity to the mines.

Table 4-1. Summary of mitigations by Canadian Zinc and Fortune Minerals in the Reports of Environmental Assessment for the Prairie Creek and Nico mines.

	Prairie Creek	Nico
Hiring Policies and Practices		
Recruit and hire aboriginal people and locally source businesses	✓	✓
Encourage project contractors to hire from local communities	✓	✓
Provide flexible entry requirements for skills, language, and education	✓	✓
Prioritize students and employee family for summer staff positions	✓	✓
Working Conditions and Benefits		
Provide round-trip transportation from regional communities	✓	✓
Observe workplace human rights, safety and non-discrimination	✓	✓
Offer on-site training, mentoring, and apprenticeships	✓	✓
Provide money management orientation	✓	✓
Provide opportunities for promotion and advancement	✓	✓
Develop a strategy to remove employment barriers for women		✓
Shorten shift work rotations to allow for easier childcare		✓
Employee Health and Well-being		
Provide cultural sensitivity training to all employees	✓	✓
Provide a community liaison and culturally sensitive counselling	✓	✓
Provide on-site medically trained personnel	✓	✓
Collaborate with communities to address off-site substance abuse	✓	✓
Support employees to seek confidential help with substance abuse issues	✓	✓
Provide a volunteer incentive for community cultural programming		✓
Permit use of aboriginal language for informal communication on-site		✓
Provide private accommodations during mine operation		✓
Provide nutritional and country foods when available		✓
Provide communication links for employees to contact communities	✓	✓
Provide indoor and outdoor recreation opportunities	✓	✓
Community Relations and Outreach		
Sponsor community events and activities	✓	✓
Participate in community events and activities	✓	✓
Provide scholarships, investment, and sponsorships in communities	✓	✓
Communicate and consult with communities throughout development	✓	✓
Provide information, classroom visits, and tours to community schools	✓	✓
Target employment information to female students in the communities		✓
Communicate with health care providers to mitigate impacts		✓
Develop closure plans in consultation with communities		✓
Community-based Monitoring		
Provide site visits to Elders to assist in designing site monitoring plans		✓
Contract environmental monitoring by the aboriginal communities		✓
Establish a culture camp near the mine site		✓
Financial Arrangements with Communities		
Fund traditional knowledge studies in development area	✓	✓
Pay royalties and taxes to all levels of government		✓
Contractual Agreements		
Negotiate Impact Benefit Agreements with aboriginal governments	✓	✓
Negotiate a socio-economic agreement with the GNWT	✓	✓
Implement socio-economic monitoring and adaptive management	✓	✓

4.3.2 Sentiment Analysis of the Public Hearings Transcripts

Sentiment categories can be used to present the semantic orientation (or topicality) of the public hearings (Mohammad & Turney, 2013). I inductively categorized the most frequent terms across public hearing participants in the two transcripts into six sentiment categories. My sentiment categories were (1) human health, (2) land, (3) subsistence, (4) communication and consultation, (5) wage economy, and (6) timelines (Table 4-2).

Table 4-2. Sentiment categories for most frequent terms employed in the public hearing transcripts for Prairie Creek and Nico.

Prairie Creek		**Nico**	
Community			
Community Nahanni	Support	Children Community Communities Elder Elders Live	Living People Support Tlicho Young
Land			
Environmental Land National Park	Parks Place River Site	Area Areas Behchoko Environment Hislop Lake	Land Place River Site Whati
Subsistence			
Fish	Water	Animals Caribou Fish Hunting	Knowledge Traditional Water Wildlife
Communication and Consultation			
Concern Concerns Heard Impact Impacts Important Information Issue	Issues Opportunity Process Talk Talking Understand Understanding	Concern Concerns Heard Impact Impacts Information Important Issues Opportunity	Process Respect Speak Speaking Talk Talked Talking Understand
Wage Economy			
Development Economic Project	Road Waste Working	Development Mines Mining Money Operation	Project Road Work Worked Working
Timelines			
Long Future	Potential Winter	Future Happen Long Past	Time Winter Year Years

Through the public health lens, each sentiment category indicates the centrality of health and socio-economic impacts to the public hearings. “Community” as a topic area refers to the collective identity of aboriginal peoples, and social networks as a protective factor (Kirmayer et al, 2011). “Land” represents a dynamic between cultural and spiritual livelihood and the siting of developments in aboriginal territories, which can disrupt the health giving effects of land-based activities (Wilson, 2003). “Subsistence” includes traditional activities and resources for aboriginal peoples, which are intrinsic to both historical survival and modern identity (Brown-Leonardi, 2012). “Communication and consultation” indicates access to the process of participation in EAs, which affords aboriginal stakeholders a greater measure of self-determination over health and socio-economic issues (Houde, 2007). “Wage economy” presents both material aspects and experiences of industrialization, recognizing the need to manage developments to realize a positive legacy in the north and its communities (Noble & Birk, 2011). “Timelines” refers to both the perceived swiftness of development and an obligation to consider its effects on the capacity for the healthy aboriginal communities of future generations (Davison & Hawe, 2012).

4.3.3 Term Frequency-Inverse Document Frequency of the Public Hearings Transcripts

TF*IDF differs from simple frequency analysis by indicating n-grams (one or more related terms) of key importance when normalized for their occurrence throughout a document set (Grimmer & Stewart, 2013; Peng et al, 2014). TF*IDF can be used in a number of ways; here, I used it to show which n-grams characterize the public hearings transcripts, and their comparative strength (Table 4-3)

Table 4-3. Key terms, term frequency-inverse document frequency and cases employing terms from the Prairie Creek and Nico public hearing transcripts.

Prairie Creek				Nico			
N-grams	TF • IDF	Cases	% Cases	N-grams	TF • IDF	Cases	% Cases
Road	151.6	24	35.8	*Caribou*	253.5	53	36.6
Water Quality	142.6	23	34.3	*Wetlands*	221.1	20	13.8
Discharge	103.1	12	17.9	*Closure*	185.7	37	25.5
Toxicity	84.9	8	11.9	*Water Quality*	175.4	21	14.5
Mercury	82.4	11	16.4	*Monitoring*	168.5	37	25.5
Tailings	80.4	17	25.4	*Traditional Knowledge*	158.8	31	21.4
Wildlife	77.7	16	23.9	*Access Road*	100.0	27	18.6
Impacts	75.4	35	37.3	*Tlicho People*	94.5	31	21.4
Paste Backfill	43.2	11	16.4	*Hislop Lake*	89.3	42	29.0
Management Plan	40.1	9	13.4	*Marian River*	86.3	25	17.2

The Prairie Creek public hearing TF*IDF n-grams emphasized terminology of regulation (impacts, and water quality), operations (paste backfill, road, and management plan), ecosystem resources (wildlife), and contamination (discharge, toxicity, mercury, and tailings). In contrast, the Nico n-grams emphasize terminology of regulation (water quality), operations (access road, closure), ecosystem resources (caribou, wetlands), affected people and places (Tlicho people, Hislop Lake, and Marian River), and information gathering and sharing (monitoring, traditional knowledge). Notably, while the range of n-gram frequency by case occurrence was similar in both Prairie Creek (17.20-36.60%) and Nico (13.40-35.80%), TF*IDF for Prairie Creek ranged from only 40.4 to 151.6, while for Nico it ranged from 86.3 to 253.5. As well, the ten n-grams with the highest TF*IDF in Nico have higher scores that all but the top three n-grams in Prairie Creek. Recalling that TF*IDF is a measure of the strength of n-grams in characterizing documents, it appears that there is stronger characterization by the foremost n-grams in the Nico versus Prairie Creek public hearing transcript (Robertson, 2004).

4.3.4 Stakeholder Group Grade Level and Proportions Analysis of the Public Hearings Transcripts

I used document category proportion analysis to indicate the number of participants (cases), clarity of communication (grade level), testimony amount (number of words and percent of total length), and testimony breadth (number of unique words and percent of total vocabulary) for each stakeholder group in both public hearings (Table 4-4).

Table 4-4. Cases, grade level, number of words, percent of total length, number of unique words, and percent of vocabulary for each stakeholder group in Prairie Creek and Nico.

	Cases	Grade Level	Number of Words	Percent of Total Length	Number of Unique Words	Percent of Total Vocabulary
Prairie Creek						
Total	58	N/A	170101	100	8010	100
Proponent	9	10.1	43307	25.5	4544	56.7
Aboriginal	22	7.8	26283	15.5	3199	39.9
Territorial	3	9.9	9138	5.4	1796	22.4
Federal	15	10.2	46993	27.6	4597	57.4
Regulator	9	7.5	44380	26.1	3168	39.6
Nico						
Total	142	N/A	338348	100	11540	100
Proponent	15	10.8	58421	17.3	5129	44.5
Aboriginal	87	6.2	154937	45.8	8408	72.9
Territorial	12	8.1	8892	2.6	1820	15.8
Federal	15	9.5	22576	6.7	2902	25.2
Regulator	13	7.2	93522	27.6	5101	44.2

The number of cases included in the analysis (representing transcripts with more than procedural content) and aboriginal participants differed between Prairie Creek (cases=58, aboriginal participants= 22) and Nico (cases=142, aboriginal participants = 87). In both Prairie Creek (10.1 and 10.2) and Nico (9.5 and 10.8), communication by the proponent and federal government participants employed a higher degree of complexity (as grade level) than communication by aboriginal community members (Prairie Creek= 7.8, Nico= 6.2). At the same time, the regulators in both Prairie Creek (7.5) and Nico (7.2) communicated at level similar to the aboriginal participants. In Prairie Creek, federal

(27.6%), proponent (25.5%), and regulators (26.1%) participants led the other stakeholder groups by providing around 80% of testimony in the public hearing, with aboriginal (15.5%) participants providing a much smaller proportion. In Nico, aboriginal (45.8%) stakeholders provided close to half of the testimony, followed by regulators (27.6%).

Another notable difference between the two transcripts is the extent of lemmatized vocabulary; Prairie Creek presents 8,010 unique word stems, while Nico has 11,540. Aboriginal stakeholder communication employed only 39.9% of the vocabulary terms in Prairie Creek, compared to 72.9% in Nico. The proponent (56.7%) and federal government (57.4%) participants employed the greatest proportion of the vocabulary in Prairie Creek. In Nico, the aboriginal participants were followed by the proponents (44.5%) and regulators (44.2%) in proportionate use of vocabulary.

4.3.5 Correspondence Plotting Analysis of the Public Hearings Transcripts

Using Wordstat, I generated a correspondence plot, which presents the relative similarity of the five stakeholder groups according to the text of the public hearing transcript, including the proponent, aboriginal communities, territorial government, federal government, and regulators. In Prairie Creek, 54.8% of the variability (axis 1: 29.7%, eigenvalue 0.36, and axis 2: 25.1%, eigenvalue 0.31) is depicted, with a third, unseen, dimension (axis 3: 23.3%, eigenvalue 0.29) accounting for a cumulative variability of 78.1% (Figure 4-2).

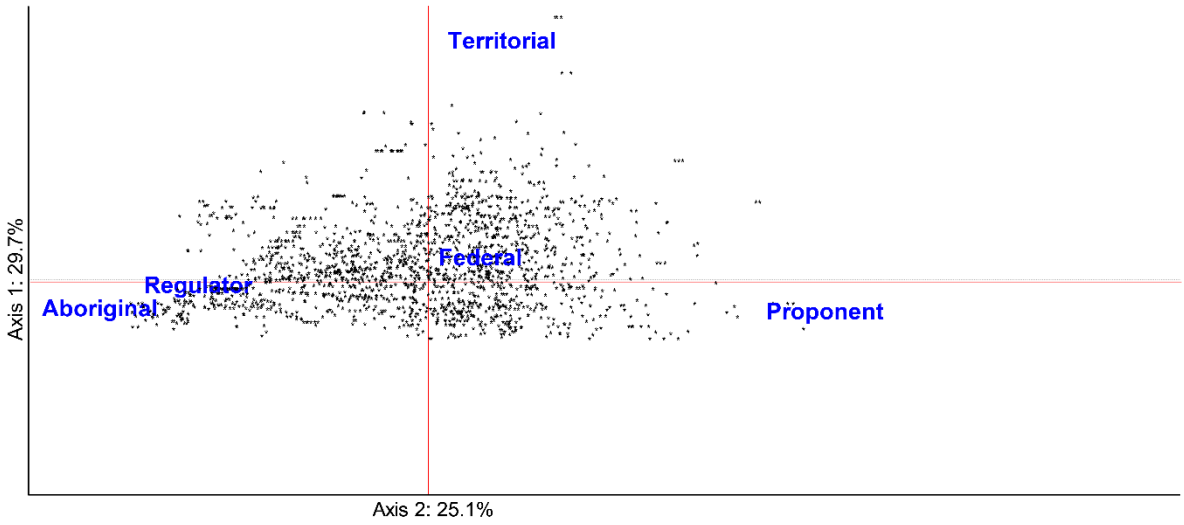

Figure 4-2. Prairie Creek correspondence plot of public hearing transcript text by stakeholder group.

The correspondence plot for Prairie Creek public hearing transcript indicates within the variability shown that the aboriginal stakeholder group was most similar to the regulators. Otherwise, each of the proponent, and territorial and federal governments occupied statistical positions nearly equidistant from each other. Only the federal group presents similarity to aboriginal stakeholder groups and regulators in the Prairie Creek public hearing correspondence plot.

In Nico, 67.7% of the variability (axis 1: 50.6%, eigenvalue 0.21, and axis 2: 17.1%, eigenvalue 0.07) is depicted, with a third, unseen, dimension (axis 3, 16.9%, eigenvalue 0.07) accounting for a cumulative variability of 84.6%. The correspondence plot for Nico indicates within the variability shown that the aboriginal stakeholder group was not similar to other stakeholders, while the proponent, federal, territorial, and regulatory stakeholders aligned with each other to a greater extent. In the Nico case, aboriginal and federal stakeholders were the least aligned (Figure 4-3).

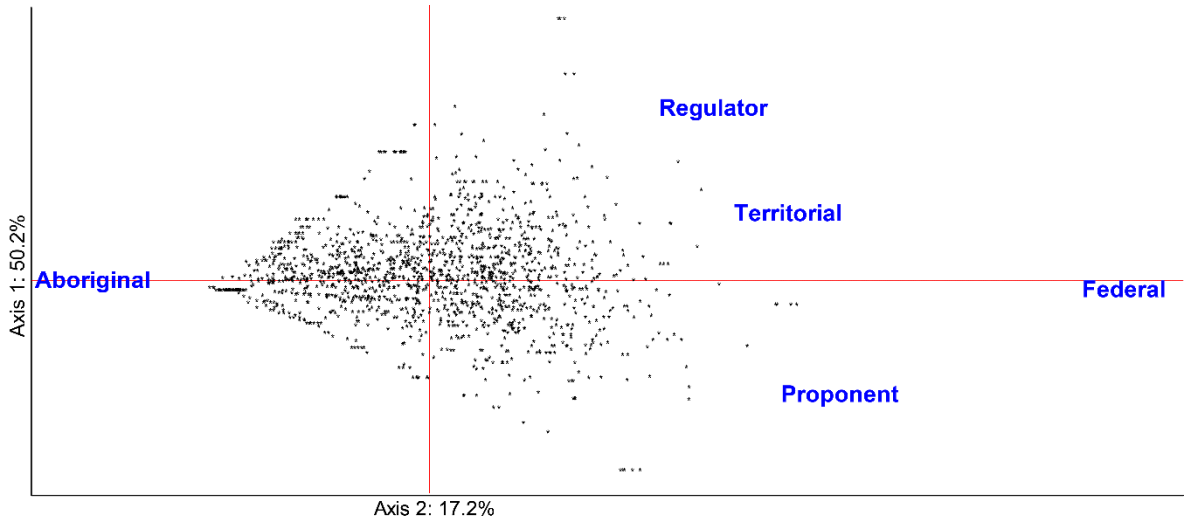

Figure 4-3. Nico correspondence plot of public hearing transcript text by stakeholder group.

4.4 Discussion

4.4.1 Content

Framing health and socio-economic issues in public hearings.

In examining the content of the public hearings, my first aim was to indicate evidence from the participation of individuals in different stakeholder groups that health and socio-economic concerns are central issues. This aim was most informed by the sentiment category and TF*IDF automated content analyses.

Sentiment category analysis revealed that the most frequent non-stopword and non-procedural terms in the Prairie Creek and Nico public hearing transcripts concern relevant socio-economic and health issues (community, land, subsistence, communication and consultations, wage economy, and timelines). The sentiment categories reflect aboriginal views of health and well-being in the literature, which tend to be community-centred, balanced between humans and the environment, and concerned with intergenerational equity (Kirmayer et al, 2011; Marks et al, 2007).

My TF*IDF analysis indicates that both transcripts' n-grams refer to the technical terminology of regulation, operations, and ecosystem resources. While Prairie Creek's n-grams refer additionally to the technical issue of contamination, Nico's n-grams refer to

the conceptual issues of affected people and places, and information gathering and sharing. This difference parallels the contrast between technical and conceptual learning in the natural resource management literature (Rodela et al, 2012). Whereas technical learning reflects stakeholder experiences to address a problem and achieve a goal, conceptual learning involves a shift in understanding the problem itself to reframe objectives, strategies, and even processes of decision-making (Fitzpatrick et al, 2011). In order to effectively mitigate the health and socio-economic impacts of development, EAs should address both technical and conceptual issues, due to the complexity of health inequities and health impacts in aboriginal communities (Bronson & Noble, 2006; Duhaime et al, 2004; Gibson, 2011). In the Prairie Creek EA, however, a greater technical focus may reflect emphasis on well-established procedures to identify and mitigate bio-physical environmental effects, as opposed to the consideration of health and socio-economic impacts (Noble & Bronson, 2006).

4.4.2 Communication Practices

Characterizing stakeholder group dialogue in public hearings.

In examining the relative positions which characterize the multi-stakeholder dialogue in public hearings, my aim was to relate the alignment of stakeholder groups in the public hearings. This aim was most informed by my stakeholder group grade level and proportions analysis, and correspondence plotting analysis.

In the northern Canadian context, multi-stakeholder participation is needed to integrate consideration of complex health and socio-economic impacts to aboriginal peoples into the highly technical context of developments (Kryzanowski & McIntyre, 2011). Without a two-way communication and consultation that is accessible and responsive to affected aboriginal peoples, it is unlikely EA will foster sustainable development that contributes to community health and well-being (Berger, 2010; Gamble, 1978; Houde, 2007). In both the Prairie Creek and Nico EAs, development proponents and federal government communicated with greater complexity (grade level) than either the aboriginal or regulator stakeholder groups, which might impede effective consultation (Centre for the North, 2012).

Additionally, there are some notable differences between the two public hearing transcripts. In NWT, while the Tlicho land claim has been finalized (along with the

Inuvialuit, Gwich'in, and Sahtu), the Dehcho land claim is still currently under negotiation (Auditor General of Canada, 2010). Clearly, more time was allotted to the Nico public hearings than to Prairie Creek, as evidenced by the length of the transcript. There are more unique lemmatized vocabulary items in Nico versus Prairie Creek. Further, aboriginal stakeholder group participants occupied more of the total transcript, and used more of the vocabulary in Nico versus Prairie Creek. Although text modeling does not produce evidence of causation, whether and why aboriginal stakeholder groups with settled land claims participate more extensively in public hearings may be an area warranting further research (Christensen & Grant, 2007).

Similarly, my correspondence plotting analysis indicates two distinct dynamics for stakeholder group alignment in the Prairie Creek versus Nico public hearings. Whereas in Prairie Creek the aboriginal stakeholder group appears somewhat aligned with the regulator group, in Nico, the aboriginal stakeholder group does not appear to be aligned with any other group. Where aboriginal communities have more support for their position in an EA, such as the conclusion of a comprehensive land claim, they can influence the dialogue to better reflect aboriginal values and worldviews (Ballard & Banks, 2003; Hanna & Vanclay, 2013; Houde, 2007). My interpretation of the correspondence plots is that the Tlicho were an assertive stakeholder group in the Nico public hearings, with support from my sentiment analysis that they articulated health and socio-economic issues. As a corollary to that interpretation, the aboriginal stakeholder group in Prairie Creek may not have enjoyed the same level of support for their position to present an independent influence in the EA process (Caine et al, 2007). However, the alignment of the regulator stakeholder group with participants representing the Nahanni Butte Dene and the Liidlii Kue peoples may indicate at least some recognition of their local input (Christensen & Grant, 2007). Thus, the alignment of these two stakeholder groups may indicate accommodation in the EA process (Centre for the North, 2012). In the past court cases have been pursued by aboriginal peoples in regions without settled land claims, such as the Dehcho and the Akaitcho, where communication and consultations during EAs were deemed to be unsatisfactory (Auditor General of Canada, 2010).

4.4.3 Linkages

Process to outcomes in the environmental assessments.

In examining the linkages between public hearing processes and recommendation outcomes, my aim was to indicate the need for EA to consider improving population health in aboriginal communities beyond the life of the project. This aim was most informed by my document review of projects and the health and socio-economic mitigations in the reports of EA.

In northern Canadian EA, linkages between process and outcomes are influenced by the political context, such as governments' obligation to consult with aboriginal peoples (Government of Canada, 2011). Despite the greater influence enjoyed by aboriginal stakeholder groups with established land claims, many of the stipulations in Prairie Creek and Nico are problematic because they address only project-scale impacts and benefits (Bronson & Noble, 2006). Since EA is focused on mitigating significant adverse environmental effects, it often focuses on preventing negative outcomes, rather than making a positive contribution to health and socio-economic well-being over the long term (Gibson, 2011).

Accordingly, the majority of stipulations in Prairie Creek and Nico can be broadly considered as either on site (hiring policies and practices, working conditions and benefits, and employee health and well-being) or community targeted (community relations and outreach, community-based monitoring, and financial arrangements with communities). Certainly, both on site stipulations for unique working conditions supportive of aboriginal peoples, and coordinating the industry presence, funding, information, and planning with communities, are sound practices for development operations in remote regions (Birley, 2005; Fitzpatrick et al, 2011). Nevertheless, tying individual opportunity and collective financial benefit to the cyclical economics of natural resource development may present numerous problems for diversification in communities; aboriginal people do not wish to be caught in a resource trap (Brown-Leonardi, 2012; Centre for the North, 2012; Johnson & Miyanishi, 2012; Paci & Villebrun, 2005; Weaver & Cunningham, 1985).

Mitigations in the Prairie Creek and Nico EAs recommended that proponents negotiate separate commitments (contractual agreements) with territorial and aboriginal community governments to address health and socio-economic issues (Galbraith et al,

2007; Noble & Birk, 2011). As well, they required the implementation of socio-economic monitoring and adaptive management. However, no mitigations were put in place in either EA to provide a community-focused platform for public health planning, as opposed to mitigation for the life of the project (Kwiatkowski, 2011). The literature suggests that to integrate health into EAs, local, regional, and national authorities must systematically incorporate health impact assessment into relevant research and policies, employing sufficient guidance and expertise to address health and socio-economic impacts, as mandated by legislation (Kryzanowski & McIntyre, 2011; McCaig, 2005; Ozkan & Schott, 2012). The communities themselves are best positioned to conduct community health studies and implement public health planning (Brown-Leonardi, 2012; Kwiatkowski, 2011; Wilson & Young, 2008). Yet, the project-scale of EA places the onus on the proponents instead of aboriginal communities to plan for and measure improvements in health status relative to northern developments (Noble & Birk, 2011).

4.5 Conclusion and Recommendations

This research is among the first using automated content analysis to construct text models of public hearings transcripts, analyzing two recent EAs in the Mackenzie Valley, Canada. In NWT, EAs are currently the primary forum for participants and decision-makers to identify and mitigate health and socio-economic impacts of development (Armitage, 2005). From this analysis, it is evident that political access for aboriginal communities produced public hearing content with more extensive and diverse expressed concern for health and socio-economic issues (Beierle, 2002; Fitzpatrick et al, 2008). At the same time, increasing support for the influence of aboriginal participants relative to federal and territorial governments, industry, and MVEIRB (as regulators and EA facilitators) shifted the orientation of multi-stakeholder dialogue to incorporate conceptual in addition to technical learning (Fitzpatrick et al, 2011; Onkila, 2011). Moreover, recommendations in the reports of EA reflect these concerns and shifts proportionate to the degree of aboriginal community participation (Berger, 2010). These factors may be supportive of minimizing risks and maximizing benefits on the project scale.

However, the literature indicates that EAs should focus on the linkages between development and broader concerns for population health, since improving community health status involves complex socio-ecological mechanisms (Bronson & Noble, 2006; Gibson, 2011). Rather than mitigations for health and socio-economic impacts over the life

of a project, long term public health planning may be needed for aboriginal communities to realize improvements in health status (Kwiatkowski, 2011). With the prospect of devolution in NWT, the territorial government will play an increasingly pivotal role in delivery of health care, education, social services, and public health planning around natural resource development (Alcantara, 2013). Given the advantages of aboriginal community participation in EAs for content, linkages, and outcomes supporting health and well-being, future research should examine how development can better integrate aboriginal communities, so that they too may assume greater responsibility for health and socio-economic issues in the long term (Lavoie, 2013).

4.6 Works Cited

Alcantara, C. (2013). Preferences, perceptions, and veto players: Explaining devolution negotiation outcomes in the Canadian territorial north. *Polar Record*. 49(2), 167-179.

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change*. 18(1), 86-98.

Armitage, D. R. (2005). Collaborative environmental assessment in the Northwest Territories, Canada. *Environmental Impact Assessment Review*. 25(3), 239-258.

Asselin, J., & Parkins, J. R. (2009). Comparative case study as social impact assessment: Possibilities and limitations for anticipating social change in the far north. *Social Indicators Research*. 94(3), 483-497.

Auditor General of Canada. (2010). Sustaining Development in the Northwest Territories. In *The Spring 2010 Report of the Auditor General of Canada* (1-34). Ottawa: Minister of Public Works and Government Services Canada.

Ballard, C., & Banks, G. (2003) Resource wars: The anthropology of mining. *Annual Review of Anthropology*. 32, 287-313.

Beh, E. J. (1998). A comparative study of scores for correspondence analysis with ordered categories. *Biometrical Journal*. 40(4), 413-429.

Beierle, T. C. (2002). The quality of stakeholder-based decisions. *Risk Analysis*. 22(4), 739-749.

Berger, T. (2010). Land use planning: Land claims and Canada's north. In *Canada's north: What's the plan?* (pp 7-35). Ottawa: Conference Board of Canada.

Birley, M. (2005). Health impact assessment in multinationals: A case study of the Royal Dutch/Shell Group. *Environmental Impact Assessment Review*. 25(7-8), 702-713.

Bronson, J., & Noble, B. F. (2006). Health determinants in Canadian northern environmental impact assessment. *Polar Record*. 42(4), 315-324.

Brown-Leonardi, C. J. (2012). Notions of property: Traditional land use and boundaries in the Deh Cho region. *Polar Record*. 48(3), 249-254.

Budge, I., & Pennings, P. (2007). Do they work? Validating computerised word frequency estimates against policy series. *Electoral Studies*. 26(1), 121-129.

Caine, K. J., Davison, C. M., & Stewart, E. J. (2009). Preliminary field-work: Methodological reflections from northern Canadian research. *Qualitative Research*. 9(4), 489-513.

Caine, K. J., Salomons, M. J., & Simmons, D. (2007). Partnerships for social change in the Canadian North: Revisiting the insider-outsider dialectic. *Development and Change*. 38(3), 447-471.

Centre for the North. (2012). *Getting it right: Assessing and building resilience in Canada's north*. Ottawa, ON: Conference Board of Canada.

Centre for the North. (2011). *Striking a balance: Impacts of major natural resource projects in the north: Briefing*. Ottawa, ON: Conference Board of Canada.

Charmaz, K. (2004). Premises, principles, and practices in qualitative research: Revisiting the foundations. *Qualitative Health Research*. 14(7), 976-993.

Chatwood, S., Bjerregaard, P., & Kue Young, T. (2012). Global health - A circumpolar perspective. *American Journal of Public Health*. 102(7), 1246-1249.

Christensen, J., & Grant, M. (2007). How political change paved the way for indigenous knowledge: The Mackenzie Valley Resource Management Act. *Arctic*. 60(2), 115-123.

Conference Board of Canada. (2013). *The future of mining in Canada's north: Economic performance and trends*. Ottawa: M. Caron-Vuotari & G. Rheaume.

Cundill, G., & Rodela, R. (2012). A review of assertions about the processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*. 113, 7-14.
Davison, C. M., & Hawe, P. (2012). All that glitters: Diamond mining and Tåîchô youth in Behchokö, Northwest Territories. *Arctic*. 65(2), 214-228.
Duhaime, G., Searles, E., Usher, P. J., Myers, H., & Fréchette, P. (2004). Social cohesion and living conditions in the Canadian arctic: From theory to measurement. *Social Indicators Research*. 66(3), 295-317.
Fidler, C., & Hitch, M. (2007). Impact and Benefit Agreements: A contentious issue for environmental and aboriginal justice. *Environments*. 35(2), 49-69.
Fitzpatrick, P., Fonseca, A., & McAllister, M. L. (2011). From the Whitehorse Mining Initiative towards sustainable mining: Lessons learned. *Journal of Cleaner Production*. 19(4), 376-384.
Fitzpatrick, P., Sinclair, A. J., & Mitchell, B. (2008). Environmental impact assessment under the Mackenzie Valley Resource Management Act: Deliberative democracy in Canada's north? *Environmental Management*. 42(1), 1-18.
Flicker, S., & Worthington, C. A. (2012). Public health research involving aboriginal peoples: Research ethics board stakeholders' reflections on ethics principles and research processes. *Canadian Journal of Public Health*. 103(1), 19-22.
Galbraith, L., Bradshaw, B., & Rutherford, M. B. (2007). Towards a new supraregulatory approach to environmental assessment in northern Canada. *Impact Assessment and Project Appraisal*. 25(1), 27-41.
Gamble, D. J. (1978). The Berger Inquiry: An impact assessment process. *Science*. 199(4332), 946-952.
Gibson, R. B. (2011). Application of a contribution to sustainability test by the Joint Review Panel for the Canadian Mackenzie Gas Project. *Impact Assessment and Project Appraisal*. 29(3), 231-244.
Gibson, G., & Klinck, J. (2005). Canada's resilient north: The impact of mining on aboriginal communities. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health*. 3(1), 116-139.
Government of Canada. (2011). *Aboriginal Consultation and Accomodation: Updated Guidelines for Federal Officials to Fulfill the Duty to Consult*. Ottawa: Aboriginal Affairs and Northern Development Canada.
Grimmer, J., & Stewart, B. M. (2013). Text as data: The promise and pitfalls of automatic content analysis methods for political texts. *Political Analysis*. 21(3), 267-297.
Hall, R. (2013). Diamond mining in Canada's Northwest Territories: A colonial continuity. *Antipode*. 45(2), 376-393.
Hanna, P., & Vanclay, F. (2013). Human rights, indigenous peoples and the concept of Free, Prior and Informed Consent. *Impact Assessment and Project Appraisal*. 31(2), 146-157.
Hopkins, D. J., & King, G. (2010). A method of automated nonparametric content analysis for social science. *American Journal of Political Science*. 54(1), 229-247.
Houde, N. (2007). The six faces of traditional ecological knowledge: Challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 12(2).
Johnson, E. A., & Miyanishi, K. (2012). The boreal forest as a cultural landscape. *Annals of the New York Academy of Sciences*. 1249, 151-165.
King, M., Smith, A., & Gracey, M. (2009). Indigenous health part 2: The underlying causes of the health gap. *Lancet*. 374(9683), 76-85.

Kryzanowski, J. A., & McIntyre, L. (2011). A holistic model for the selection of environmental assessment indicators to assess the impact of industrialization on indigenous health. *Canadian Journal of Public Health*. 102(2), 112-117.
Kwiatkowski, R. E. (2011). Indigenous community based participatory research and health impact assessment: A Canadian example. *Environmental Impact Assessment Review*. 31(4), 445-450.
Kwiatkowski, R. E., & Ooi, M. (2003). Integrated environmental impact assessment: a Canadian example. *Bulletin of the World Health Organization*. 81(6), 434-438.
Laver, M., & Garry, J. (2000). Estimating policy positions from political texts. *American Journal of Political Science*. 44(3), 619-634.
Lavoie, J. G. (2013). Policy silences: Why Canada needs a national First Nations, Inuit and Metis health policy. *International Journal of Circumpolar Health*. 72, 1-7.
Leech, N. L., & Onwuegbuzie, A. J. (2011). Beyond constant comparison qualitative data analysis: Using NVivo. *School Psychology Quarterly*. 26(1), 70-84.
Lowe, W., Benoit, K., Slava, M., & Laver, M. (2011). Scaling policy preferences from coded political texts. *Legislative Studies Quarterly*. 36(1), 123-155.
Mackenzie Valley Environmental Impact Review Boad [MVEIRB]. (2013). Report of environmental assessment and reasons for decision: EA 0809-004 Fortune Minerals Limited Nico Project. Retrieved from the MVEIRB Public Registry http://www.reviewboard.ca/upload/project_document/EA0809-004_NICO_Report_of_EA_and_Reasons_for_Decision.PDF
Mackenzie Valley Environmental Impact Review Boad [MVEIRB]. (2011). Report of environmental assessment and reasons for decision: EA0809-002: Canadian Zinc Corporation Prairie Creek Mine. Retrieved from the MVEIRB Public Registry. http://reviewboard.ca/upload/project_document/EA0809-002_Report_of_Environmental_Assessment_and_Reasons_for_Decision_1328709638.PDF
Marmot, M., Allen, J., Bell, R., & Goldblatt, P. (2012). Building of the global movement for health equity: From Santiago to Rio and beyond. *Lancet*. 379(9811), 181-188.
McCaig, K. (2005). Canadian insights: The challenges of an integrated environmental assessment framework. *Environmental Impact Assessment Review*. 25(7-8), 737-746.
Mohammad, S. M., & Turney, P. D. (2013). Crowdsourcing a word-emotion association lexicon. *Computational Intelligence*. 29(3), 436-465.
Nadasdy, P. (2002). "Property" and aboriginal land claims in the Canadian subarctic: Some theoretical considerations. *American Anthropologist*. 104(1), 247-261.
Noble, B., & Birk, J. (2011). Comfort monitoring? Environmental assessment follow-up under community-industry negotiated environmental agreements. *Environmental Impact Assessment Review*. 31(1), 17-24.
Noble, B., & Bronson, J. (2006). Practitioner survey of the state of health integration in environmental assessment: The case of northern Canada. *Environmental Impact Assessment Review*. 26(4), 410-424.
Notzke, C. (1995). A new perspective in aboriginal natural resource management: Co-management. *Geoforum*. 26(2), 187-209.
O'Neil, J. D. (1986). The politics of health in the fourth world: A northern Canadian example. *Human Organization*. 45(2), 119-128.
Onkila, T. (2011). Multiple forms of stakeholder interaction in environmental management: Business arguments regarding differences in stakeholder relationships. *Business Strategy and the Environment*. 20(6), 379-393.
Ozkan, U. R., & Schott, S. (2013). Sustainable development and capabilities for the polar region. *Social Indicators Research*. 114(3), 1259-1283.

Paci, C., & Villebrun, N. (2005). Mining Denendeh: A Dene Nation perspective on community health impacts of mining. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health*. 3(1), 71-86.
Peng, T., Liu, L., & Zuo, W. (2014). PU text classification enhanced by term frequency-inverse document frequency-improved weighting. *Concurrency Computation Practice and Experience*. 26(3), 728-741.
Peters, V., & Wester, F. (2007). How qualitative data analysis software may support the qualitative analysis process. *Quality and Quantity*. 41(5), 635-659.
Polkinghorne, D. E. (2006). An agenda for the second generation of qualitative studies. *International Journal of Qualitative Studies on Health and Well-being*. 1(2), 68-77.
Potvin, L., Gendron, S., Bilodeau, A., & Chabot, P. (2005). Integrating social theory into public health practice. *American Journal of Public Health*. 95(4), 591-595.
Provalis. (2014). Wordstat Software.
Python. (2014). Natural Language Toolkit [NLTK].
QSR International. (2014). NVivo Version 10 Software.
Ritter, T. L. (2007). Sharing environmental health practice in the North American arctic: A focus on water and wastewater service. *Journal of Environmental Health*. 69(8), 50-55.
Robertson, S. (2004). Understanding inverse document frequency: On theoretical arguments for IDF. *Journal of Documentation*. 60(5), 503-520.
Rodela, R., Cundill, G., & Wals, A. E. J. (2012). An analysis of the methodological underpinnings of social learning research in natural resource management. *Ecological Economics*. 77, 16-26.
Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 19(6), 349-357.
Weaver, C., & Cunningham, A. M. (1985). Social theory, impact assessment and northern native communities. *Berkeley Planning Journal*. 2(1).
Wilson, G. N., & Alcantara, C. (2012). Mixing politics and business in the Canadian arctic: Inuit corporate governance in Nunavik and the Inuvialuit settlement region. *Canadian Journal of Political Science*. 45(4), 781-804.
Wilson, K., & Young, T. K. (2008). An overview of aboriginal health research in the social sciences: Current trends and future directions. *International Journal of Circumpolar Health*. 67(2-3), 179-189.
Wilson, K. (2003). Therapeutic landscapes and First Nations peoples: An exploration of culture, health and place. *Health & Place*. 9(2), 83-93.

Chapter Five:

"How Can Geographic Information Systems Support Public Health Planning for Development in Northern Canada?"

5.1 Introduction

5.1.1 Natural Resource Development and Health Inequities

In the Canadian arctic and sub-arctic, accelerating natural resource development has raised concerns about the health and well-being of remote aboriginal communities (Chatwood et al, 2012). Industrial proponents, government, and some members of the aboriginal leadership promote development as an economic means to raise the standard of living, and improve quality of life, in the north (Birley, 2005; Wilson & Alcantara, 2012). However, development confronts a historical legacy of cumulative bio-physical, socio-economic, heritage, and health impacts in obtaining social license from many aboriginal people who live in proximity to the proposed projects (Gamble, 1978; Nuttall, 2009; Usher, 2003).

At the level of the environment, observed negative impacts include environmental contamination; habitat fragmentation; damage to plants; wildlife avoidance; traffic congestion; and noise (Auditor General of Canada, 2010; Wilson & Rosenberg, 2002). At the level of communities, impacts include stress on infrastructure; income stratification; loss of social cohesion, language and culture; long term increases in chronic illness; heightened risk perception; and interference with subsistence and land-based cultural practices (Asselin & Parkins, 2009; Davison & Hawe, 2012). Both scholars and practitioners in aboriginal communities question whether the benefits of development indeed outweigh the risks (Hall, 2013; Kirmayer et al, 2011; Ozkan & Schott, 2013).

In public health research, the factors or characteristics of an individual or community that constrain or enable the realization of health and well-being are referred to as the social determinants of health (Marmot et al, 2012). Aboriginal people benefit from positive social determinants of health such as robust social support networks, strong connections to the physical environment, and a resilient and supportive culture (Flicker & Worthington, 2012; Wilson, 2003). Compared to national and regional averages, however, aboriginal peoples in northern Canada experience many population health inequities.

These inequities include crowded housing, poor water and sanitation systems, limited infrastructure, food insecurity, low incomes, lower educational attainment, and decreased access to culturally appropriate health services (Chatwood et al, 2012; King et al, 2009; Kwiatkowski & Ooi, 2003; Lauster & Tester, 2010; Ritter, 2007).

According to the social determinants of health perspective, poorer indicators of social wellness can translate into poorer health outcomes (Bronson & Noble, 2006; Kryzanowski & McIntyre, 2011; Potvin et al, 2005). Indeed, many northern aboriginal peoples do experience lower life expectancies, higher prevalence of obesity and overweight, higher morbidity and mortality from infectious and chronic diseases, and increased rates of social pathologies such as addictions, violence, injuries, and risky sexual behaviours (Birley, 2005; Chatwood et al, 2012; Gracey & King, 2009; Wilson & Young, 2008). Aboriginal communities with health inequities may be more susceptible to the negative health impacts of development (Kwiatkowski, 2011; Noble & Bronson, 2006).

In this light, many researchers argue that review processes should identify and mitigate development impacts on the social determinants of health, rather than focusing on purely economic benefits and opportunities (Bronson & Noble, 2006; Gibson, 2011; Davison & Hawe, 2012). At the same time, processes must be accessible and inclusive for aboriginal peoples, whose breadth and depth of knowledge about their communities is vital to understanding health inequities (Armitage, 2005; Wright et al, 2009). New tools integrating aboriginal priorities and worldviews are needed to gather and interpret the complex evidence of development impacts, and help ensure that development makes a net contribution to sustainability in the north (Bronson & Noble, 2006; Gibson, 2011; Paci & Villebrun, 2005).

My research examines how Geographic Information Systems (GIS) can serve as a platform to collect and coordinate multi-stakeholder perspectives on health inequities and impacts relative to developments, for improving public health in northern aboriginal communities. This qualitative study is among the first on this topic to consult with stakeholders in a northern Canadian environmental assessment, focusing on the Nico mining project proposed in the Wek'eezhii region of the Mackenzie Valley in the Northwest Territories (NWT), Canada.

5.1.2 Environmental Assessment in the Northwest Territories, Canada

In Canada, environmental assessment (EA) is the legislative process to engage multiple stakeholders for the public review of natural resource developments (McCaig, 2005). For aboriginal peoples, the *Canadian Environmental Assessment Act* states that EA should mitigate changes in the environment affecting four areas. These areas include 1) health and socio-economic conditions, 2) physical and cultural heritage, 3) traditional use of land and resources, and 4) historical, archeological, paleontological, or architecturally significant sites (S.C. 2012, c. 19, s. 52).

In the Mackenzie Valley sub-arctic region of the NWT, the conclusion (Sahtu, Gwich'in, and Tlicho regions) and negotiation (Dehcho and Akaitcho regions) of Comprehensive Land Claims and Self-Government Agreements provides additional context for aboriginal peoples in reviewing natural resource developments (Auditor General of Canada, 2010). The *Mackenzie Valley Resource Management Act* legislates the coordination of EAs in every part of the Mackenzie Valley, in accordance with current and future land claims (Fitzpatrick et al, 2008; S.C. 1998, c. 25). Arguably, at the level of practice, the Resource Management Act provides the most extensive provisions for aboriginal peoples' participation in natural resource management across the circumpolar north (Auditor General of Canada, 2010; Berger, 2010). This is because co-management structures of this legislation place power directly in the hands of aboriginal community members, who sit on decision-making boards (S.C. 1998, c. 25).

In the NWT, EAs are initiated after natural resource development proponents submit applications to the appropriate Land and Water Board in the project's settlement region (Christensen & Grant, 2007). In the Wek'eezhii region, the Wek'eezhii Land and Water Board (WLWB) both screens and regulates projects, meaning it determines whether projects require EA, and how EA approvals are regulated and enforced (Armitage, 2005). The Mackenzie Valley Environmental Impact Review Board (MVEIRB) conducts EAs for the Wek'eezhii region, and throughout the Mackenzie Valley, as a co-management tribunal (Auditor General of Canada, 2010).

Co-management mandates the equivalence of traditional knowledge and scientific evidence in reviewing natural resource projects (Houde, 2007; Lewis & Sheppard, 2006). In addition to this provision, both the WLWB and the MVEIRB are composed of 50%

aboriginal board membership (Armitage et al, 2008). Drawn from the region of the project, and from across the Mackenzie Valley, aboriginal board members exercise direct decision-making authority (Christensen & Grant, 2007). Moreover, the *Tlicho Land Claim and Self-Government Act*, as the most comprehensive land claim in Canadian history, informs EA for projects in the Wek'eezhii region (Auditor General of Canada, 2010; S.C. 2005, c. 1). Under that agreement, the Tlicho aboriginal government in Wek'eezhii has the power to provide "policy directions", which may effectively approve or reject developments at the EA stage (S.C. 2005, c. 1, 22.3.10). It is important to understand these unique factors in addressing the applicability of my research findings to the broader context of development reviews in other circumpolar regions.

Aboriginal people's access to decision-makers and full participation in decision-making is imperative to natural resource management that can address health inequities and impacts in northern communities, and elsewhere (Kwiatkowski & Ooi, 2003; Notzke, 1995). Nevertheless, in giving equal weight to traditional knowledge and scientific evidence, considerable effort and expertise to coordinate information is required (Kryzanowski & McIntyre, 2011; McCaig, 2005). Thus, my research investigates the relevance of GIS technology, a dynamic tool for information documentation, integration, analysis, and communication, in coordinating evidence supportive of aboriginal community health and well-being, relative to developments (McCarthy et al, 2012; Wright et al, 2009).

5.1.3 Geographic Information Systems

GIS is considered one of the frontiers of social science (Butz & Torrey, 2006). It consists of hardware, software, and personnel to collect, manage, analyse, and communicate geospatial data (Palmer, 2012). As a technology for mapping different layers of information, GIS permits collaboration between disciplines, and the integration of diverse data sets linked by their geospatial location (Leszczynski, 2009).

Over the past forty or more years, aboriginal organizations have employed GIS as a tool to negotiate land claims in circumpolar regions (Chapin et al, 2005; Houde, 2007; Louis et al, 2012). GIS has also emerged as a dynamic platform for participatory research, planning, and decision-making with aboriginal communities (Brubaker et al, 2011; Eisner et al, 2012; Lewis & Sheppard, 2006; McCarthy et al, 2012). As such, GIS may prove an

effective way to integrate and synthesize aboriginal community members' perspectives with those of EA practitioners when considering the complex evidence of health impacts relative to natural resource developments (Robbins, 2003). GIS has the advantage of being readily decipherable to the scientific and legal communities (Bailey & Grossardt, 2010; Wright et al, 2009). At the same time, aboriginal organizations can use its data management capacities to ensure confidentiality and preserve their system of access to sensitive cultural information (Chambers et al, 2004).

GIS is readily extensible to complex analysis and problem-solving. In the context of EAs, GIS can combine layers of data on historical land use; sacred sites; watersheds; subsistence hunting, fishing, and gathering; vegetation and wildlife; development land use; transportation corridors; community infrastructure; health services; and more (Chapin et al, 2005; Wright et al, 2009). Moreover, GIS visualizations can simplify the communication of highly complex geospatial concepts (Lewis & Sheppard, 2006). With many advantages, however, come challenges in the application of the technology. Using an organizational analysis framework derived from qualitative analysis of interview data, my research examines how GIS can leverage public health planning to address health inequities and impacts in a northern Canadian EA process, and the challenges faced in trying to make effective use of GIs as a communication tool in a multi-stakeholder process.

5.1.4 Objectives of the Study and Theoretical Framework

In examining how GIS can serve as platform for the integration of evidence about health impacts relative to developments, my research derives from two trends in the natural resource management literature. First, health impact assessment and public health planning are emerging topics in Canadian EA, focused on public participation and multi-stakeholder processes to promote community health and well-being as a key factor in decision-making (Kwiatkowski, 2011; McCaig, 2005; Snyder et al, 2012). Research indicates multi-stakeholder processes, which are also called "deliberative democracy" or "social learning", produce greater satisfaction for participants and higher quality decision-making in EAs (Armitage et al, 2008; Beierle, 2002; Cundill & Rodela, 2012; Fitzpatrick et al, 2008; Rodela et al, 2012). Second, participatory research using GIS is increasing, with many researchers asserting that GIS can facilitate data integration, management, and decision-making for more effective self-determination and self-governance in aboriginal communities (Brubaker et al, 2011; Eisner et al, 2012; González et al, 2008; Louis et al,

2012; McCarthy et al, 2012). Self-determination and self-governance are imperative for aboriginal peoples to realize their own concepts of community health and well-being (King et al, 2009; Lavoie, 2013; Macintosh, 2012).

To examine the convergence of these trends, my study employs organizational analysis as a theoretical framework to report my findings from qualitative research about a northern Canadian EA process (Winiecki, 2010). Organizational analysis can illustrate how shared objectives operate within social practices by different stakeholders during the process of EA, and how technology can be adapted for achieving those objectives (Scott & Davis, 2007). Based on Scott and Davis's (2007) definition, I structured my findings according to four key organizational variables: 1) Objective, 2) Process, 3) Social Practice, and 4) Technology (Scott & Davis, 2007).

In applying this organizational analysis framework, I had two objectives. First, I aimed for a concise and yet comprehensive collation of the relevant portions of my interview data, in support of research participants' expressed interest in generating a content analysis of the interviews (Caine et al, 2009; Caine et al, 2007; Flicker & Worthington, 2012). Second, I aimed for a presentation of my results that is amenable to comparison with other EA processes, so that practitioners outside of my study context might consider from this model the applicability of GIS in their own practice (Lammers, 2011).

5.2 Methods

5.2.1 Case Study Context

My research focused on the EA for the Nico gold-cobalt-copper-bismuth mine in the Wek'eezhii region of the NWT, proposed by Fortune Minerals Limited in 2009 (Nico EA0809-004)(MVEIRB, 2013). The Nico project comprises both open pit and underground mining, ore processing, tailings and mine rock management areas, a camp site, waste management facilities, an effluent treatment facility, and roads within the mine site (MVEIRB, 2013). It is staked on a parcel of land leased to Fortune Minerals, but otherwise surrounded by the Tlicho Settlement Region. The proposed Nico mine would be located only 50 kilometers outside of the Tlicho community of Whati (population 509), and in proximity to all of the other Tlicho communities of Behchoko (population 2064),

Gameti (population 311), and Wekweeti (population 145) (Government of the Northwest Territories Bureau of Statistics, 2011).

I selected Nico as a case study in early 2012, as part of initial fieldwork consultations with staff of the MVEIRB and the Tlicho Government (Caine et al, 2009). These stakeholders identified Nico as a project in which GIS was employed in a novel capacity, and for which aboriginal community health and well-being was a prominent concern. To gain an understanding of the EA process as it was unfolding, I attended two out of six days of the Nico public hearings in Behchoko, NWT in October 2012. Active participation by the Tlicho government and community members in the Nico EA indicated that the project posed potential impacts in each of the four areas outlined in the *Canadian Environmental Assessment Act* (c. 2012, c. 19, s. 52). Aboriginal participants were concerned about health and socio-cultural impacts, industrialization causing loss of physical and cultural heritage, heightened risk perception reducing traditional land and resource use, and the destruction of culturally significant sites (MVEIRB, 2013). MVEIRB deemed Nico likely to have significant adverse impacts on the bio-physical and cultural environment in the report of EA (MVEIRB, 2013). However, MVEIRB placed measures of compliance to mitigate those impacts into place, and the Nico project received final EA approval in 2013.

5.2.2 Interviewee Recruitment

I recruited 13 stakeholders in the Nico EA, drawn from the territorial government, regional regulatory agencies, the aboriginal government and its consultants, and the proponents and its consultants (Table 5-1).

Table 5-1. Nico environmental assessment stakeholder affiliations.

Category	Affiliations
Government of Northwest Territories	*Department of Environment and Natural Resources*
	Department of Health and Social Services
Regulators	*Mackenzie Valley Environmental Impact Review Board*
	Wek'eezhii Land and Water Board
Aboriginal Government	*Tlicho Government*
	The Firelight Group
Proponent	*Fortune Minerals*
	Golder Consultants

I purposively sampled interviewees to be representative of all of the key regional groups working with GIS and/or in an implementation capacity around mitigating impacts of the Nico mine on Tlicho communities. I identified interviewees directly from participation in my preliminary field work consultations (n=4), through networking at the public hearings (n=3), through participation recorded in the public record of the Nico EA (n=1), and through snowball sampling based on the suggestions of already interviewed individuals or other experts (n=5). I invited all interviewees via email, providing them with a letter of invitation, the information and informed consent form, and the interview guide, prior to an interview. The University of Alberta Health Research Ethics Board 1 reviewed and gave ethical approval to my research protocol, recruitment process, letter of invitation, information and informed consent form, and interview guide. The Aurora Research

Institute licensed my NWT research for 2013 and 2014 (License #15242 and License #15409).

5.2.3 Interview Guides

To develop my interview guide, I conducted a literature review of research about aboriginal peoples in relation to Canadian EA legislation, health impacts of circumpolar development, and GIS in aboriginal community governance and natural resource management. In addition, I completed two research studies. The first study comprised a qualitative content analysis of 30 interviews I conducted with circumpolar policy makers, researchers, and practitioners on GIS, concerned with indigenous community health and well-being relative to development (McGetrick, unpublished results; see Chapter 3). In the second study, I conducted automated content analysis of public hearing transcripts from the Nico and Prairie Creek EAs conducted by MVEIRB between 2008 and 2013 (McGetrick, unpublished results; see Chapter 4). Thus, the interview guides were based on identified areas where GIS could potentially contribute to public health planning, and probed for confirmations, refutations, and examples (Charmaz, 2004). My thesis committee members, with expertise in health impact assessment, qualitative research, arctic policy, law, and risk communication, reviewed and revised the interview guide for depth and breadth of coverage (Table 5-2).

Table 5-2. Nico environmental assessment stakeholders interview guide.

1. *Could you please tell me about your participation in the Nico environmental assessment?*
2. *Did you achieve your goals in the process, if not why not?*
3. *What impacts do you think the Nico project will have in communities?*
4. *Can you comment on the use of Geographic Information Systems, or GIS, to map different information as part of the Nico environmental assessment?*
5. *Can you please comment on how the Traditional Knowledge and Use studies contributed to decision-making in the Nico environmental assessment?*
6. *Can you comment on how community members contributed to decision-making in the Nico environmental assessment?*
7. *What did you and other stakeholders do to incorporate heath impacts during the Nico environmental assessment?*
8. *Do you think that health was appropriately considered in the Nico environmental assessment, overall? Please provide an example, if possible, or explain how it was not considered.*
9. *Do you think that GIS will be a useful and feasible tool in monitoring health impacts and reporting results of the Nico project to communities? Why or why not?*
10. *Do you foresee an opportunity to work with community members in the future to help monitor the impacts of the Nico project?*
11. *Is there anything else you would like to add?*

5.2.4 Data Collection

I conducted semi-structured interviews on site in Yellowknife or Behchoko (n=11) or by telephone (n=2) to gather interviewees' perspectives on the use of GIS in an EA process. I digitally recorded the interviews, which ranged from approximately 40 minutes to one hour in length. I transcribed the recordings verbatim, de-identified them, and formatted them for analysis in NVivo 10 (Leech & Onwuegbuzie, 2011; Peters & Wester, 2007; QSR International, 2014). To aid in my interpretation of the interviews, I took field notes, recorded my post-interview reflections, and noted ideas, theories, and methods while transcribing and verifying the transcripts (Polkinghorne, 2006). I returned the transcripts

to interviewees for validation. Validation by interviewees is important for the accuracy of data for analysis, and rigour of the research (Onwuegbuzie & Leech, 2007). The interviewees provided minor revisions to their transcripts, which I incorporated into the data for analysis prior to coding in NVivo.

5.2.5 Data Analysis

In my analysis, I used NVivo 10 version software to review each transcript (QSR International, 2013). My analysis employed the constant comparison method, which involves abstracting the data into "codes" by continually engaging with the research question, studying supplementary interpretive material, reviewing the literature, and reflecting on similarities and differences across the dataset (Hallberg, 2006; Leech & Onwuegbuzie, 2011; Starks & Trinidad, 2007). I documented this process of coding through reflexively "memo-ing" at every stage (Peters & Wester, 2007). Although the codes emerged inductively from the data, I was able to increase the efficiency of my coding by referring to the memos generated in my previous study with circumpolar experts (McGetrick, unpublished results; see Chapter 3). The process of coding allowed me to generate a provisional conceptual frame for my data; the eight final codes that I used and the categories into which I grouped them are presented below (Table 5-3).

Table 5-3. Categories, codes, and definitions for analysis of the Nico environmental assessment stakeholder interviews.

Categories	Codes	Definition
Development Outcomes	*Negative Impacts of Development*	Negative outcomes for aboriginal community members, region, and environment
	Positive Impacts of Development	Positive outcomes for aboriginal community members, region, and environment
Environmental Assessments and Uncertainty	*Environmental Assessment*	Stages of formally reviewing a natural resource project, including adjunct processes such as socio-economic and impact benefit agreements
	Uncertainty	Scarcity of knowledge or certainty about evidence or the course of events pertaining to development
Bridging Knowledge Gaps	*Stakeholders*	Actions and collaboration of parties to the environmental assessment to identify and mitigate mine impacts
	Community Involvement	Engagement of aboriginal community members' perspectives and traditional knowledge to review the development
Knowledge Integration	*Forms of Data*	Qualitative and quantitative data protocols, collection, analysis, and interpretation for baselines and monitoring
	Geographic Information Systems	Data, hardware, software, and personnel to collect, store, manipulate, retrieve, and display geospatial data

From this provisional coding frame, I created a code book consisting of my codes, their definitions, keywords, and examples of coded text, grouped by category. An experienced second coder was trained using the codebook to code transcripts for 61.5% of the transcripts: one from each of the stakeholder affiliations. We calculated the kappa coefficient for each code in NVivo 10 (QSR International, 2013). We discussed all codes with kappa scores of less than 0.8, above the 0.6 value indicating substantial inter-coder

agreement (Landis & Koch, 1977). We clarified the definitions of the codes and reviewed codes to resolve conflicting interpretations. After discussions kappa scores were recalculated and all were above 0.8 (with 40 of the 48 above 0.9) indicating excellent agreement (McHugh, 2012).

5.2.6 Synthesizing Emergent Themes in the Data

From my provisional coding frame, I synthesized emerging themes in the data by adapting key variables (Objective, Process, Social Practice, and Technology) from an organization analysis framework (Scott & Davis, 2007). Objective corresponds to the "development outcomes" category. This key variable refers to identifying and mitigating potential health impacts in a multi-stakeholder EA process (McCaig, 2005). Process corresponds to the "environmental assessments and uncertainty" category. This key variable delineates the structure and knowledge gaps in EA, and defines the activity space for GIS innovation (Winiecki, 2010). Social practice corresponds with the "bridging knowledge gaps" category. This key variable consists of ways that stakeholders can bridge the knowledge gap with aboriginal communities on health and well-being during EA (Armitage, 2005; Reckwitz, 2002). Finally, technology corresponds to the "knowledge integration" category. This key variable comprises the work or tasks that convert inputs into outputs, such as the integration of traditional knowledge and scientific evidence on a GIS platform (Chambers et al, 2004; Scott & Davis, 2007).

5.2.7 Study Limitations

In pursuing qualitative field work with stakeholders in a northern Canadian EA, it is important to address bias in terms of the choice of topics, research sites, and organizations on which to focus (Brown, 2003; Caine et al, 2007; Flicker & Worthington, 2012; Scammell, 2010). My research examined organizational objectives, processes, social practices, and technologies under governing legislation (federal and territorial) and land claims in the NWT, Canada. This topic reflects a climate of certain empowerment for the Tlicho peoples in the Wek'eezhii region, which may not apply to other circumpolar regions, or indigenous groups (Forbes & Stammler, 2009). The research sites involved mainly office environments in Yellowknife and Behchoko, where our discussion of traditional practices, land-based activities, and even GIS was abstracted rather than conducted or observed. Therefore, my research does not purport to capture social practices "on-the-

ground", but merely the ways that those practices could inform EA processes. In addition, my research focused on regional stakeholders with some role in GIS analysis or mitigating impacts of the Nico mine on Tlicho communities. Federal EA practitioners, whose roles and responsibilities in this EA tended to focus more on purely environmental impacts, were not involved in the research (MVEIRB, 2013). Nevertheless, the regionally based interviewees extensively addressed relevant issues for aboriginal peoples affected by changes in the environment as set out in the *Canadian Environmental Assessment Act*, the *Mackenzie Valley Resource Management Act*, and the *Tlicho Land Claims and Self-Government Act* (S.C. 2012, c. 19, s. 52; S.C. 2005, c. 1; S.C. 1998, c. 25).

5.3 Results and Discussion

5.3.1 Objective: Development Outcomes

Interviewees converged in their description of objectives around the legislative mandate to identify and mitigate impacts in the Canadian Environmental Assessment Act (S.C. 2012, c. 19, s. 52). This mandate includes environmental effects on aboriginal peoples' health and socio-economic conditions; physical and cultural heritage; traditional use and resources; and historical, archeological, or otherwise significant sites.

> *[Environmental assessments] evaluate what I see as the trade-offs between impacts and benefits of a project, including environmental and socio-economic issues, and extending beyond to spiritual and cultural, a full breadth of review (Interviewee 001)*

Within their respective fields, interviewees indicated conceptual versus technical issues for realizing the objective, reflecting a distinction in the natural resource management literature (Fitzpatrick et al, 2011; McCarthy et al, 2012). Interviewees described how conceptual issues were raised to help identify impacts, and technical issues in devising, and eventually implementing, mitigations.

> *We've done our best to make the [MVEIRB] board understand what our main concerns were, pertaining to land, water, caribou, and wildlife in general, and the health of our people, upstream and downstream … so that they can understand fully the impact on all the Tlicho communities (Interviewee 002)*

> *[We] want to make sure that we're meeting the terms [and] recognizing people's concerns … [attempting] to push forward the science a little bit, [trying] new techniques and new analyses, and learn[ing] what we can (Interviewee 003)*

Within aboriginal peoples' holistic conceptions, bio-physical environmental impacts can have significant effects on individual, family, and community health and well-being (Kwiatkowski, 2011; Wilson & Rosenberg, 2002). The socio-ecological perspective, which links human health and well-being to the social and physical environment, can be useful to understand the immediacy of the environmental context in remote northern aboriginal communities (Kirmayer et al, 2011). Although the socio-ecological perspective is not made explicit, the *Canadian Environmental Assessment Act* inculcates this distinction in specifying impacts of environmental effects on aboriginal peoples (S.C. 2012, c. 19, s. 52). However, it is fair to argue that the limitations of current legislation for health impact assessment necessitates active efforts by affected indigenous communities to ensure their concerns are addressed (Lavoie, 2013; MacIntosh, 2012). Interviewees characterized how development, by changing the socio-ecological context, could negatively affect Tlicho community health and well-being.

> *In the broad sense of community wellness, there are a number of things that many people would consider to be health impacts … many of them are linked with harvesting … other ones had to do with how this could exacerbate existing social problems, or create new ones [affecting] social wellness (Interviewee 004)*

In theory, accurate and precise conceptualization of impacts to the socio-ecological context should indicate pathways or mechanisms through which such impacts can be mitigated (Marmot et al, 2012). Thus, the conceptual objective of identifying health and socio-economic impacts can furnish valuable technical insight for designing community interventions to mitigate those impacts (Marks et al, 2007).

Interviewees commonly cited prosperity, as economic integration, employment, income, royalties, business opportunities, and training, as a positive socio-ecological impact, by providing Tlicho communities with socio-economic benefits (Conference Board of Canada, 2013).

> *I think positive [impacts] would be employment. Hopefully, some training, and sustainable training so that people could become carpenters or electricians, and carry that skill forward when the mine life is over (Interviewee 005)*

> *In terms of bringing in groceries to the stores, hopefully, the cost of living will go down [with] access year round. If you want to go and haul things, you go. You don't have to fly in and fly out as before (Interviewee 002)*

Development has improved some economic indicators (like per capita income) in the circumpolar arctic; however, the population health of those regions lags behind undeveloped ones in certain respects (Chatwood et al, 2012). In mixed subsistence and wage economies, development can skew economic values, disrupting traditional socio-ecological pathways and mechanisms supplying protective factors in community health and well-being (Horwitz & Finlayson, 2011; Usher et al, 2003). On a conceptual and technical level, interviewees recognized that measures to address health inequities must correspond with the distinctive historical, social, and cultural context of Tlicho communities, and not rely on purely economic incentives (Marks et al, 2007). In the Nico EA, for example, MVEIRB stipulated that a culture camp be established at Hislop Lake, to prevent loss of traditional use in proximity to the mine footprint (MVEIRB, 2013).

> *An economic compensation for an economic impact is legitimate mitigation … If you have a cultural mitigation for a cultural impact … or a bio-physical mitigation for a bio-physical impact, great. But if you start crossing those, you wind up with things that look like mitigations that don't truly mitigate (Interviewee 004)*

> *That's going to be good, to have a culture camp … to send our young children out there … They're going to learn about their own history, what our Elders all went through … all sorts of traditional skills (Interviewee 006)*

Overall, interviewees expressed an eager willingness to address the articulated concerns of the Tlicho leadership and community members. Within the current legislative framework in Wek'eezhii, EA procedures are sufficiently flexible to be modified through consultation and accommodation practices (Fidler & Hitch, 2007). It appears that the more clearly impacts can be conceptualized, the likelier they will be addressed by the MVEIRB through the EA. Arguably, GIS technology that can help to conceptualize complex socio-ecological relationships holds potential to improve aboriginal communities' public health planning in relation to development (Chapin et al, 2005).

5.3.2 Process: Environmental Assessments and Uncertainty

In the Mackenzie Valley, the current EA process has a mandate to identify and mitigate the aforementioned impacts in its aboriginal communities (Christensen & Grant, 2007). In theory, the conceptual and technical work involved in accomplishing that objective should indicate socio-ecological pathways and mechanisms to improve population health outcomes, overall (Marmot et al, 2012). However, EA in practice tends to prioritize health and well-being of individuals employed or otherwise involved at the project site, and identifying and mitigating impacts to the bio-physical environment (Bronson & Noble, 2006; McCaig, 2005). Interviewees described a gap in the EA process for measuring and responding to social and economic changes in the broader aboriginal communities.

> *It's an unfortunate failing of the system that there are no regulatory mechanisms such as land use permits or water licenses that deal directly with socio-economic impacts (Interviewee 004)*

Because changes in socio-ecological context are considered "outside-the-fence" for development projects, public health planning falls to stakeholders working in conjunction with the EA process (McCaig, 2005). Interviewees described how the territorial and Tlicho governments coordinate their efforts through the Tlicho Community Services Agency (TCSA), with the expectation that the Tlicho will eventually exercise the authority for health care in its territory under the *Tlicho Land Claims and Self-Government Act* (Lavoie, 2013; S.C. 2005, c. 1).

> *It is a very engaged group with the TCSA [on] the socio-economic side [and] the social determinants of health … where we could go to monitor, what we can monitor, if we can make changes … We've really started trying to open this up with the leadership that's there right now (Interviewee 007)*

In a past survey of northern EA practitioners, the SDH were reportedly considered in only about half of EA processes (Noble & Bronson, 2006). However, interviewees described the potential for expanding consideration of human health and well-being in Mackenzie Valley EAs, if warranted by community member's participation in the process (Kryzanowski & McIntyre, 2011).

> *If there was greater discussion about issues involving health of people, [we could] incorporate that … But it starts at the grassroots … people bringing it to the attention of the [MVEIRB] board as an issue, as a concern from the people (Interviewee 008)*

In the Wek'eezhii region, opportunities to examine socio-ecological pathways and mechanisms by engaging directly with community members include community meetings, baseline studies, traditional knowledge studies, and public hearing processes (Armitage, 2005). Interviewees described some of these efforts and the importance that they placed on input from community members.

> *We had what are called scoping sessions … went into the communities [with] translators [and] sat down and asked people what are the key issues with this project [and] how they would prioritize those key issues (Interviewee 008)*

> *We had meetings in the communities where we talked to people … we had an issue database where we wrote down their concerns and questions. Those were incorporated into the environmental assessment … we went through the list and we said, have we answered this question, or not? If we haven't, then we need to find a way to work it in (Interviewee 009)*

With access and opportunities for iterative communication and consultation, more appropriate decision-making is possible- howsoever limited in focus to the prescribed slate of issues (Centre for the North, 2012; Kwiatkowski, 2011). Interviewees described innovations in the Nico EA process that will help to inform regulatory targets by collating information about community members' values (Racher et al, 2011).

> *[For example], water quality objectives are really important to figure out in the environmental assessment process. Those are not numbers, a lot of the times … what we're looking for is more a narrative statement of where are people comfortable on a value basis (Interviewee 010)*

Although the public health planning that occurs is not mandated within Mackenzie Valley EA processes currently, there appears to be potential for integration in the future. GIS could serve as a platform for that integration, in light of the diverse frameworks and timelines involved (Wright et al, 2009). In any case, GIS could potentially support the efforts of the TCSA, by facilitating complex analyses for effective public health planning (Flicker & Worthington, 2012; Marks et al, 2007; Palmer, 2012). Investing in GIS, moreover, as a dynamic repository of evidence across stakeholder disciplines, could prevent loss of information, and simplify data management, as EA processes and jurisdictions evolve (Ballard & Banks, 2003; González et al, 2008).

5.3.3 Social Practice: Bridging Knowledge Gaps

A key social practice that distinguishes EA in the Mackenzie Valley is the equivalence of traditional knowledge and scientific evidence under the *Mackenzie Valley Resource Management Act* (Christensen & Grant, 2007; Fitzpatrick et al, 2008; S.C. 1998, c. 25). Over the past forty or so years, aboriginal peoples have accomplished judicial recognition of aboriginal title, subsistence harvesting rights, and oral history (Houde, 2007). These achievements have bolstered the role of traditional knowledge in EA, an area where aboriginal people are unassailably expert (Christensen & Grant, 2007; Ellis, 2005). Interviewees explained the relevance of traditional knowledge for decision-making; some expressed consternation in confronting a cultural gradient.

> *Traditional knowledge is a legislated requirement [in] the MVEIRB process and policy guidelines … [and] the Government of the Northwest Territories in all its decision-making incorporates traditional knowledge where appropriate (Interviewee 011)*

> *I think the whole problem with traditional knowledge is that it gets very political very quickly (Interviewee 003)*

In the broadest terms, "traditional knowledge" refers to cultural ideas, insights, and practices developed by aboriginal communities in relation to their ancestral territories (Chambers et al, 2004). In the literature, recognition of traditional knowledge serves to counter individualized representation of health inequities, and to support aboriginal people's own holistic conceptions of health and well-being (Lauster & Tester, 2010; Macintosh, 2012; O'Neil, 1986). Traditional knowledge is vital to aboriginal people's connection with social support networks, the physical environment, and dynamic culture (Flicker & Worthington, 2012; Wilson & Alcantara, 2012).

> *I would say traditional knowledge has much more to do with health [and] healthy people … than scientific knowledge in this region … [I]t's only been in the last … fifty years that science has had an impact … People have retained their traditional ways [which] I think … has a lot more to do with health than the current society (Interviewee 005)*

Interviewees described how traditional knowledge is used in EA baselines, as well as the state of current efforts to utilize it in monitoring. These social practices provide more meaningful consultation and support capacity building to mitigate SDH impacts (McCarthy et al, 2012; Wright et al, 2009).

> *With baseline, it informs along with the scientific baseline information … That's where environmental assessment really uses traditional knowledge. In terms of follow-up and using traditional knowledge for monitoring … that's a whole other use and that's something that everyone's still grappling with (Interviewee 010)*

> *Traditional knowledge reports tend to be … not a yearly output of data or information … I could definitely see the results of a traditional knowledge study lending hand to the conclusions [of] various other monitoring initiatives, helping us to interpret those results (Interviewee 011)*

Importantly, traditional knowledge is expertise unique to aboriginal peoples and communities (Ellis, 2005; Stevenson, 1996). Interviewees described how the Tlicho resisted representation of their traditional knowledge from outside the community in the Nico EA.

> *For people to share things, you have to really build a lot of trust, and you have to get to know someone really well … I think that Nico themselves had done traditional knowledge work, had contracted out to do that, and it was really, really inadequate (Interviewee 005)*

> *The Tlicho felt more confident in their own results than [the proponent's] … it allowed them to identify culturally sensitive areas that they felt couldn't be identified any other way. They had their own protocol in that respect (Interviewee 009)*

The Nico EA is notably one of an increasing number of cases where the aboriginal community engaged in social practice by representing their own traditional knowledge in a multi-stakeholder process (Eisner et al, 2012; McCarthy et al, 2012; Stewart et al, 2008). Interviewees described ongoing traditional knowledge research by the Tlicho communities, as well as the empowerment of conceptualizing and technically managing community-driven evidence.

> *Reality is that many companies do these studies for communities, and the companies then give the information to the proponents, and then they decide how they use that information … we work directly from the communities. It goes into a community database, where they then get to manage that information, and decide what information gets shared with the proponent (Interviewee 012)*

> *In every one of the communities, elders have worked with us … interviews on caribou migration …., [the] plants project, [the] habitat project … collect[ing] all the place names in Tlicho, in our language … It's mainly going to be on a website. It was all entered into a database and analysed- our GIS person will map all that information (Interviewee 006)*

As community members increasingly refer to traditional knowledge as a social practice in EA, GIS can facilitate appropriate stewardship of the data within aboriginal communities (Chapin et al, 2005). Traditional knowledge studies integrated with EAs can help to produce accurate and precise indicators of community health and well-being (Kwiatkowski, 2011; Kwiatkowski & Ooi, 2003). Those indicators can play an important role in public health planning to understand socio-ecological pathways and mechanisms to address health inequities and impacts relative to development (Marks et al, 2007).

5.3.4 Technology: Knowledge Integration

GIS technology has been instrumental to the negotiation of land claims in Canada, by asserting the rights and presence of aboriginal peoples on the geopolitical landscape (Houde, 2007; Louis et al, 2012). Interviewees described how GIS can communicate similar issues in the EA context, providing a platform for aboriginal people's perspectives and concerns about health and well-being within a landscape of accumulating scientific evidence.

> *Many companies look at the maps, and they don't see any First Nations features … The importance of doing these baseline studies is to put First Nations on the map … their territories. To be able to document them in a way that can be relevant, and can be something that is a useful tool, such as in an environmental assessment (Interviewee 012)*

> *A GIS platform is going to come in really handy, [when] expanding it to a 39,000 square kilometer platform from [the Nico] scale, which was 4000 hectares … primarily things like cumulative impacts … All of those are going to be on a map, and they're going to start to look at spatial and temporal relationships (Interviewee 009)*

GIS can serve as the locus for scientific evidence, traditional knowledge, and other information to identify and mitigate development impacts through effective public health planning (Wright et al, 2009). Interviewees described the complexity of scientific evidence displayed in a GIS, matched with the complexity of traditional knowledge.

> *We do modelling [of] the vegetation, the soils, the water, access to water … slope, percent slope [and] then include all the archeology sites on top of it … assign values [of] high, medium, and low potentials for historical resources … those are exactly the places we find a lot of sites (Interviewee 013)*

> *We developed a direct to digital map capture process [of] places or resources such as camps, trails … hunting or fishing areas, berry or plant collection areas … But*

> *then we also include … non-site specific things [like] stories, or the knowledge that's transferred, where you can't actually confine it to a physical location … One is the site specific, and one is the non-site specific (Interviewee 012)*

GIS can assist in the appropriate stewardship of aboriginal people's confidential data for integration with scientific evidence (Chambers et al, 2004; Chapin et al, 2005; Palmer, 2012). At the same time, particularly where GIS can appear prohibitively sophisticated, interviewees described the importance of communicating the relevance of analyses to community members (Leszczynski, 2009; Lewis & Sheppard, 2006; Robbins, 2003).

> *We use GIS to do some really fascinating analysis for eggheads who are into that kind of stuff. But I told you that also what we heard from the communities is they don't care about our analysis. We show up at the meetings with these huge binders, and that gets people's goats up, actually (Interviewee 003)*

> *[Show] it more in the Tlicho way … this is how it was in the past, this is how it is today, and how it's going to look in the future, after the mine … put it together, to do the presentation … The environment, is it going to be the same, or is it going to look different? Yes, that's how I would have put it (Interviewee 006)*

> *[GIS can provide] a better understanding, yes. A better visual understanding (Interviewee 002)*

Another important feature of GIS technology is the dynamic nature of digital data, allowing stakeholders to more easily maintain up-to-date information over the long term (Brubaker et al, 2011; Eisner et al, 2012; McCarthy et al, 2012). Interviewees described the advantages of digital information, and future efforts to facilitate access to data from a central repository.

> *Here's what we've put together, based on what they've said … many participants [can] see that, actually, their information doesn't go into this black hole … You can build upon it … Add some more levels of precision. More information about those sites (Interviewee 012)*

> *We are also looking at a repository for GIS data, coming forward … [where] they would collect data from the various boards and from the various monitoring programs and through Government of the Northwest Territories departments. They would have a central location for that (Interviewee 008)*

GIS as a communication tool has a history in aboriginal organizations for providing evidence in decision-making forums (Chapin et al, 2005). Between stakeholders, GIS technology can combine a variety of complex inputs into visual outputs that serve specific objectives within an EA process (Jankowski & Nyerges, 2001; Wright et al, 2009). As a

digital data platform, GIS is dynamic, permitting integration and collaboration between stakeholders (González et al, 2008). Participatory processes employing GIS with aboriginal communities thus can aid in understanding socio-ecological pathways and mechanisms to identify and mitigate the diverse impacts of natural resource developments.

5.4 Conclusion and Recommendations

This qualitative study is among the first to consult with stakeholders in a northern Canadian EA on how GIS might improve public health planning to address the SDH in aboriginal communities relative to development. Adapting Scott and Davis's (2007) organizational analysis perspective, I organized my findings into the key variables of objective, process, social practice, and technology (Scott & Davis, 2007). My aim using this approach was twofold. First, I aimed to collate the relevant interview data in a manner requested by the research participants, who indicated the usefulness of such results to their work (Caine et al, 2009; Caine et al, 2007; Flicker & Worthington, 2012). Second, I aimed to provide a presentation of the research amenable to comparisons with EA processes outside of the Mackenzie Valley. In Wek'eezhii, with the provisions of the *Tlicho Land Claims and Self-Government Act*, the MVEIRB conducts arguably the most inclusive co-management process for EA in Canada, if not the circumpolar north (Christensen & Grant, 2007; Fitzpatrick et al, 2008; S.C. 2005, c. 1). By analyzing the role for GIS in the Nico process using a relatively discrete set of variables, I hoped to expand the applicability of my results for other jurisdictions.

GIS is useful to conduct complex analyses, and the socio-ecological perspective is a helpful framework for such analyses. Conceptualization of pathways and mechanisms through which social factors influence health and well-being can improve technical design of interventions to appropriately mitigate related impacts. Such work need not employ GIS, although GIS can then serve as a platform to synthesize that information with other forms of evidence. GIS can also be used to align diverse EA processes, particularly as institutions and jurisdictions evolve. Based on the expressed interest of community members, Mackenzie Valley EAs may incorporate more public health planning in the future. Innovative efforts by the territorial government and TCSA to address the social determinants of health in that area can be preserved in a GIS to inform emerging processes. In social practice, aboriginal communities' stewardship of traditional

knowledge with GIS affords them greater autonomy in the EA process (Macintosh, 2012). Such a GIS platform can support the culturally appropriate development of community-driven indicators of health and well-being. Finally, GIS technology can provide a compelling visual presentation of the equivalence of traditional knowledge (and other community-driven data) with scientific evidence in an EA context.

More research is needed on the participatory processes for GIS in EAs, particularly in the context of conceptualizing socio-ecological pathways and mechanisms for development impacts on the socio-ecological parameters of health and well-being. As participatory GIS research continues to emerge in an EA context, long term effectiveness studies will help in informing evaluations. In the meantime, it appears that stakeholders can at least incrementally contribute to public health planning through EAs by appropriate documentation, analysis, and decision-making with aboriginal communities (Chambers et al, 2004). GIS technologies can facilitate that objective by accessible, streamlined, iterative and processes that facilitate social practice for community-driven data (Centre for the North, 2012; McCarthy et al, 2012).

5.5 Works Cited

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change*. 18(1), 86-98.

Armitage, D. R. (2005). Collaborative environmental assessment in the Northwest Territories, Canada. *Environmental Impact Assessment Review*. 25(3), 239-258.

Asselin, J., & Parkins, J. R. (2009). Comparative case study as social impact assessment: Possibilities and limitations for anticipating social change in the far north. *Social Indicators Research*. 94(3), 483-497.

Auditor General of Canada. (2010). Sustaining development in the Northwest Territories. In *The Spring 2010 Report of the Auditor General of Canada* (1-34). Ottawa: Minister of Public Works and Government Services Canada.

Bailey, K., & Grossardt, T. (2010). Toward structured public involvement: Justice, geography and collaborative geospatial/geovisual decision support systems. *Annals of the Association of American Geographers, 100*(1), 57-86.

Ballard, C., & Banks, G. (2003) Resource wars: The anthropology of mining. *Annual Review of Anthropology*. 32, 287-313.

Beierle, T. C. (2002). The quality of stakeholder-based decisions. *Risk Analysis*. 22(4), 739-749.

Berger, T. (2010). Land use planning: Land claims and Canada's north. In *Canada's north: What's the plan?* (pp 7-35). Ottawa: Conference Board of Canada.

Birley, M. (2005). Health impact assessment in multinationals: A case study of the Royal Dutch/Shell Group. *Environmental Impact Assessment Review*. 25(7-8), 702-713.

Bronson, J., & Noble, B. F. (2006). Health determinants in Canadian northern environmental impact assessment. *Polar Record*. 42(4), 315-324.

Brown, P. (2003). Qualitative methods in environmental health research. *Environmental Health Perspectives*. 111(14), 1789-1798.

Brubaker, M. Y., Bell, J. N., Berner, J. E., & Warren, J. A. (2011). Climate change health assessment: A novel approach for Alaska Native communities. *International Journal of Circumpolar Health*. 70(3), 266-273.

Butz, W. P., & Torrey, B. B. (2006). Some frontiers in social science. *Science*. 312(5782), 1898-1900.

Caine, K. J., Davison, C. M., & Stewart, E. J. (2009). Preliminary field-work: Methodological reflections from northern Canadian research. *Qualitative Research*. 9(4), 489-513.

Caine, K. J., Salomons, M. J., & Simmons, D. (2007). Partnerships for social change in the Canadian North: Revisiting the insider-outsider dialectic. *Development and Change*. 38(3), 447-471.

Canadian Environmental Assessment Act, Consolidated Statutes of Canada. (2012, c. 19, s. 52). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/C-15.21.pdf

Centre for the North. (2012). *Getting it right: Assessing and building resilience in Canada's north*. Ottawa, ON: Conference Board of Canada.

Chambers, K. J., Corbett, J., Keller, C. P., & Wood, C. J. B. (2004). Indigenous knowledge, mapping, and GIS: A diffusion of innovation perspective. *Cartographica*. 39(3), 19-31.

Chapin, M., Lamb, Z., & Threlkeld, B. (2005) Mapping indigenous lands. *Annual Review of Anthropology*. 34, 619-638.

Charmaz, K. (2004). Premises, principles, and practices in qualitative research: Revisiting the foundations. *Qualitative Health Research*. 14(7), 976-993.

Chatwood, S., Bjerregaard, P., & Kue Young, T. (2012). Global health - A circumpolar perspective. *American Journal of Public Health*. 102(7), 1246-1249.
Christensen, J., & Grant, M. (2007). How political change paved the way for indigenous knowledge: The Mackenzie Valley Resource Management Act. *Arctic*. 60(2), 115-123.
Conference Board of Canada. (2013). *The future of mining in Canada's north: Economic performance and trends*. Ottawa: M. Caron-Vuotari & G. Rheaume.
Cundill, G., & Rodela, R. (2012). A review of assertions about the processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*. 113, 7-14.
Davison, C. M., & Hawe, P. (2012). All that glitters: Diamond mining and Tåîchô youth in Behchokö, Northwest Territories. *Arctic*. 65(2), 214-228.
Eisner, W. R., Jelacic, J., Cuomo, C. J., Kim, C., Hinkel, K. M., & Del Alba, D. (2012). Producing an indigenous knowledge web GIS for arctic Alaska communities: Challenges, successes, and lessons learned. *Transactions in GIS*. 16(1), 17-37.
Ellis, S. C. (2005). Meaningful consideration? A review of traditional knowledge in environmental decision making. *Arctic*. 58(1), 66-77.
Fidler, C., & Hitch, M. (2007). Impact and Benefit Agreements: A contentious issue for environmental and aboriginal justice. *Environments*. 35(2), 49-69.
Fitzpatrick, P., Sinclair, A. J., & Mitchell, B. (2008). Environmental impact assessment under the Mackenzie Valley Resource Management Act: Deliberative democracy in Canada's north? *Environmental Management*. 42(1), 1-18.
Flicker, S., & Worthington, C. A. (2012). Public health research involving aboriginal peoples: Research ethics board stakeholders' reflections on ethics principles and research processes. *Canadian Journal of Public Health*. 103(1), 19-22.
Forbes, B. C., & Stammler, F. (2009). Arctic climate change discourse: The contrasting politics of research agendas in the west and Russia. *Polar Research*. 28(1), 28-42.
Gamble, D. J. (1978). The Berger Inquiry: An impact assessment process. *Science*. 199(4332), 946-952.
Gibson, R. B. (2011). Application of a contribution to sustainability test by the Joint Review Panel for the Canadian Mackenzie Gas Project. *Impact Assessment and Project Appraisal*. 29(3), 231-244.
González, A., Gilmer, A., Foley, R., Sweeney, J., & Fry, J. (2008). Technology-aided participative methods in environmental assessment: An international perspective. *Computers, Environment and Urban Systems*. 32(4), 303-316.
Government of Northwest Territories Bureau of Statistics. (2011). *Population Projections*. http://www.statsnwt.ca/population/community-projections/ [Last accessed on April 27, 2014]
Gracey, M., & King, M. (2009). Indigenous health part 1: Determinants and disease patterns. *Lancet*. 374(9683), 65-75.
Hall, R. (2013). Diamond mining in Canada's Northwest Territories: A colonial continuity. *Antipode*. 45(2), 376-393.
Hallberg, L. R. M. (2006). The "core category" of grounded theory: Making constant comparisons. *International Journal of Qualitative Studies on Health and Well-being*. 1(3), 141-148.
Horwitz, P., & Finlayson, C. M. (2011). Wetlands as settings for human health: Incorporating ecosystem services and health impact assessment into water resource management. *BioScience*. 61(9), 678-688.
Houde, N. (2007). The six faces of traditional ecological knowledge: Challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 12(2).

Jankowski, P., & Nyerges, T. (2001). GIS-supported collaborative decision making: Results of an experiment. *Annals of the Association of American Geographers*. 91(1), 48-70.
King, M., Smith, A., & Gracey, M. (2009). Indigenous health part 2: The underlying causes of the health gap. *Lancet*. 374(9683), 76-85.
Kirmayer, L. J., Dandeneau, S., Marshall, E., Phillips, M. K., & Williamson, K. J. (2011). Rethinking resilience from indigenous perspectives. *Canadian Journal of Psychiatry*. 56(2), 84-91.
Kryzanowski, J. A., & McIntyre, L. (2011). A Holistic Model for the Selection of Environmental Assessment Indicators to Assess the Impact of Industrialization on Indigenous Health. *Canadian Journal of Public Health*. 102(2), 112-117.
Kwiatkowski, R. E. (2011). Indigenous community based participatory research and health impact assessment: A Canadian example. *Environmental Impact Assessment Review*. 31(4), 445-450.
Kwiatkowski, R. E., & Ooi, M. (2003). Integrated environmental impact assessment: a Canadian example. *Bulletin of the World Health Organization*. 81(6), 434-438.
Lammers, J. C. (2011). How institutions communicate: Institutional messages, institutional logics, and organizational communication. *Management Communication Quarterly*. 25(1), 154-182.
Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*. 33(1), 159-174.
Lauster, N., & Tester, F. (2010). Culture as a problem in linking material inequality to health: On residential crowding in the arctic. *Health and Place*. 16(3), 523-530.
Lavoie, J. G. (2013). Policy silences: Why Canada needs a national First Nations, Inuit and Metis health policy. *International Journal of Circumpolar Health*. 72, 1-7.
Leech, N. L., & Onwuegbuzie, A. J. (2011). Beyond constant comparison qualitative data analysis: Using NVivo. *School Psychology Quarterly*. 26(1), 70-84.
Leszczynski, A. (2009). Poststructuralism and GIS: is there a 'disconnect'? *Environment and Planning D: Society and Space*. 27(4), 581 – 602.
Lewis, J. L., & Sheppard, S. R. J. (2006). Culture and communication: Can landscape visualization improve forest management consultation with indigenous communities? *Landscape and Urban Planning*. 77(3), 291-313.
Louis, R. P., Johnson, J. T., & Pramono, A. H. (2012). Introduction: Indigenous cartographies and counter-mapping. *Cartographica*. 47(2), 77-79.
Macintosh, C. (2012). Relational theory and indigenous health: Insights for law reform and policy development. In J. Downie & J. Llewellyn (Eds.), *Being relational: Reflections on relational theory and health law and policy* (230-254). Vancouver: University of British Columbia Press.
Mackenzie Valley Environmental Impact Review Board [MVEIRB]. (2013). Report of environmental assessment and reasons for decision: EA 0809-004 Fortune Minerals Limited Nico Project. Retrieved from the MVEIRB Public Registry http://www.reviewboard.ca/upload/project_document/EA0809-004_NICO_Report_of_EA_and_Reasons_for_Decision.PDF
Mackenzie Valley Resource Management Act. Consolidated Statutes of Canada. (1998, c. 25). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/M-0.2.pdf
Marks, E., Cargo, M. D., & Daniel, M. (2007). Constructing a health and social indicator framework for indigenous community health research. *Social Indicators Research*. 82(1), 93-110.
Marmot, M., Allen, J., Bell, R., & Goldblatt, P. (2012). Building of the global movement for health equity: From Santiago to Rio and beyond. *The Lancet*. 379(9811), 181-188.

McCaig, K. (2005). Canadian insights: The challenges of an integrated environmental assessment framework. *Environmental Impact Assessment Review*. 25(7-8), 737-746.
McCarthy, D. D. P., Whitelaw, G. S., Anderson, S., Cowan, D., McGarry, F., Robins, A., Gardner, H. L., Barbeau, C. D., Charania, N. A., General, Z., Liedtke, J., Sutherland, C., Alencar, P. & Tsuji, L. J. S. (2012). Collaborative geomatics and the Mushkegowuk Cree First Nations: Fostering adaptive capacity for community-based sub-arctic natural resource management. *Geoforum*. 43(2), 305-314.
McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*. 22(3), 276-282.
Noble, B., & Bronson, J. (2006). Practitioner survey of the state of health integration in environmental assessment: The case of northern Canada. *Environmental Impact Assessment Review*. 26(4), 410-424.
Notzke, C. (1995). A new perspective in aboriginal natural resource management: Co-management. *Geoforum*. 26(2), 187-209.
Nuttall, M. (2009). Energy development and Aboriginal rights in northern Canada. In A. Dey-Nuttall & M. Nuttall (Eds.), *Canada's and Europe's northern dimensions* (71-84). Oulu: University of Oulu Press.
O'Neil, J. D. (1986). The politics of health in the fourth world: A northern Canadian example. *Human Organization*. 45(2), 119-128.
Onwuegbuzie, A. J., & Leech, N. L. (2007). Validity and qualitative research: An oxymoron? *Quality and Quantity*. 41(2), 233-249.
Ozkan, U. R., & Schott, S. (2013). Sustainable development and capabilities for the polar region. *Social Indicators Research*. 114(3), 1259-1283.
Paci, C., & Villebrun, N. (2005). Mining Denendeh: A Dene Nation perspective on community health impacts of mining. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health*. 3(1), 71-86.
Palmer, M. (2012). Theorizing indigital geographic information networks. *Cartographica*. 47(2), 80-91.
Peters, V., & Wester, F. (2007). How qualitative data analysis software may support the qualitative analysis process. *Quality and Quantity*. 41(5), 635-659.
Polkinghorne, D. E. (2006). An agenda for the second generation of qualitative studies. *International Journal of Qualitative Studies on Health and Well-being*. 1(2), 68-77.
Potvin, L., Gendron, S., Bilodeau, A., & Chabot, P. (2005). Integrating social theory into public health practice. *American Journal of Public Health*. 95(4), 591-595.
QSR International. (2014). NVivo Version 10 Software.
Racher, K. I., Hutchinson, N., Hart, D., Fraser, B., Clark, B., Fequet, R., Ewaschuk, P. & Cliffe-Phillips, M. (2011). Linking environmental assessment to environmental regulation through adaptive management. *Integrated Environmental Assessment and Management*. 7(2), 301-302.
Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *European Journal of Social Theory*. 5(2), 243-263.
Ritter, T. L. (2007). Sharing environmental health practice in the North American arctic: A focus on water and wastewater service. *Journal of Environmental Health*. 69(8), 50-55.
Robbins, P. (2003). Beyond ground truth: GIS and the environmental knowledge of herders, professional foresters, and other traditional communities. *Human Ecology*. 31(2), 233-254.
Rodela, R., Cundill, G., & Wals, A. E. J. (2012). An analysis of the methodological underpinnings of social learning research in natural resource management. *Ecological Economics*. 77, 16-26.

Scammell, M. K. (2010). Qualitative environmental health research: An analysis of the literature, 1991-2008. *Environmental Health Perspectives*. 118(8), 1146-1154.
Scott, R., W., & Davis, G., F. (2007). The subject is organizations; The verb is organizing. In *Organizations and Organizing: Rational, Natural, and Open System Perspectives* (1-34). New Jersey: Pearson Prentice Hall.
Snyder, J., Wagler, M., Lkhagvasuren, O., Laing, L., Davison, C., & Janes, C. (2012). An equity tool for health impact assessments: Reflections from Mongolia. *Environmental Impact Assessment Review*. 34, 83-91.
Starks, H., & Trinidad, S. B. (2007). Choose your method: A comparison of phenomenology, discourse analysis, and grounded theory. *Qualitative Health Research*. 17(10), 1372-1380.
Stevenson, M. G. (1996). Indigenous knowledge in environmental assessment. *Arctic*. 49(3), 278-291.
Stewart, E. J., Jacobson, D., & Draper, D. (2008). Public Participation Geographic Information Systems (PPGIS): Challenges of implementation in Churchill, Manitoba. *Canadian Geographer*. 52(3), 351-366.
Tlicho Land Claims and Self-Government Act. Consolidated Statutes of Canada. (2005, c. 1). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/T-11.3.pdf
Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 19(6), 349-357.
Usher, P. J. (2003). Environment, race and nation reconsidered: Reflections on aboriginal land claims in Canada. *Canadian Geographer*. 47(4), 365-382.
Usher, P. J., Duhaime, G., & Searles, E. (2003). The household as an economic unit in arctic aboriginal communities, and its measurement by means of a comprehensive survey. *Social Indicators Research*. 61(2), 175-202.
Wilson, G. N., & Alcantara, C. (2012). Mixing politics and business in the Canadian arctic: Inuit corporate governance in Nunavik and the Inuvialuit settlement region. *Canadian Journal of Political Science*. 45(4), 781-804.
Wilson, K. (2003). Therapeutic landscapes and First Nations peoples: An exploration of culture, health and place. *Health & Place*. 9(2), 83-93.
Wilson, K., & Rosenberg, M. W. (2002). Exploring the determinants of health for First Nations peoples in Canada: Can existing frameworks accommodate traditional activities? *Social Science & Medicine*. 55(11), 2017-2031.
Wilson, K., & Young, T. K. (2008). An overview of Aboriginal health research in the social sciences: Current trends and future directions. *International Journal of Circumpolar Health*. 67(2-3), 179-189.
Winiecki, D. J. (2010). Rational, natural, and open: Organizational system typologies and their relevance for performance improvement professionals. *Performance Improvement*. 49(5), 35-41.
Wright, D. J., Duncan, S. L., & Lach, D. (2009). Social power and GIS technology: A review and assessment of approaches for natural resource management. *Annals of the Association of American Geographers*. 99(2), 254-272.

Chapter Six:

"Conclusion"

6.1 Introduction

In this chapter, I summarise and synthesize my key findings, present a list of recommendations, detail those recommendations, and suggest two areas for future research. Using a mixed methods and two case studies, my thesis addressed the following question:

> *How can Geographic Information Systems (GIS) improve communication and consultation about health inequities and impacts to indigenous populations in natural resource development decision-making forums for circumpolar regions?*

Natural resource development is increasing in the circumpolar arctic and subarctic regions of Canada, the United States, Russia, Finland, Sweden, Norway, Iceland, and Greenland, home to over thirty indigenous peoples (Kraft Sloan & Hik, 2008; Ozkan & Schott, 2013). Industrial proponents, government, and some members of the indigenous leadership argue that development will improve community health and well-being by raising the standard of living, and improving quality of life in remote communities (Birley, 2005; Wilson & Alcantara, 2012). Nevertheless, development confronts a vast legacy of impacts to indigenous peoples, leading many to question whether the benefits of industrialization can indeed outweigh the risks (Gamble, 1978; Nuttall, 2009; Usher, 2003). New tools integrating indigenous peoples' priorities and worldviews are necessary to gather and interpret the complex evidence of development impacts, ensuring that any development will make a net positive contribution to sustainability in the north (Bronson & Noble, 2006; Gibson, 2011; Paci & Villebrun, 2005).

My research is some of the first to examine how Geographic Information Systems (GIS) might serve as a shared platform for coordination and synthesis of multi-stakeholder perspectives about positive and negative impacts of natural resource developments on health and well-being for northern indigenous communities. I found that the willingness and capacity for indigenous communities to employ GIS in decision-making forums is relative to its acceptability, which is increasing through "counter mapping" as an emerging social practice (Chambers et al, 2004; Louis et al, 2012). Health and socio-economic concerns about development are important to circumpolar indigenous communities, who

extensively raise these issues in decision-making forums. In that context, interviewees acknowledged the utility of GIS in collecting, analysing, interpreting, and communicating both scientific evidence and traditional knowledge to address health inequities and impacts. However, interviewees recognized and asserted that indigenous communities have the most to gain by leveraging GIS technologies and applications in unique and imaginative ways. The way that I envisioned the utility of GIS in approaching my research question is likely very different from the way that indigenous communities envision it for themselves. Thus, participatory or community-driven processes for GIS education, training, and research have an important role to facilitate appropriate "counter-mapping" within community-defined structures and acceptability. With all of the advantages of GIS for the complex scoping of developments, the management of diverse datasets, and the networking of monitoring efforts, it is this question of appropriateness or acceptability that defines how GIS can improve communication and consultation in decision-making forums. My results can be understood with three main themes.

First, indigenous self-determination and governance was a cross-cutting issue for all three of my research papers. Across arctic and subarctic jurisdictions, systems for indigenous governance have evolved differently, leading to different protections (or lack thereof) for indigenous rights (Fondahl et al, 2001; Forbes & Stammler, 2009). Nevertheless, there is widespread agreement in the academic community that self-determination and governance are prerequisite to appropriate public health planning to implement indigenous peoples' health concepts, priorities, and systems (Hanna & Vanclay, 2013; Lavoie, 2013; MacIntosh, 2012). Interviewees spoke of both the historical disenfranchisement of indigenous peoples, and the hope that equitable consultation processes lend to their aspirations for self-determination, governance, and healthy communities (Hanna & Vanclay, 2013; Berger, 2010; Gamble, 1978). In my document review / automated content analysis, I found evidence to the effect that indigenous people who through land claims and other legal mechanisms enjoy more support for their rights can exert greater influence on the consultation dialogue (Ballard & Banks, 2003; Hanna & Vanclay, 2013; Houde, 2007). Moreover, the most robust consultation process are inclusive, accessible, flexible, iterative, and comprehensive, accommodating indigenous peoples' participation in decision-making for more satisfactory outcomes (Beierle, 2002; Centre for the North, 2012).

A second theme of my research was that impacts to the socio-ecological parameters of health and well-being that are identified and mitigated in decision-making forums must be responsive and correspond to circumpolar indigenous peoples' own concerns (Armitage, 2005; Davison & Hawe, 2012; King et al, 2009; Marmot et al, 2012; Wright et al, 2009). My interviews and document review / automated content analysis indicated that indigenous people's health and well-being concepts are community-centred, balanced between humans and the environment, and concerned with intergenerational equity (Kirmayer et al, 2011; Marks et al, 2007). Indigenous peoples must be empowered to articulate their own knowledge and perspectives to inform effective public health planning in relation to developments (Getty, 2010; Marks et al, 2007). Indigenous peoples' knowledge allows for more effective mitigation of development impacts by targeting appropriate socio-ecological pathways and mechanisms. Currently, environmental assessment (EA) practice is weighted toward legislated mandates to protect the biophysical environment, and employers' responsibility for occupational health and safety (Bronson & Noble, 2006). A shift to incorporate equity-based health impact assessment into EAs is needed, so that the benefits outweigh the risks to circumpolar indigenous communities.

A third theme in my data was meeting the unique demands of communities interested in leveraging GIS technologies and applications for "counter-mapping" (Chapin, 2005; Stewart et al, 2008). While GIS may appear compelling to many in the academic community, indigenous communities prior to adopting it must be able to demonstrate its utility for their own needs and aspirations (Chambers et al, 2004). In addition software, hardware, data, and personnel, GIS needs to serve an appropriate and acceptable role within established community structures, priorities, and worldviews. Knowledge generation by community members that provides timely, relevant, and local-scale information could help communities to challenge some of the assumptions preventing the integration of health impact assessment practices into existing review processes (Armitage, 2005; Brubaker et al, 2012; Ellis, 2005; Louis et al, 2012). Education, training, collaboration, and leadership to establish community-based GIS through participatory processes needs to reflect the demand for demonstrated utility as defined by the communities themselves (Chambers et al, 2004; Epp et al, 1991).

6.2 Recommendations

In summaries of my findings as noted above and in Chapters 3, 4, and 5, I present three recommendations regarding how GIS could improve communication and consultation about health inequities and impacts in circumpolar indigenous communities, relative to natural resource development:

- Circumpolar nations should establish legal norms that recognize a full range of rights for indigenous populations.
- Circumpolar jurisdictions should revise environmental assessment frameworks to incorporate equity-based health impact assessment.
- Circumpolar researchers and health practitioners working with community-based participatory GIS should publish their detailed protocols for knowledge translation.

Circumpolar nations should establish legal norms that recognize a full range of rights for indigenous populations.

Although a necessary, not a sufficient, condition, laws, legal frameworks, and policies are needed that redress the historical disenfranchisement of circumpolar indigenous peoples (Berger, 2010; Gamble, 1978; Usher et al, 1992). In some jurisdictions, this would involve acceleration of ongoing processes, while in others a shift in national conceptions of indigenous rights. National and regional legislation must recognize indigenous peoples' longstanding stewardship of traditional territories, right to manage their resources, and holistic concept of health and well-being (Hanna & Vanclay, 2013; Macintosh, 2013; MacIntosh, 2012). For environmental assessments (EAs), the legal norms must include meaningful consultation.

Circumpolar jurisdictions should revise environmental assessment frameworks to incorporate equity-based health impact assessment.

In Canada, the United States, Europe, and Russia, EAs are the primary public forum where regulatory oversight can be implemented to identify and mitigate the impacts of development on indigenous peoples (Kwiatkowski, 2011; Kwiatkowski & Ooi, 2003; Robbins, 2003; Solodyankina & Koeppel, 2013). Many policy-makers, researchers, and practitioners argue that EAs should examine linkages between natural resource development and the socio-ecological parameters of health and well-being, expanding

consideration of positive and negative impacts to "outside-the-fence" (Bronson & Noble, 2006; Kirmayer et al, 2011; Kwiatkowski, 2011; Noble & Bronson, 2006). To accomplish this goal, health impact assessment must assume formal prominence in natural resource development decision-making over the long term (Gibson, 2011; Kwiatkowski, 2011; McCaig, 2005; Noble & Birk, 2011). Moreover, equity-based participatory processes as part of new frameworks would help to empower indigenous peoples to identify and mitigate health inequities and impacts according to their own priorities and world views (Snyder et al, 2012).

Circumpolar researchers and health practitioners working with community-based participatory GIS should publish detailed protocols for knowledge translation.

New applications of GIS are considered to be on the frontiers of social science; the technology can capture traditional knowledge, environmental, and health data in a dynamic format on a shared platform (Butz & Torrey, 2006). Participatory GIS research should be community-focused, and provide timely, relevant, local-scale data to empower indigenous peoples in decision-making forums (Caine et al, 2009; Chapin et al, 2005; Flicker & Worthington, 2012). As more acceptable and appropriate processes for "counter mapping" emerge, it is important to document success in these processes to advance the state of the practice in indigenous cartography (Louis et al, 2012; Palmer, 2012). When indigenous communities and their collaborators combine "counter mapping" efforts across cultures and geographies, the economies of scale could produce conceptual and technical gains between jurisdictions (Chambers et al, 2004; Hanna & Vanclay, 2013).

6.3 Future Research

My findings combined with other research on GIS as a communication tool in decision-making forums present two prospective areas of further research. Future research should be situated within the emerging literature of health impact assessment and public health planning for natural resource development, and the use of GIS in participatory research with indigenous peoples (Chapin et al, 2005; Eisner et al, 2012; González et al, 2008; Kwiatkowski & Ooi, 2003; McCaig, 2005; McCarthy et al, 2012; Snyder et al, 2012; Tripathi & Bhattarya, 2004).

First, research is needed to accurately and precisely conceptualize socio-ecological pathways and mechanisms through which development impacts indigenous peoples' health and well-being (Bronson & Noble, 2006; Kirmayer et al, 2011; Marmot et al, 2012; Noble & Bronson, 2006). Indigenous people and indigenous research methodologies should be central to these efforts, and supported by the resources of government and academia (CIHR, 2010; Duhaime et al, 2004; Flicker & Worthington, 2012; Getty, 2010; Lavoie, 2013; Ritter, 2007).

Second, additional research is needed to evaluate best practices for employing GIS in participatory research with indigenous peoples (Brubaker et al, 2011; Lewis & Sheppard, 2006; Louis et al, 2012; Palmer, 2012; Robbins, 2003; Stewart et al, 2008; Wright et al, 2009). By establishing GIS as a tool for "counter mapping", indigenous communities' vision for the technology could inform public health planning in ways that are yet to be imagined (Lavoie, 2013; Macintosh, 2012; Potvin et al, 2005).

6.4 Works Cited

Alcantara, C. (2013). Preferences, perceptions, and veto players: Explaining devolution negotiation outcomes in the Canadian territorial north. *Polar Record*. 49(2), 167-179.

Bailey, K., & Grossardt, T. (2010). Toward structured public involvement: Justice, geography and collaborative geospatial/geovisual decision support systems. *Annals of the Association of American Geographers*. 100(1), 57-86.

Ballard, C., & Banks, G. (2003) Resource wars: The anthropology of mining. *Annual Review of Anthropology*. 32, 287-313.

Bartlett, J. G., Madariaga-Vignudo, L., O'Neil, J. D., & Kuhnlein, H. V. (2007). Identifying indigenous peoples for health research in a global context: a review of perspectives and challenges. *International Journal of Circumpolar Health*. 66(4), 287-307.

Beierle, T. C. (2002). The quality of stakeholder-based decisions. *Risk Analysis*. 22(4), 739-749.

Berger, T. (2010). Land use planning: Land claims and Canada's north. In *Canada's north: What's the plan?* (pp 7-35). Ottawa: Conference Board of Canada.

Birley, M. (2005). Health impact assessment in multinationals: A case study of the Royal Dutch/Shell Group. *Environmental Impact Assessment Review*. 25(7-8), 702-713.

Bronson, J., & Noble, B. F. (2006). Health determinants in Canadian northern environmental impact assessment. *Polar Record*. 42(4), 315-324.

Brubaker, M. Y., Bell, J. N., Berner, J. E., & Warren, J. A. (2011). Climate change health assessment: A novel approach for alaska native communities. *International Journal of Circumpolar Health*. 70(3), 266-273.

Butz, W. P., & Torrey, B. B. (2006). Some frontiers in social science. *Science*. 312(5782), 1898-1900.

Caine, K. J., Davison, C. M., & Stewart, E. J. (2009). Preliminary field-work: Methodological reflections from northern Canadian research. *Qualitative Research*. 9(4), 489-513.

Centre for the North. (2012). *Getting it right: Assessing and building resilience in Canada's north*. Ottawa, ON: Conference Board of Canada.

Chambers, K. J., Corbett, J., Keller, C. P., & Wood, C. J. B. (2004). Indigenous knowledge, mapping, and GIS: A diffusion of innovation perspective. *Cartographica*. 39(3), 19-31.

Chapin, M., Lamb, Z., & Threlkeld, B. (2005) Mapping indigenous lands. *Annual Review of Anthropology*. 34, 619-638.

Chatwood, S., Bjerregaard, P., & Kue Young, T. (2012). Global health - A circumpolar perspective. *American Journal of Public Health*. 102(7), 1246-1249.

Christensen, J., & Grant, M. (2007). How political change paved the way for indigenous knowledge: The Mackenzie Valley Resource Management Act. *Arctic*. 60(2), 115-123.

Conference Board of Canada. (2013). *The future of mining in Canada's north: Economic performance and trends*. Ottawa: M. Caron-Vuotari & G. Rheaume.

Cundill, G., & Rodela, R. (2012). A review of assertions about the processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*. 113, 7-14.

Davison, C. M., & Hawe, P. (2012). All that glitters: Diamond mining and Tåîchô youth in Behchokö, Northwest Territories. *Arctic*. 65(2), 214-228.

Duhaime, G., Searles, E., Usher, P. J., Myers, H., & Fréchette, P. (2004). Social cohesion and living conditions in the Canadian arctic: From theory to measurement. *Social Indicators Research*. 66(3), 295-317.

Eisner, W. R., Jelacic, J., Cuomo, C. J., Kim, C., Hinkel, K. M., & Del Alba, D. (2012). Producing an indigenous knowledge web GIS for arctic Alaska communities: Challenges, successes, and lessons learned. *Transactions in GIS*. 16(1), 17-37.
Ellis, S. C. (2005). Meaningful consideration? A review of traditional knowledge in environmental decision making. *Arctic*. 58(1), 66-77.
Fitzpatrick, P., Fonseca, A., & McAllister, M. L. (2011). From the Whitehorse Mining Initiative towards sustainable mining: Lessons learned. *Journal of Cleaner Production*. 19(4), 376-384.
Flicker, S., & Worthington, C. A. (2012). Public health research involving aboriginal peoples: Research ethics board stakeholders' reflections on ethics principles and research processes. *Canadian Journal of Public Health*. 103(1), 19-22.
Fondahl, G., Lazebnik, O., Poelzer, G., & Robbek, V. (2001). Native 'land claims', Russian style. *Canadian Geographer*. 45(4), 545-561.
Forbes, B. C., & Stammler, F. (2009). Arctic climate change discourse: The contrasting politics of research agendas in the west and Russia. *Polar Research*. 28(1), 28-42.
Gamble, D. J. (1978). The Berger Inquiry: An impact assessment process. *Science*. 199(4332), 946-952.
Getty, G. A. (2010). The journey between western and Indigenous research paradigms. *Journal of Transcultural Nursing*. 21(1), 5-14.
Gibson, R. B. (2011). Application of a contribution to sustainability test by the Joint Review Panel for the Canadian Mackenzie Gas Project. *Impact Assessment and Project Appraisal*. 29(3), 231-244.
González, A., Gilmer, A., Foley, R., Sweeney, J., & Fry, J. (2008). Technology-aided participative methods in environmental assessment: An international perspective. *Computers, Environment and Urban Systems*. 32(4), 303-316.
Hanna, P., & Vanclay, F. (2013). Human rights, Indigenous peoples and the concept of Free, Prior and Informed Consent. *Impact Assessment and Project Appraisal*. 31(2), 146-157.
Houde, N. (2007). The six faces of traditional ecological knowledge: Challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 12(2).
King, M., Smith, A., & Gracey, M. (2009). Indigenous health part 2: The underlying causes of the health gap. *Lancet*. 374(9683), 76-85.
Kirmayer, L. J., Dandeneau, S., Marshall, E., Phillips, M. K., & Williamson, K. J. (2011). Rethinking resilience from indigenous perspectives. *Canadian Journal of Psychiatry*. 56(2), 84-91.
Kueffer, C., Underwood, E., Hadorn, G. H., Holderegger, R., Lehning, M., Pohl, C., Schirmer, M., Schwarzenbach, R., Stauffacher, M., Wuelser, G. & Edwards, P. (2012). Enabling effective problem-oriented research for sustainable development. *Ecology and Society*. 17(4).
Kwiatkowski, R. E. (2011). Indigenous community based participatory research and health impact assessment: A Canadian example. *Environmental Impact Assessment Review*. 31(4), 445-450.
Kwiatkowski, R. E., & Ooi, M. (2003). Integrated environmental impact assessment: A Canadian example. *Bulletin of the World Health Organization*. 81(6), 434-438.
Lavoie, J. G. (2013). Policy silences: Why Canada needs a national First Nations, Inuit and Metis health policy. *International Journal of Circumpolar Health*. 72, 1-7.
Lewis, J. L., & Sheppard, S. R. J. (2006). Culture and communication: Can landscape visualization improve forest management consultation with indigenous communities? *Landscape and Urban Planning*. 77(3), 291-313.

Louis, R. P., Johnson, J. T., & Pramono, A. H. (2012). Introduction: Indigenous cartographies and counter-mapping. *Cartographica*. 47(2), 77-79.
MacIntosh, C. (2013). The role of law in ameliorating global inequalities in indigenous peoples' health. *Journal of Law Medicine & Ethics*. 41(1), 74-88.
Macintosh, C. (2012). Relational theory and indigenous health: Insights for law reform and policy development. In J. Downie & J. Llewellyn (Eds.), *Being relational: Reflections on relational theory and health law and policy* (230-254). Vancouver: University of British Columbia Press.
Marks, E., Cargo, M. D., & Daniel, M. (2007). Constructing a health and social indicator framework for indigenous community health research. *Social Indicators Research*. 82(1), 93-110.
Marmot, M., Allen, J., Bell, R., & Goldblatt, P. (2012). Building of the global movement for health equity: From Santiago to Rio and beyond. *The Lancet*. 379(9811), 181-188.
McCaig, K. (2005). Canadian insights: The challenges of an integrated environmental assessment framework. *Environmental Impact Assessment Review*. 25(7-8), 737-746.
McCarthy, D. D. P., Whitelaw, G. S., Anderson, S., Cowan, D., McGarry, F., Robins, A., Gardner, H. L., Barbeau, C. D., Charania, N. A., General, Z., Liedtke, J., Sutherland, C., Alencar, P. & Tsuji, L. J. S. (2012). Collaborative geomatics and the Mushkegowuk Cree First Nations: Fostering adaptive capacity for community-based sub-arctic natural resource management. *Geoforum*. 43(2), 305-314.
National Snow and Ice Data Center. (2014). Exchange for Local Observations and Knowledge of the Arctic [ELOKA]. http://eloka-arctic.org/ [Last accessed on April 27, 2014].
Noble, B., & Birk, J. (2011). Comfort monitoring? Environmental assessment follow-up under community-industry negotiated environmental agreements. *Environmental Impact Assessment Review*. 31(1), 17-24.
Noble, B., & Bronson, J. (2006). Practitioner survey of the state of health integration in environmental assessment: The case of northern Canada. *Environmental Impact Assessment Review*. 26(4), 410-424.
Nuttall, M. (2009). Energy development and aboriginal rights in northern Canada. In A. Dey-Nuttall & M. Nuttall (Eds.), *Canada's and Europe's northern dimensions* (71-84). Oulu: University of Oulu Press.
Ozkan, U. R., & Schott, S. (2013). Sustainable development and capabilities for the polar region. *Social Indicators Research*. 114(3), 1259-1283.
Palmer, M. (2012). Theorizing indigital geographic information networks. *Cartographica*. 47(2), 80-91.
Potvin, L., Gendron, S., Bilodeau, A., & Chabot, P. (2005). Integrating social theory into public health practice. *American Journal of Public Health*. 95(4), 591-595.
Ritter, T. L. (2007). Sharing environmental health practice in the North American arctic: A focus on water and wastewater service. *Journal of Environmental Health*. 69(8), 50-55.
Robbins, P. (2003). Beyond ground truth: GIS and the environmental knowledge of herders, professional foresters, and other traditional communities. *Human Ecology*. 31(2), 233-254.
Rodela, R. (2013). The social learning discourse: Trends, themes and interdisciplinary influences in current research. *Environmental Science and Policy*. 25, 157-166.
Rodela, R., Cundill, G., & Wals, A. E. J. (2012). An analysis of the methodological underpinnings of social learning research in natural resource management. *Ecological Economics*. 77, 16-26.

Rogers, W., & Lange, M. M. (2013). Rethinking the vulnerability of minority populations in research. *American Journal of Public Health*. 103(12), 2141-2146.
Snyder, J., Wagler, M., Lkhagvasuren, O., Laing, L., Davison, C., & Janes, C. (2012). An equity tool for health impact assessments: Reflections from Mongolia. *Environmental Impact Assessment Review*. 34, 83-91.
Solodyankina, S., & Koeppel, J. (2009). The environmental impact assessment process for oil and gas extraction projects in the Russian Federation: Possibilities for improvement. *Impact Assessment and Project Appraisal*. 27(1), 77-83.
Stewart, E. J., Jacobson, D., & Draper, D. (2008). Public Participation Geographic Information Systems (PPGIS): Challenges of implementation in Churchill, Manitoba. *Canadian Geographer*. 52(3), 351-366.
Tripathi, N., & Bhattarya, S. (2004). Integrating indigenous knowledge and GIS for participatory natural resource management: State of the practice. *The Electronic Journal of Information Systems in Developing Countries*. 17(3), 1-13.
Usher, P. J., Tough, F. J., & Galois, R. M. (1992). Reclaiming the land: Aboriginal title, treaty rights and land claims in Canada. *Applied Geography*. 12(2), 109-132.
Wright, D. J., Duncan, S. L., & Lach, D. (2009). Social power and GIS technology: A review and assessment of approaches for natural resource management. *Annals of the Association of American Geographers*. 99(2), 254-272.

Bibliography

Alcantara, C. (2013). Preferences, perceptions, and veto players: Explaining devolution negotiation outcomes in the Canadian territorial north. *Polar Record*. 49(2), 167-179.

Anderson, P. J., Yoder, S., Fogels, E., Krieger, G. & McLaughlin, J. (2013). The state of Alaska's early experience with institutionalization of health impact assessment. *International Journal of Circumpolar Health*. 72, 1-5.

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change*. 18(1), 86-98.

Armitage, D. R. (2005). Collaborative environmental assessment in the Northwest Territories, Canada. *Environmental Impact Assessment Review*. 25(3), 239-258.

Aslaksen, I., Glomsrød, S., & Myhr, A. I. (2013). Post-normal science and ecological economics: Strategies for precautionary approaches and sustainable development. *International Journal of Sustainable Development*. 16(1-2), 107-126.

Asselin, J. & Parkins, J. R. (2009). Comparative case study as social impact assessment: Possibilities and limitations for anticipating social change in the far north. *Social Indicators Research*. 94(3), 483-497.

Auditor General of Canada. (2010). Sustaining development in the Northwest Territories. In *The Spring 2010 Report of the Auditor General of Canada* (1-34). Ottawa: Minister of Public Works and Government Services Canada.

Bailey, K., & Grossardt, T. (2010). Toward structured public involvement: Justice, geography and collaborative geospatial/geovisual decision support systems. *Annals of the Association of American Geographers*. 100(1), 57-86.

Ballard, C., & Banks, G. (2003) Resource wars: The anthropology of mining. *Annual Review of Anthropology*. 32, 287-313.

Bartlett, J. G., Madariaga-Vignudo, L., O'Neil, J. D., & Kuhnlein, H. V. (2007). Identifying indigenous peoples for health research in a global context: A review of perspectives and challenges. *International Journal of Circumpolar Health*. 66(4), 287-307.

Beh, E. J. (1998). A comparative study of scores for correspondence analysis with ordered categories. *Biometrical Journal*. 40(4), 413-429.

Beierle, T. C. (2002). The quality of stakeholder-based decisions. *Risk Analysis*. 22(4), 739-749.

Benoit, K., Laver, M., & Mikhaylov, S. (2009). Treating words as data with error: Uncertainty in text statements of policy positions. *American Journal of Political Science*. 3(2), 495-513.

Berger, T. (2010). Land use planning: Land claims and Canada's north. In *Canada's north: What's the plan?* (pp 7-35). Ottawa: Conference Board of Canada.

Bernard, L., & Ostländer, N. (2008). Assessing climate change vulnerability in the arctic using Geographic Information Services in Spatial Data Infrastructures. *Climatic Change*. 87(1-2), 263-281.

Birley, M. (2005). Health impact assessment in multinationals: A case study of the Royal Dutch/Shell Group. *Environmental Impact Assessment Review*. 25(7-8), 702-713.

Bjerregaard, P. (2011). The Arctic Health Declaration. *International Journal of Circumpolar Health*. 70(1), 101-102.

Bone, C., Alessa, L., Altaweel, M., Kliskey, A., & Lammers, R. (2011). Assessing the impacts of local knowledge and technology on climate change vulnerability in remote communities. *International Journal of Environmental Research and Public Health*. 8(3), 733-761.

Brinkmann, S. (2007). Could interviews be epistemic?: An alternative to qualitative opinion polling. *Qualitative Inquiry*. 13(8), 1116-1138.

Bronson, J., & Noble, B. F. (2006). Health determinants in Canadian northern environmental impact assessment. *Polar Record*. *42*(4), 315-324.

Brown, J. H., Burnside, W. R., Davidson, A. D., Delong, J. R., Dunn, W. C., Hamilton, M. J., Zuo, W. (2011). Energetic limits to economic growth. *BioScience*. 61(1), 19-26.

Brown, P. (2003). Qualitative methods in environmental health research. *Environmental Health Perspectives*. 111(14), 1789-1798.

Brown-Leonardi, C. J. (2012). Notions of property: Traditional land use and boundaries in the Deh Cho region. *Polar Record*. 48(3), 249-254.

Brubaker, M. Y., Bell, J. N., Berner, J. E., & Warren, J. A. (2011). Climate change health assessment: A novel approach for Alaska Native communities. *International Journal of Circumpolar Health*. 70(3), 266-273.

Budge, I., & Pennings, P. (2007). Do they work? Validating computerised word frequency estimates against policy series. *Electoral Studies*. 26(1), 121-129.

Burnard, P., Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Analysing and presenting qualitative data. *British Dental Journal*. 204(8), 429-432.

Butz, W. P., & Torrey, B. B. (2006). Some frontiers in social science. *Science*. *312*(5782), 1898-1900.

Caelli, K., Ray, L., & Mill, J. (2003). 'Clear as mud': Toward greater clarity in generic qualitative research. *International Journal of Qualitative Methods*. 2(2).

Caine, K. J., Davison, C. M., & Stewart, E. J. (2009). Preliminary field-work: Methodological reflections from northern Canadian research. *Qualitative Research*. 9(4), 489-513.

Caine, K. J., Salomons, M. J., & Simmons, D. (2007). Partnerships for social change in the Canadian North: Revisiting the insider-outsider dialectic. *Development and Change*. 38(3), 447-471.

Calder v. British Columbia (Attorney General). 1973, Supreme Court Report 313. Retrieved from the Judgements of the Supreme Court of Canada website http://scc-csc.lexum.com/scc-csc/scc-csc/en/item/5113/index.do

Canadian Environmental Assessment Act, Consolidated Statutes of Canada. (2012, c. 19, s. 52). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/C-15.21.pdf

Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and Humanities Research Council of Canada (2010). *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*. Retrieved from http://www.pre.ethics.gc.ca/pdf/eng/tcps2/TCPS_2_FINAL_Web.pdf

Carter, S. M., & Little, M. (2007). Justifying knowledge, justifying method, taking action: Epistemologies, methodologies, and methods in qualitative research. *Qualitative Health Research*. 17(10), 1316-1328.

Centre for the North. (2012). *Getting it right: Assessing and building resilience in Canada's north*. Ottawa, ON: Conference Board of Canada.

Centre for the North. (2011). *Striking a balance: Impacts of major natural resource projects in the north: Briefing*. Ottawa, ON: Conference Board of Canada.

Chambers, K. J., Corbett, J., Keller, C. P., & Wood, C. J. B. (2004). Indigenous knowledge, mapping, and GIS: A diffusion of innovation perspective. *Cartographica*. 39(3), 19-31.

Chapin, M., Lamb, Z., & Threlkeld, B. (2005) Mapping indigenous lands. *Annual Review of Anthropology*. 34, 619-638.

Charmaz, K. (2004). Premises, principles, and practices in qualitative research: Revisiting the foundations. *Qualitative Health Research*. 14(7), 976-993.

Chatwood, S., Bjerregaard, P., & Kue Young, T. (2012). Global health - a circumpolar perspective. *American Journal of Public Health*. 102(7), 1246-1249

Christensen, J., & Grant, M. (2007). How political change paved the way for indigenous knowledge: The Mackenzie Valley Resource Management Act. *Arctic*. 60(2), 115-123.

Conference Board of Canada. (2013). *The future of mining in Canada's north: Economic performance and trends*. Ottawa: M. Caron-Vuotari & G. Rheaume.

Constitution Act, Consolidated Statutes of Canada. (1982, being Schedule B to the Canada Act 1982 (UK), 1982, c 11). Retrieved from the Canadian Legal Information Institute website http://www.canlii.org/en/ca/laws/stat/schedule-b-to-the-canada-act-1982-uk-1982-c-11/latest/schedule-b-to-the-canada-act-1982-uk-1982-c-11.html

Conference Board of Canada. (2013). *The future of mining in Canada's north: Economic performance and trends*. Ottawa: M. Caron-Vuotari & G. Rheaume.

Coppock, J. T., & Rhind, D. W. (1991). The history of GIS. In P. A. Longley, M. F. Goodchild, D. J. Maguire & D. W. Rhind (Eds.), *Geographic Information Systems*. New York: Wiley.

Cundill, G., & Rodela, R. (2012). A review of assertions about the processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*. 113, 7-14.

Davison, C. M., & Hawe, P. (2012). All that glitters: Diamond mining and Tåîchô youth in Behchokö, Northwest Territories. *Arctic*. 65(2), 214-228.

Delgamuukw v. British Columbia. 1977, 3 Supreme Court Report 1010. Retrieved from the Judgements of the Supreme Court of Canada website http://scc-csc.lexum.com/scc-csc/scc-csc/en/item/1569/index.do

Derry, R. (2012). Reclaiming marginalized stakeholders. *Journal of Business Ethics*. 111(2), 253-264.

Dew, K. (2007). A health researcher's guide to qualitative methodologies. *Australian and New Zealand Journal of Public Health*. 31(5), 433-437.

Dinkins, S. C. (2005). Shared inquiry: Socratic hermeneutic interpre-viewing. In P. Ironside & N. Diekelmann (Eds.), *Beyond Method: Philosophical Conversations in Healthcare Research and Scholarship* (111-147). Madison: University of Wisconsin Press.

Duhaime, G., Searles, E., Usher, P. J., Myers, H., & Fréchette, P. (2004). Social cohesion and living conditions in the Canadian arctic: From theory to measurement. *Social Indicators Research*. 66(3), 295-317.

Eisner, W. R., Jelacic, J., Cuomo, C. J., Kim, C., Hinkel, K. M., & Del Alba, D. (2012). Producing an indigenous knowledge web GIS for arctic Alaska Communities: Challenges, successes, and lessons learned. *Transactions in GIS*. 16(1), 17-37.

Ellis, S. C. (2005). Meaningful consideration? A review of traditional knowledge in environmental decision making. *Arctic*. 58(1), 66-77.

Epp, H., Rigby, B., & Bruce, B. (1991). Remote sensing and Geographic Information System training requirements in arctic Canada. *Arctic*. 44(Suppl. 1), 11-14.

Erden, Z., Schneider, A., & von Krogh, G. (In Press). The multifaceted nature of social practices: A review of the perspectives on practice-based theory building about organizations. *European Management Journal*. DOI: 10.1016/j.emj.2014.01.005

Fidler, C., & Hitch, M. (2007). Impact and Benefit Agreements: A contentious issue for environmental and aboriginal justice. *Environments*. 35(2), 49-69.

Fitzpatrick, P., Fonseca, A., & McAllister, M. L. (2011). From the Whitehorse Mining Initiative towards sustainable mining: Lessons learned. *Journal of Cleaner Production*. 19(4), 376-384.

Fitzpatrick, P., Sinclair, A. J., & Mitchell, B. (2008). Environmental impact assessment under the Mackenzie Valley Resource Management Act: Deliberative democracy in Canada's north? *Environmental Management*. 42(1), 1-18.

Flicker, S., & Worthington, C. A. (2012). Public health research involving aboriginal peoples: Research ethics board stakeholders' reflections on ethics principles and research processes. *Canadian Journal of Public Health*. 103(1), 19-22.

Fondahl, G., Lazebnik, O., Poelzer, G., & Robbek, V. (2001). Native 'land claims', Russian style. *Canadian Geographer*. 45(4), 545-561.

Forbes, B. C., & Stammler, F. (2009). Arctic climate change discourse: The contrasting politics of research agendas in the west and Russia. *Polar Research*. 28(1), 28-42.

Ford, J. D. (2012). Indigenous health and climate change. *American Journal of Public Health*. 102(7), 1260-1266.

Ford, J. D., & Beaumier, M. (2011). Feeding the family during times of stress: Experience and determinants of food insecurity in an Inuit community. *Geographical Journal*. 177(1), 44-61.

Galbraith, L., Bradshaw, B., & Rutherford, M. B. (2007). Towards a new supraregulatory approach to environmental assessment in northern Canada. *Impact Assessment and Project Appraisal*. 25(1), 27-41.

Gamble, D. J. (1978). The Berger Inquiry: An impact assessment process. *Science,* 199(4332), 946-952.

Getty, G. A. (2010). The journey between western and indigenous research paradigms. *Journal of Transcultural Nursing*. 21(1), 5-14.

Gibson, R. B. (2011). Application of a contribution to sustainability test by the Joint Review Panel for the Canadian Mackenzie Gas Project. *Impact Assessment and Project Appraisal*. 29(3), 231-244.

Gibson, G., & Klinck, J. (2005). Canada's resilient north: The impact of mining on aboriginal communities. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health*. 3(1), 116-139.

Givens, L. M. & Saumure, K. (2008). Trustworthiness. In L. M. Given (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods* (896-897). Thousand Oaks: SAGE Publications.

González, A., Gilmer, A., Foley, R., Sweeney, J., & Fry, J. (2008). Technology-aided participative methods in environmental assessment: An international perspective. *Computers, Environment and Urban Systems*. 32(4), 303-316.

Government of Canada. (2011). *Aboriginal Consultation and Accommodation: Updated Guidelines for Federal Officials to Fulfill the Duty to Consult*. Ottawa: Aboriginal Affairs and Northern Development Canada.

Government of Northwest Territories Bureau of Statistics. (2011). *Population Projections*. http://www.statsnwt.ca/population/community-projections/ [Last accessed on April 27, 2014]

Gracey, M., & King, M. (2009). Indigenous health part 1: Determinants and disease patterns. *Lancet*. 374(9683), 65-75.

Grimmer, J., & Stewart, B. M. (2013). Text as data: The promise and pitfalls of automatic content analysis methods for political texts. *Political Analysis*. 21(3), 267-297.

Haida Nation v. British Columbia (Minister of Forests). 2004, 3 Supreme Court Report 511. Retrieved from the Judgements of the Supreme Court of Canada website http://scc-csc.lexum.com/scc-csc/scc-csc/en/item/2189/index.do

Hall, R. (2013). Diamond mining in Canada's Northwest Territories: A colonial continuity. *Antipode*. 45(2), 376-393.

Hallberg, L. R. M. (2006). The "core category" of grounded theory: Making constant comparisons. *International Journal of Qualitative Studies on Health and Well-being*. 1(3), 141-148.

Hanna, P., & Vanclay, F. (2013). Human rights, indigenous peoples and the concept of Free, Prior and Informed Consent. *Impact Assessment and Project Appraisal*. 31(2), 146-157.

Homburg, V., & Georgiadou, Y. (2009). A Tale of two trajectories: How spatial data infrastructures travel in time and space. *Information Society*. 25(5), 303-314.

Hopkins, D. J., & King, G. (2010). A method of automated nonparametric content analysis for social science. *American Journal of Political Science*. 54(1), 229-247.

Horwitz, P., & Finlayson, C. M. (2011). Wetlands as settings for human health: Incorporating ecosystem services and health impact assessment into water resource management. *BioScience*. 61(9), 678-688.

Houde, N. (2007). The six faces of traditional ecological knowledge: Challenges and opportunities for Canadian co-management arrangements. *Ecology and Society*. 12(2).

Jankowski, P., & Nyerges, T. (2001). GIS-supported collaborative decision making: Results of an experiment. *Annals of the Association of American Geographers*. 91(1), 48-70.

Johnson, E. A., & Miyanishi, K. (2012). The boreal forest as a cultural landscape. *Annals of the New York Academy of Sciences*. 1249, 151-165.

Kelly, P. (2014). Intercultural comparative research: rethinking insider and outsider perspectives. *Oxford Review of Education*. 40(2), 246-265.

King, M., Smith, A., & Gracey, M. (2009). Indigenous health part 2: The underlying causes of the health gap. *Lancet*. 374(9683), 76-85.

Kirmayer, L. J., Dandeneau, S., Marshall, E., Phillips, M. K., & Williamson, K. J. (2011). Rethinking resilience from indigenous perspectives. *Canadian Journal of Psychiatry*. 56(2), 84-91.

Kraft Sloan, K., & Hik, D. (2008). International Polar Year as a catalyst for sustaining arctic research. *Sustainable Development Law & Policy*. 8(1), 4-7.

Kryzanowski, J. A., & McIntyre, L. (2011). A holistic model for the selection of environmental assessment indicators to assess the impact of industrialization on indigenous health. *Canadian Journal of Public Health*. 102(2), 112-117.

Kueffer, C., Underwood, E., Hadorn, G. H., Holderegger, R., Lehning, M., Pohl, C., Schirmer, M., Schwarzenbach, R., Stauffacher, M., Wuelser, G. & Edwards, P. (2012).

Enabling effective problem-oriented research for sustainable development. *Ecology and Society*. 17(4).

Kwiatkowski, R. E. (2011). Indigenous community based participatory research and health impact assessment: A Canadian example. *Environmental Impact Assessment Review*. 31(4), 445-450.

Kwiatkowski, R. E., & Ooi, M. (2003). Integrated environmental impact assessment: A Canadian example. *Bulletin of the World Health Organization*. 81(6), 434-438.

Lammers, J. C. (2011). How institutions communicate: Institutional messages, institutional logics, and organizational communication. *Management Communication Quarterly*. 25(1), 154-182.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*. 33(1), 159-174.

Lauster, N., & Tester, F. (2010). Culture as a problem in linking material inequality to health: On residential crowding in the arctic. *Health and Place*. 16(3), 523-530.

Laver, M., & Garry, J. (2000). Estimating policy positions from political texts. *American Journal of Political Science*. 44(3), 619-634.

Lavoie, J. G. (2013). Policy silences: Why Canada needs a national First Nations, Inuit and Métis health policy. *International Journal of Circumpolar Health*. 72, 1-7.

Leech, N. L., & Onwuegbuzie, A. J. (2011). Beyond constant comparison qualitative data analysis: Using NVivo. *School Psychology Quarterly*. 26(1), 70-84.

Leszczynski, A. (2009). Poststructuralism and GIS: Is there a 'disconnect'? *Environment and Planning D: Society and Space*. 27(4), 581 – 602.

Lewis, J. L., & Sheppard, S. R. J. (2006). Culture and communication: Can landscape visualization improve forest management consultation with indigenous communities? *Landscape and Urban Planning*. 77(3), 291-313.

Louis, R. P., Johnson, J. T., & Pramono, A. H. (2012). Introduction: Indigenous cartographies and counter-mapping. *Cartographica*. 47(2), 77-79.

Lowe, W., Benoit, K., Slava, M., & Laver, M. (2011). Scaling policy preferences from coded political texts. *Legislative Studies Quarterly*. 36(1), 123-155.

MacIntosh, C. (2013). The role of law in ameliorating global inequalities in indigenous peoples' health. *Journal of Law Medicine & Ethics*. 41(1), 74-88.

Macintosh, C. (2012). Relational theory and indigenous health: Insights for law reform and policy development. In J. Downie & J. Llewellyn (Eds.), *Being Relational:*

Reflections on Relational Theory and Health Law and Policy (230-254). Vancouver: University of British Columbia Press.

Mackenzie Valley Environmental Impact Review Board [MVEIRB]. (2014a). Canadian Zinc Corporation - Prairie Creek Mine - EA0809-002 [2008]. Retrieved from the MVEIRB Public Registry http://www.reviewboard.ca/registry/project.php?project_id=70 [Last accessed on May 7, 2014]

Mackenzie Valley Environmental Impact Review Board [MVEIRB]. (2014b). Fortune Minerals Ltd. - Nico Project - EA0809-004. Retrieved from the MVEIRB Public Registry [2009] http://www.reviewboard.ca/registry/project.php?project_id=72 [Last accessed on May 7, 2014]

Mackenzie Valley Environmental Impact Review Board [MVEIRB]. (2013). Report of environmental assessment and reasons for decision: EA 0809-004 Fortune Minerals Limited Nico Project. Retrieved from the MVEIRB Public Registry http://www.reviewboard.ca/upload/project_document/EA0809-004_NICO_Report_of_EA_and_Reasons_for_Decision.PDF

Mackenzie Valley Environmental Impact Review Boad [MVEIRB]. (2011). Report of environmental assessment and reasons for decision: EA0809-002: Canadian Zinc Corporation Prairie Creek Mine. Retrieved from the MVEIRB Public Registry. http://reviewboard.ca/upload/project_document/EA0809-002_Report_of_Environmental_Assessment_and_Reasons_for_Decision_1328709638.PDF

Mackenzie Valley Resource Management Act. Consolidated Statutes of Canada. (1998, c. 25). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/M-0.2.pdf

Malterud, K. (2001). Qualitative research: Standards, challenges, and guidelines. *Lancet*. 358(9280), 483-488.

Marks, E., Cargo, M. D., & Daniel, M. (2007). Constructing a health and social indicator framework for indigenous community health research. *Social Indicators Research*. 82(1), 93-110.

Marmot, M., Allen, J., Bell, R., & Goldblatt, P. (2012). Building of the global movement for health equity: From Santiago to Rio and beyond. *The Lancet*. 379(9811), 181-188.

Mayan, M. J. (2009). *Essentials of Qualitative Inquiry*. Walnut Creek, CA: Left Coast Press.

Mays, N., & Pope, C. (1995). Rigour and qualitative research. *British Medical Journal.* 311(6997), 109-112.

McCaig, K. (2005). Canadian insights: The challenges of an integrated environmental assessment framework. *Environmental Impact Assessment Review*. 25(7-8), 737-746.

McCarthy, D. D. P., Whitelaw, G. S., Anderson, S., Cowan, D., McGarry, F., Robins, A., Gardner, H. L., Barbeau, C. D., Charania, N. A., General, Z., Liedtke, J., Sutherland, C., Alencar, P. & Tsuji, L. J. S. (2012). Collaborative geomatics and the Mushkegowuk Cree First Nations: Fostering adaptive capacity for community-based sub-arctic natural resource management. *Geoforum*. 43(2), 305-314.

McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*. 22(3), 276-282.

Mohammad, S. M., & Turney, P. D. (2013). Crowdsourcing a word-emotion association lexicon. *Computational Intelligence*. 29(3), 436-465.

Moran-Ellis, J., Alexander, V. D., Cronin, A., Dickinson, M., Fielding, J., Sleney, J., & Thomas, H. (2006). Triangulation and integration: Processes, claims and implications. *Qualitative Research*. 6(1), 45-59.

Morse, J. M., Barrett, M., Mayan, M., Olson, K., & Spiers, J. (2002). Verification strategies for establishing reliability and validity in qualitative research. *International Journal of Qualitative Methods*. 1(2), 1-19.

Nadasdy, P. (2002). "Property" and aboriginal land claims in the Canadian subarctic: Some theoretical considerations. *American Anthropologist*. 104(1), 247-261.

National Snow and Ice Data Center. (2014). Exchange for Local Observations and Knowledge of the Arctic [ELOKA]. http://eloka-arctic.org/ [Last accessed on April 27, 2014].

Noble, B., & Birk, J. (2011). Comfort monitoring? Environmental assessment follow-up under community-industry negotiated environmental agreements. *Environmental Impact Assessment Review*. 31(1), 17-24.

Noble, B., & Bronson, J. (2006). Practitioner survey of the state of health integration in environmental assessment: The case of northern Canada. *Environmental Impact Assessment Review*. 26(4), 410-424.

Nolas, S. M. (2014). Towards a new theory of practice for community health psychology. *Journal of Health Psychology*. 19(1), 126-136.

Notzke, C. (1995). A new perspective in aboriginal natural resource management: Co-management. *Geoforum*. 26(2), 187-209.

Nuttall, M. (2009). Energy development and aboriginal rights in northern Canada. In A. Dey-Nuttall & M. Nuttall (Eds.), *Canada's and Europe's northern dimensions* (71-84). Oulu: University of Oulu Press.

O'Neil, J. D. (1986). The politics of health in the fourth world: A northern Canadian example. *Human Organization*. 45(2), 119-128.

Onkila, T. (2011). Multiple forms of stakeholder interaction in environmental management: Business arguments regarding differences in stakeholder relationships. *Business Strategy and the Environment*. 20(6), 379-393.

Onwuegbuzie, A. J., & Leech, N. L. (2007). Validity and qualitative research: An oxymoron? *Quality and Quantity*. 41(2), 233-249.

Ozkan, U. R., & Schott, S. (2013). Sustainable development and capabilities for the polar region. *Social Indicators Research*. 114(3), 1259-1283.

Paci, C., & Villebrun, N. (2005). Mining Denendeh: A Dene Nation perspective on community health impacts of mining. *Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health*. 3(1), 71-86.

Palmer, M. (2012). Theorizing indigital geographic information networks. *Cartographica*. 47(2), 80-91.

Peng, T., Liu, L., & Zuo, W. (2014). PU text classification enhanced by term frequency-inverse document frequency-improved weighting. *Concurrency Computation Practice and Experience*. 26(3), 728-741.

Peters, V., & Wester, F. (2007). How qualitative data analysis software may support the qualitative analysis process. *Quality and Quantity*. 41(5), 635-659.

Petheram, L., Stacey, N., Campbell, B. M., & High, C. (2012). Using visual products derived from community research to inform natural resource management policy. *Land Use Policy*. 29(1), 1-10.

Pfeiffer, C., Glaser, S., Vencatesan, J., Schliermann-Kraus, E., Drescher, A., & Glaser, R. (2008). Facilitating participatory multilevel decision-making by using interactive mental maps. *Geospatial Health*. 3(1), 103-112.

Polkinghorne, D. E. (2006). An agenda for the second generation of qualitative studies. *International Journal of Qualitative Studies on Health and Well-being*. 1(2), 68-77.

Poore, B. S., & Chrisman, N. R. (2006). Order from noise: Toward a social theory of geographic information. *Annals of the Association of American Geographers*. 96(3), 508-523.

Pop, I. A., van Ingen, E., & van Oorschot, W. (2013). Inequality, wealth and health: Is decreasing income inequality the key to create healthier societies? *Social Indicators Research*. 113(3), 1025-1043.

Potvin, L., Gendron, S., Bilodeau, A., & Chabot, P. (2005). Integrating social theory into public health practice. *American Journal of Public Health*. 95(4), 591-595.

Provalis. (2014). Wordstat Software.

Python. (2014). Natural Language Toolkit [NLTK].

QSR International. (2014). NVivo Version 10 Software.

Racher, K. I., Hutchinson, N., Hart, D., Fraser, B., Clark, B., Fequet, R., Ewaschuk, P. & Cliffe-Phillips, M. (2011). Linking environmental assessment to environmental regulation through adaptive management. *Integrated Environmental Assessment and Management*. 7(2), 301-302.

Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *European Journal of Social Theory*. 5(2), 243-263.

Ritter, T. L. (2007). Sharing environmental health practice in the North American arctic: A focus on water and wastewater service. *Journal of Environmental Health*. 69(8), 50-55.

Robbins, P. (2003). Beyond ground truth: GIS and the environmental knowledge of herders, professional foresters, and other traditional communities. *Human Ecology*. 31(2), 233-254.

Robertson, S. (2004). Understanding inverse document frequency: On theoretical arguments for IDF. *Journal of Documentation*. 60(5), 503-520.

Rodela, R. (2013). The social learning discourse: Trends, themes and interdisciplinary influences in current research. *Environmental Science and Policy*. 25, 157-166.

Rodela, R., Cundill, G., & Wals, A. E. J. (2012). An analysis of the methodological underpinnings of social learning research in natural resource management. *Ecological Economics*. 77, 16-26.

Rogers, W., & Lange, M. M. (2013). Rethinking the vulnerability of minority populations in research. *American Journal of Public Health*. 103(12), 2141-2146.

Sahakian, M., & Wilhite, H. (2014). Making practice theory practicable: Towards more sustainable forms of consumption. *Journal of Consumer Culture*. 14(1), 25-44.

Scammell, M. K. (2010). Qualitative environmental health research: An analysis of the literature, 1991-2008. *Environmental Health Perspectives*. 118(8), 1146-1154.

Scientists Act, Revised Statutes of the Northwest Territories. (1988, c. S-4). Retrieved from the Canadian Legal Information Institute website http://www.canlii.org/en/nt/laws/stat/rsnwt-1988-c-s-4/latest/rsnwt-1988-c-s-4.html

Scott, R., W., & Davis, G., F. (2007). The subject is organizations; The verb is organizing. In *Organizations and Organizing: Rational, Natural, and Open System Perspectives* (1-34). New Jersey: Pearson Prentice Hall.

Snyder, J., Wagler, M., Lkhagvasuren, O., Laing, L., Davison, C., & Janes, C. (2012). An equity tool for health impact assessments: Reflections from Mongolia. *Environmental Impact Assessment Review*. 34, 83-91.

Solodyankina, S., & Koeppel, J. (2009). The environmental impact assessment process for oil and gas extraction projects in the Russian Federation: Possibilities for improvement. *Impact Assessment and Project Appraisal*. 27(1), 77-83.

Spangenberg, J. H. (2010). The growth discourse, growth policy and sustainable development: Two thought experiments. *Journal of Cleaner Production*. 18(6), 561-566.

Starks, H., & Trinidad, S. B. (2007). Choose your method: A comparison of phenomenology, discourse analysis, and grounded theory. *Qualitative Health Research*. 17(10), 1372-1380.

Stevenson, M. G. (1996). Indigenous knowledge in environmental assessment. *Arctic*. 49(3), 278-291.

Stewart, E. J., Jacobson, D., & Draper, D. (2008). Public participation Geographic Information Systems (PPGIS): Challenges of implementation in Churchill, Manitoba. *Canadian Geographer*. 52(3), 351-366.

Tlicho Land Claims and Self-Government Act. Consolidated Statutes of Canada. (2005, c. 1). Retrieved from the Government of Canada Justice Laws website http://laws-lois.justice.gc.ca/PDF/T-11.3.pdf

Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 19(6), 349-357.

Tripathi, N., & Bhattarya, S. (2004). Integrating indigenous knowledge and GIS for participatory natural resource management: State of the practice. *The Electronic Journal of Information Systems in Developing Countries*. 17(3), 1-13.

Turnpenny, J., Jones, M., & Lorenzoni, I. (2011). Where now for post-normal science?: A critical review of its development, definitions, and uses. *Science Technology and Human Values*. 36(3), 287-306.

Usher, P. J. (2003). Environment, race and nation reconsidered: Reflections on aboriginal land claims in Canada. *Canadian Geographer*. 47(4), 365-382.

Usher, P. J., Duhaime, G., & Searles, E. (2003). The household as an economic unit in arctic aboriginal communities, and its measurement by means of a comprehensive survey. *Social Indicators Research*. 61(2), 175-202.

Usher, P. J., Tough, F. J., & Galois, R. M. (1992). Reclaiming the land: Aboriginal title, treaty rights and land claims in Canada. *Applied Geography*. 12(2), 109-132.

Weaver, C., & Cunningham, A. M. (1985). Social theory, impact assessment and northern native communities. *Berkeley Planning Journal*. 2(1).

Wilson, G. N., & Alcantara, C. (2012). Mixing politics and business in the Canadian arctic: Inuit corporate governance in Nunavik and the Inuvialuit settlement region. *Canadian Journal of Political Science*. 45(4), 781-804.

Wilson, K., & Young, T. K. (2008). An overview of aboriginal health research in the social sciences: Current trends and future directions. *International Journal of Circumpolar Health*. 67(2-3), 179-189.

Wilson, K. (2003). Therapeutic landscapes and First Nations peoples: An exploration of culture, health and place. *Health & Place*. 9(2), 83-93.

Winiecki, D. J. (2010). Rational, natural, and open: Organizational system typologies and their relevance for performance improvement professionals. *Performance Improvement*. 49(5), 35-41.

Winslow, C. E. A. (1920). The untilled fields of public health. *Science*. 51(1306), 23-33.

Wright, D. J., Duncan, S. L., & Lach, D. (2009). Social power and GIS technology: A review and assessment of approaches for natural resource management. *Annals of the Association of American Geographers*. 99(2), 254-272.

Appendices

Appendix A: Chapter Three Ethics Approval

Notification of Approval

Date:	June 29, 2012	
Study ID:	Pro00031998	
Principal Investigator:	Jennifer McGetrick	
Study Supervisor:	Tania Bubela	
Study Title:	Pilot Study: Expert Assessment of Geographic Information Systems (GIS) for Health Impact Assessment of Natural Resource Development in Canada's North	
Approval Expiry Date:	June 28, 2013	
Approved Consent Form:	Approval Date 8/6/2012	Approved Document SPH Information and Informed Consent Form (McGetrick)
Sponsor/Funding Agency:	Circumpolar/Boreal Alberta Research (C/BAR) Grant Award DIAND Northern Scientific Training Program (NSTP) Grant Award	

Thank you for submitting the above study to the Research Ethics Board 1. Your application has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Research Ethics Board does not encompass authorization to access the staff, students, facilities or resources of local institutions for the purposes of the research.

Sincerely,

Dr. Trish Reay
Associate Chair, Research Ethics Board 1

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix B: Chapter Three Information and Informed Consent Form

UNIVERSITY OF ALBERTA

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Information Sheet for the University of Alberta Research Project:

Pilot Study: Expert Assessment of Geographic Information Systems (GIS) for the Health Impact Assessment of Natural Resource Development in Canada's North

Contacts: This study is run by Jennifer Ann McGetrick (MSc Department of Public Health Sciences) under the supervision of Dr. Tania Bubela (Department of Public Health Sciences).

If you have any questions about this research and/or your participation, please contact:

Research Investigator:	**OR**	**Supervisor:**
Jennifer Ann McGetrick		Tania Bubela
Department of Public Health Sciences		Department of Public Health Sciences
3-279 Edmonton Clinic Health Academy		3-279 Edmonton Clinic Health Academy
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Purpose: This pilot study will interview circumpolar health experts in academics, industry, and policy. Its purpose is understand how geographic information systems (GIS) may be used as a communication tool to consult with communities on health impacts during environmental assessments on natural resource developments in Canada's north. The pilot study will be used to develop a research framework and interview/consultation guides for community level work.

Background: Natural resource development is accelerating in northern Canada, which is characterized by small and remote communities, with historically limited socio-economic opportunities. The health impacts of such developments have been extensively documented in the literature, and are increasingly considered in the environmental assessments conducted prior to project approvals. Because the health impacts of these developments upon northern communities can be profound, it is important that communities be consulted about the potential risks and benefits. Although GIS is extensively employed by government and industry in the north, creating dynamic digital inventories of geo-spatially referenced information, little research has been done on GIS as a communication tool for consultations with communities during environmental assessments. Thus, the study will pilot the concept of incorporating GIS into community consultations during environmental assessments in Canada's north.

What will you be asked to do? You will be asked to contribute your expert opinion on a number of topics related to health impact assessment, community consultation, and geographic information systems, during a 15 to 20 minute interview, which will be audio recorded, with your permission.

What type of personal information will be collected?

If you agree to participate, in addition to your expert opinion, we will ask you for your name, contact information and a brief description of your professional background.

Are there risks or benefits for participating?

There are no risks to you from participating in these interviews. Other than your time, there are no costs to you to participate in this study. You will not be identified in any publications or reports of the research. Your feedback will be used to develop a research framework and interview/consultation guides for further community level work.

Participation:

Your participation in this research is completely voluntary. You can choose to stop the interview at any time without giving a reason or choose not to answer any question.

Withdrawal from the study:

Even after you have agreed to participate in the interview, you may stop the interview at any time without giving a reason. You can contact us within four weeks of conducting the interview to revise your answers to the interview, or ask to withdraw so that your interview not be included in the research. If you do so, we will delete all record of your participation.

Keeping your information private:

What you have said will not be attached to your name. Instead, the written record of your interview will be given a number. The recordings and transcripts will only be used for this research and will be accessed only be research staff. All of the data collected, including audio recordings, transcripts of recordings, and any notes, will be stored in a secure place by the research investigators and kept until five years after publication of the study.

Use of the Information:

This research will be used for a Master's Thesis and for publications. The practical goal is to develop a research framework and interview/consultation guides for further community level work.

Additional Contacts:

The plan for this study has been reviewed to make sure it follows ethical guidelines and approved by the University of Alberta Research Ethics Office. For questions about participant rights and ethical conduct of research, contact the University of Alberta Research Ethics Office at 492-2615.

CONSENT FORM

To Participate in the University of Alberta Research Project:

Pilot Study: Expert Assessment of Geographic Information Systems (GIS) for the Health Impact Assessment of Natural Resource Development in Canada's North

Investigator:
Jennifer Ann McGetrick
Department of Public Health Sciences
3-279 Edmonton Clinic Health Academy
University of Alberta
Edmonton, AB, T6G 1C9
mcgetric@ualberta.ca
780-492-0392

Supervisor:
Tania Bubela
Department of Public Health Sciences
3-279 Edmonton Clinic Health Academy
University of Alberta
Edmonton, AB, T6G 1C9
tbubela@ualberta.ca
780.248.0364

Do you understand that you have been asked to be in a research study?	Yes	No
Have you read and received a copy of the attached Information Sheet?	Yes	No
Do you understand the benefits and risks involved in taking part in this research study?	Yes	No
Have you had an opportunity to ask questions and discuss this study?	Yes	No
Do you understand may withdraw from the study within four weeks of conducting the interview without providing a reason?	Yes	No
Has the issue of confidentiality been explained to you?	Yes	No
Do you consent to your interview being audio recorded?	Yes	No
Do you understand who will have access to the records from your interview?	Yes	No
Do you understand that the information you provide to develop a develop a research framework and interview/consultation guides for community level work on the use of GIS as a communication tool to consult with communities on health impacts during environmental assessments in Canada's north?	Yes	No
Can we use this information in the future for presentations and publications?	Yes	No

This study was explained to me by: Jennifer Ann McGetrick

I agree to take part in this study.

_____

Signature of Research Participant Date Printed Name

I would like to receive a copy of research results (check one): ☐ No ☐ Yes

If you would like to receive a copy of the research results please provide us with your address:

_____

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

_____ _____

Signature of Investigator Date

Appendix C: Chapter Three Interview Guide

UNIVERSITY OF ALBERTA
School of Public Health
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Interview Guide for the University of Alberta Research Project

Pilot Study: Expert Assessment of Geographic Information Systems (GIS) for the Health Impact Assessment of Natural Resource Development in Canada's North

Spoken Preamble

Thank you for taking some time to speak with me. I would like to ask you a series of questions as part of a pilot study to help me to develop a research framework and interview/consultation guides for community level work on the use of GIS as a communication tool to consult with communities on health impacts during environmental assessments in Canada's north.

The interview should take approximately 15-30 minutes. Your participation in this interview is entirely voluntary, and you may choose not to answer any questions, or to end the interview, at any time for any reason. Your interview transcript can be provided to you for review, upon request. Moreover, you may choose to revise your answers, or withdraw from the research, within four weeks of conducting the interview. With your permission, I would like to audio record this interview.

1. Can you please tell me about your background and interests?
2. Can you please describe your involvement in community consultations about natural resource developments in Canada's North?
3. In your experience, do you think that environmental assessments adequately consider the health impacts of natural resource developments? Please elaborate on the types of health impacts addressed.
   [Prompt: Infectious diseases, non-communicable diseases, social determinants of health such as housing, access to nutrition, education]
4. Can you describe your impressions of how consultation with communities during environmental assessments might better address the potential health impacts of natural resource developments?
   [Prompt: The extent to which health impacts are explicitly addressed during consultations or raised in the communications of natural resource development proponents]
5. Can you describe how geographic information systems (GIS) have been used during environmental assessments?
6. How might geographic information systems be employed to assess health impacts arising from natural resource developments?
7. Do you think that communities would be receptive to the use of GIS to address health impacts of natural resource developments during community consultations? Why, why not, and in what way?
8. What ethical concerns arise from using GIS to address health impacts of natural resource developments during community consultations?
   [Prompt: privacy, stigmatisation, community concerns on visual maps, community ownership of the data, restrictions on data use and interpretation, responsible stewardship of the GIS data]
9. Is there anything else you would like to add?

Thank you!

Appendix D: Chapter Five Ethics Approval

Notification of Approval

Date:	January 14, 2013
Study ID:	Pro00034519
Principal Investigator:	Jennifer McGetrick
Study Supervisor:	Tania Bubela
Study Title:	Multi-stakeholder Health Impact Communication in Environmental Assessment of Natural Resource Development in Northern Canada
Approval Expiry Date:	January 13, 2014

Approved Consent Form:	Approval Date	Approved Document
	14/01/2013	Environmental Assessment Health (Nico) - Information and Informed Consent Form (12-12).docx

Sponsor/Funding Agency:	C/BAR NSTP Northern Scientific Training Program	C/BAR NSTP NSTP	Canada

Thank you for submitting the above study to the Research Ethics Board 1 . Your application has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Research Ethics Board does not encompass authorization to access the staff, students, facilities or resources of local institutions for the purposes of the research.

Sincerely,

Dr. William Dunn

Chair, Research Ethics Board 1

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix E: 2013 Northwest Territories Scientific Research Licence

Licence No. 15242
File No. 12 410 946
May 09, 2013

2013
Northwest Territories Scientific Research Licence

Issued by:	**Aurora Research Institute – Aurora College** Inuvik, Northwest Territories
Issued to:	Ms. Jennifer Ann McGetrick School of Public Health, University of Alberta Law and Risk Communication in Health (LaRCH) 3-087 Edmonton Clinic Health Academy 11405 87 Avenue Edmonton, AB T6G 1C9 Canada Phone: (780) 492-0392 Fax: (780) 492-0364 Email: mcgetric@ualberta.ca
Affiliation:	School of Public Health, University of Alberta
Funding:	Circumpolar/Boreal Alberta Research (C/BAR) Grant Northern Scientific Training Program (NSTP) Grant
Team Members:	Dr. David Hik (Co-supervisor)
Title:	**Geographic Information Science (GIS) as a Health Communication Tool for Consultation with Stakeholders in Environmental Assessment of the Nico Project in the Tlicho Region, Northwest Territories**
Objectives:	To evaluate the use of Geographic Information Systems (GIS) as a health communication tool for consultation with stakeholders in environmental assessment of the Nico Project in the Tlicho Region of the Northwest Territories.
Dates of data collection:	May 20, 2013 to September 10, 2013.
Location:	Yellowknife and Behchoko.

Licence No.15242 expires on December 31, 2013
Issued in the Town of Inuvik on May 09, 2013

* **original signed** *

Jeff O'Keefe,
Director, Aurora Research Institute

Appendix F: 2014 Northwest Territories Scientific Research Licence

Licence No. 15409
File No. 12 410 946
February 04, 2014

2014
Northwest Territories Scientific Research Licence

Issued by:	**Aurora Research Institute – Aurora College** Inuvik, Northwest Territories
Issued to:	Ms. Jennifer Ann McGetrick School of Public Health, University of Alberta Law and Risk Communication in Health (LaRCH) 3-087 Edmonton Clinic Health Academy 11405 87 Avenue Edmonton, AB T6G 1C9 Canada Phone: (780) 492-0392 Fax: (780) 492-0364 Email: mcgetric@ualberta.ca
Affiliation:	School of Public Health, University of Alberta
Funding:	Circumpolar/Boreal Alberta Research (C/BAR) Grant Northern Scientific Training Program (NSTP) Grant
Team Members:	Dr. David Hik
Title:	**Geographic Information Science (GIS) as a Health Communication Tool for Consultation with Stakeholders in Environmental Assessment of the Nico Project in the Tlicho Region, Northwest Territories**
Objectives:	To evaluate the use of Geographic Information Systems (GIS) as a health communication tool for consultation with stakeholders in environmental assessment of the Nico Project in the Tlicho Region of the Northwest Territories.
Dates of data collection:	February 3, 2014 to May 1, 2014.
Location:	Yellowknife and Behchoko.

Licence No.15409 expires on December 31, 2014
Issued in the Town of Inuvik on February 04, 2014

* **original signed** *

Pippa Seccombe-Hett
Director, Aurora Research Institute

Appendix G: Chapter Five Information and Informed Consent Form

UNIVERSITY OF ALBERTA
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Edmonton, AB T6G 1C9
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Tel: 780.492.9354
Fax: 780.492.0364

Information Sheet for the University of Alberta Research Project:

Geographic Information Systems (GIS): Mitigating Health Impacts?
Nico Environmental Assessment - Tlicho Region, Northwest Territories, Canada

Contacts: This study is run by Jennifer Ann McGetrick (MSc Department of Public Health Sciences) under the supervision of Dr. Tania Bubela (Department of Public Health Sciences). If you have any questions about this research and/or your participation, please contact:

Research Investigator:
Jennifer Ann McGetrick
Department of Public Health Sciences
3-279 Edmonton Clinic Health Academy
University of Alberta
Edmonton, AB, T6G 1C9
mcgetric@ualberta.ca
780.492.0392

OR

Supervisor:
Tania Bubela
Department of Public Health Sciences
3-279 Edmonton Clinic Health Academy
University of Alberta
Edmonton, AB, T6G 1C9
tbubela@ualberta.ca
780.492.9335

Purpose: Our purpose is understand how human health was addressed in the public hearings for the Nico Mine, and what future steps might be taken to protect and promote health. This study is part of a public health graduate thesis on health impact assessment for natural resource development in northern Canada, and how geographic information systems (GIS) are used in aboriginal communities to monitor and empower community health. We would like to interview people who participated in the recent environmental assessment for Fortune Mineral's Nico Mine.

Background: Natural resource development is increasing in northern Canada, and may be contributing to a changing landscape for the social determinants of health in many communities. In the recent public hearings for the Nico Mine, over 150 people contributed to discussions about managing the potential impacts of a mine in the region. Health Canada recommends that project developers, governments, regulators, and community members involved with an environmental assessment communicate to each other about potential health impacts, and ways to protect and promote community health. By consulting with stakeholders who participated in the environmental assessment of the Nico Mine, we hope to increase understanding of how health was considered in the process, the range of community needs, and potential solutions to better address health issues in the context of this natural resource development.

What will you be asked to do? You will be asked to participate in an interview about how health issues were addressed during environmental assessment of the Nico Mine, and how health can be protected and promoted if the project is approved, during a short interview, which will be audio recorded, with your permission.

What type of personal information will be collected?

If you agree to participate, in addition to opinion, we will ask you for your name, contact information and a brief description of your interest in environmental assessment of the Nico Mine.

Are there risks or benefits for participating?

There are no risks to you from participating in these interviews. Other than your time, there are no costs to you to participate in this study. You will not be identified in any publications or reports of the research. Your feedback will be used to evaluate the consideration of health in the Nico Mine environmental assessment, and to provide input for further consideration of health in relation to the project moving forward.

Participation:

Your participation in this research is completely voluntary. You can choose to stop the interview at any time without giving a reason or choose not to answer any question.

Withdrawal from the study:

Even after you have agreed to participate in the interview, you may stop the interview at any time without giving a reason. You can contact us within four weeks of us returning your interview transcript to you to revise your answers to the interview, or ask to withdraw so that your interview not be included in the research. If you do so, we will delete all record of your participation.

Keeping your information private:

What you have said will not be attached to your name. Instead, the written record of your interview will be given a number. The recordings and transcripts will only be used for this research and will be accessed only be research staff. All of the data collected, including audio recordings, transcripts of recordings, and any notes, will be stored in a secure place by the research investigators and kept until five years after publication of the study.

Use of the Information:

This research will be used for a Master's thesis and for publications. The practical goal is to evaluate how health was addressed in the Nico Mine environmental assessment, and to identify next steps to protect and promote health.

Additional Contacts:

This research is licensed by the Aurora Research Institute #15242. The plan for this study has been reviewed to make sure it follows ethical guidelines and approved by the University of Alberta Research Ethics Office. For questions about participant rights and ethical conduct of research, contact the University of Alberta Research Ethics Office at 492-2615.

CONSENT FORM

To Participate in the University of Alberta Research Project:

Pilot Study: Expert Assessment of Geographic Information Systems (GIS) for the Health Impact Assessment of Natural Resource Development in Canada's North

Investigator:
Jennifer Ann McGetrick
Department of Public Health Sciences
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780-492-0392

Supervisor:
Tania Bubela
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3-279 Edmonton Clinic Health Academy
University of Alberta
Edmonton, AB, T6G 1C9
tbubela@ualberta.ca
780.248.0364

Do you understand that you have been asked to be in a research study?	Yes	No
Have you read and received a copy of the attached Information Sheet?	Yes	No
Do you understand the benefits and risks involved in taking part in this research study?	Yes	No
Have you had an opportunity to ask questions and discuss this study?	Yes	No
Do you understand may withdraw from the study within four weeks of receiving your interview transcript without providing a reason?	Yes	No
Has the issue of confidentiality been explained to you?	Yes	No
Do you consent to your interview being audio recorded?	Yes	No
Do you understand who will have access to the records from your interview?	Yes	No
Do you understand that the information you provide will be used to evaluate how health was addressed in the environmental assessment and identify next steps to protect and promote health?	Yes	No
Can we use this information in the future for presentations and publications?	Yes	No

This study was explained to me by: Jennifer Ann McGetrick

I agree to take part in this study.

_____

Signature of Research Participant Date Printed Name

I would like to receive a copy of research results (check one): ☐ No ☐ Yes

If you would like to receive a copy of the research results please provide us with your address:

_____

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

_____ _____

Signature of Investigator Date

Appendix H: Chapter Five Interview Guide

UNIVERSITY OF ALBERTA
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Tel: 780.492.9954
Fax: 780.492.0364

Geographic Information Systems (GIS): Mitigating Health Impacts?
Nico Environmental Assessment - Tlicho Region, Northwest Territories, Canada

1. Could you please tell me about your participation in the Nico environmental assessment?
2. Did you achieve your goals in the process, if not why not?
3. What impacts do you think the Nico project will have in Tlicho communities?
4. Can you comment on the use of Geographic Information Systems, or GIS, to map different information as part of the Nico environmental assessment?
5. Can you please comment on how the Traditional Knowledge and Use studies contributed to decision-making in the Nico environmental assessment?
6. Can you comment on how Tlicho community members contributed to decision-making in the Nico environmental assessment?
7. What did you and other stakeholders do to incorporate heath impacts during the Nico environmental assessment?
8. Do you think that health was appropriately considered in the Nico environmental assessment, overall? Please provide an example, if possible, or explain how it was not considered.
9. Do you think that GIS will be a useful and feasible tool in monitoring health impacts and reporting results of the Nico project to Tlicho communities? Why or why not?
10. Do you foresee an opportunity to work with members of the Tlicho community in the future to help monitor the impacts of the Nico project?
11. Is there anything else you would like to add?

Thank you!