An Analysis of Water Quality and Human Health Issues in First Nations Communities in Canada

ENSC 501 – Independent Environmental Study Project

By: Meredith Harbinson

Supervisors:
Dr. Anna Majury
Dr. Kristan Aronson
Dr. Chris Metcalfe

ABSTRACT

Background: The issue of contamination of drinking water in Canada, especially in First Nations communities, needs to be urgently addressed. The primary concern is microbial contamination, while chronic exposure to chemical and physical agents is also a significant issue. Although specific cases of waterborne disease outbreaks have been well-publicized in Canada, very little information is known about how exposure to unsafe drinking water is affecting the incidence rates of different diseases in First Nations communities.

Methods: Water contamination in three First Nations communities – Kashechewan, Yellow Quill and Fort Chipewyan – is examined. The prevalence of certain diseases and/or illnesses that are associated with the waterborne contaminants is examined in each community and compared to the rest of the Canadian population.

Results: First Nations communities are typically exposed to poorer water quality than other Canadian citizens, and they have disproportionately higher rates of certain diseases and illnesses.

Conclusions/Discussion: The environmental justice issue of the provision of uncontaminated drinking water in First Nations communities is best addressed through a multi-barrier approach to ensuring clean drinking water, while also implementing policy reforms for improved collaboration between First Nations communities and government parties. In this way, First Nations communities will have increased access to both healthcare and safe drinking water.
Table of Contents

Introduction ........................................................................................................................................... 3

Methods .................................................................................................................................................. 4

Part 1.0 – Guidelines for Canadian Drinking Water Quality ............................................................. 4
  1.1 Guidelines for Microbiological Parameters .................................................................................. 5
  1.2 Guidelines for Chemical and Physical Parameters ..................................................................... 6

Part 2.0 – Background .......................................................................................................................... 7
  2.1 Significance of Water to First Nations People (Traditional Ecological Knowledge) .................. 7
  2.2 The State of Water Quality in Indigenous Communities ............................................................. 8
  2.3 Health Problems Associated with Contaminated Drinking Water ............................................. 10
  2.4 First Nations Access to Healthcare ............................................................................................. 12

Part 3.0 – Current Water Quality Treatment Framework ................................................................. 13
  3.1 Role of the Federal Government ................................................................................................. 13
  3.2 The First Nations Water Management Strategy .......................................................................... 14
  3.3 Role of First Nations Communities and Band Councils .............................................................. 15
  3.4 Problems with Current Regulation Framework ........................................................................... 15

Part 4.0 – Specific Case Studies .......................................................................................................... 16
  4.1 Kashechewan First Nations, Ontario .......................................................................................... 16
  4.2 Yellow Quill First Nations, Saskatchewan ..................................................................................... 24
  4.3 Fort Chipewyan First Nations, Alberta ........................................................................................ 29

Part 5.0 – Potential Solutions and Conclusion .................................................................................. 38
  5.1 Multi-Barrier Approach .............................................................................................................. 38
  5.2 Access to Healthcare ................................................................................................................... 44
  5.3 Summary of Key Points .............................................................................................................. 46
INTRODUCTION

Canada is known as a country with abundant fresh water, yet many people are unaware of the shocking number of Canadians that lack access to safe drinking water. A disproportionate number of the people who lack access to clean drinking water live in remote First Nations communities. Many First Nations communities have been plagued by an enduring struggle to alleviate substandard drinking water quality, inadequate water treatment facilities and a lack of proper sanitation on their reserves. As of September 2010, 40% of Canada’s First Nations Communities were under a Drinking Water Advisory (DWA), a rate 2.5 times higher than communities in the rest of Canada (Health Canada, 2009; Patrick, 2011).

Annually, there are approximately 90 deaths and 90,000 illnesses in Canada attributed to exposure to contaminants in drinking water (Sierra Legal Defense Fund, 2006). In remote First Nations communities recent water quality studies have found that exposure to Shigella spp. was 26 times higher in First Nations communities than in the rest of Canada, Giardia lamblia exposure was 2.1 times higher and Helicobacter pylori exposure was 2-3 times higher (Canadian Digestive Health Foundation, 2011; Clark, 2002). The incidence of Escherichia coli illness is reported to be lower in First Nations communities; however, this anomaly can be explained by reduced consumption of beef and should not be attributed to lower levels of E. coli in the water (Shah, 2005). In addition to microbiological contaminants, many First Nations communities located in remote regions of Canada’s Boreal Forest are especially vulnerable to water degradation as a consequence of the natural resource sector releasing contaminants into the environment, including polycyclic aromatic hydrocarbons, heavy metals and other carcinogenic or toxic agents (Timoney, 2007). Thus, it is clear that many First Nations communities face disproportionately high exposure levels to waterborne bacterial, protozoan and viral agents, particulate matter and a variety of chemical/physical contaminants. However, few reports have examined how increased exposures to these contaminants are contributing to the prevalence of certain illnesses and diseases in First Nations people.
This report aims to investigate three main topics. Firstly, why water quality disparities exist between First Nations people and other Canadian citizens, and why these inequalities have not yet been rectified. Secondly, the report will examine whether illness and disease rates are greater in First Nations communities than the rest of Canada through an in-depth analysis of water quality and health issues in three First Nations communities: Kashechewan, Yellow Quill and Fort Chipewyan. Lastly, the report will investigate potential solutions to help address the water quality and human health inequalities in these communities, as well as propose a larger multi-faceted solution that is generalizable to other First Nations communities in Canada.

As an environmental justice issue, comprehensive information on water quality and health issues in First Nations communities in Canada is lacking, and insufficient resources are being devoted to alleviate this problem. Thus, the goal of this report is to compile information to increase awareness so that comprehensive and effective solutions can be designed and implemented to provide clean drinking water to First Nations communities in Canada.

METHODS

The information presented in this report is a compilation of the current literature on water quality and health disparities in First Nations communities. Where information is missing or has questionable authenticity, this is noted in the report and recommendations for future studies are suggested. The report is organized as a series of case studies. When interpreting the results of this report, it is important to be cautious when generalizing findings to other Canadian populations or First Nations communities, as the factors influencing the water and health quality could be significantly different.

PART 1: GUIDELINES FOR CANADIAN DRINKING WATER QUALITY

The Canadian Drinking Water Quality Guidelines (CDWQG) outline the maximum acceptable concentration of microbiological, chemical and radiological contaminants and standards
for physical parameters of water including taste, odour and turbidity. Since 1968 the Federal-Provincial-Territorial Committee on Drinking Water has developed and updated these guidelines that are then published by Health Canada (Health Canada, 2012). The purposes of the guidelines are to minimize risks associated with drinking water and protect the health and safety of the country (Health Canada, 2012).

The *Seventh Edition of the Guidelines for Canadian Drinking Water Quality* outlines contaminants that have the potential to lead to adverse health effects, are frequently found in Canadian water, and are detected at levels that can cause negative health effects. All guidelines are based on current scientific research related to three primary areas: health effects, aesthetic effects, and operational considerations. The information presented next on drinking water guidelines is taken from the current edition of the CDWQG (Health Canada, 2010a).

### 1.1 Guidelines for Microbiological Parameters

The most significant risk for water-related health issues result from microbial contamination with disease-causing bacteria, viruses and protozoa. Thus, microbiological guidelines are essential in ensuring public health by controlling the levels of pathogenic microorganisms. A full table of current numerical guidelines for microbiological parameters is listed in Appendix 1.

#### 1.1.1 Bacteria

Microbiological quality is determined by the presence of the indicator organism *Escherichia coli*, a fecal coliform. The maximum acceptable concentration (MAC) of *E. coli* in drinking water is zero organisms per 100mL, and no single sample should contain more than 10 total coliform organisms per 100mL, with none of these organisms being fecal coliforms. There is currently no MAC for heterotrophic plate count (HPC) bacteria or emerging bacterial pathogens. Heterotrophic bacteria are monitored by measuring increases in their concentrations above a baseline level; any increase is undesirable. The HPC helps provide a more complete analysis of bacterial water quality.
1.1.2 Protozoa and Viruses

At this time it is not possible to establish MAC for protozoa and viruses because there are no adequate tests for cysts and oocysts. Effective filtration and disinfection through a water treatment system, and using source water protection should generate water that does not pose health risks with regards to protozoan or viral contamination. Treatment measures should try to achieve a 3-log reduction and/or inactivation of cysts and oocysts for protozoa, and a 4-log reduction of viruses.

1.1.3 Turbidity

Water turbidity refers to the suspended matter, plankton and other microscopic organisms, in water. Measuring and controlling water turbidity has important health and aesthetic implications because it detracts from the appearance, taste, and odour of water and it also interferes with drinking water disinfection processes leading to unacceptable levels of waterborne bacteria, viruses and protozoa. Treatment technologies should aim to reduce turbidity levels to as low as possible, with a target of less than 0.1 Nephelometric Turbidity Units (NTU) at all times.

1.2 Guidelines for Chemical and Physical Parameters

The chemical constituents of drinking water typically cause health concerns after prolonged periods of exposure. For chemicals that are ‘probably not carcinogenic to humans’ or whose carcinogenicity is ‘inadequate for evaluation’ the tolerable daily intake is calculated by dividing the lowest no observable adverse effect level for a biologically significant response by an uncertainty factor. Carcinogenic chemicals should ideally be absent in drinking water, but this is not always possible and therefore the guidelines set the MAC as close to zero as feasible. A full table of current numerical guidelines for chemical and physical parameters is listed in Appendix 1.
PART 2.0 – BACKGROUND

“For the last seven years, Canada has been ranked the No. 1 country in the world to live in by the United Nations, but if you isolate the conditions of Aboriginal peoples, we rank sixty-third.”
– Phil Fontaine, former National Chief of the Assembly of First Nations.

2.1 Significance of Water to First Nations People (Traditional Ecological Knowledge)

Water is essential for life. For most First Nations people water has a greater significance than simply for physical survival; it also contributes to their spiritual and cultural well-being. Many First Nations communities consider water the lifeblood of Mother Earth and view water as directly contributing to the health and well-being of their community (Mascarenhas, 2007).

The unique relationship between First Nations people and their environment is recognized through Traditional Ecological Knowledge (TEK). TEK identifies that humans depend on the environment for life and it incorporates indigenous systems of knowledge and historical cultural practices into adapting new social, economic, environmental, spiritual and political changes (Mascarenhas, 2007). TEK advocates for sustainability and conservation because this knowledge system values the complex and fragile interrelationships between humans and their environment (Chiefs of Ontario, 2007).

TEK vastly differs from Western science, which largely ignores human-nature relationships. For this reason, many First Nations people believe that TEK has unrightfully been excluded in legislation relating to First Nations and has been dismissed because it is not deemed scientific or technical. Despite the fact that TEK is considered sacred and vital information to First Nations people, its rejection by government and policy makers as legitimate is exacerbating the struggle of First Nations for recognition and participation in decision-making processes that affect the health and well-being of their communities (Mascarenhas, 2007).
2.2 The State of Water Quality in First Nations Communities

For years many First Nations communities have suffered from exposure to substandard drinking water quality, inadequate water treatment facilities and a lack of proper sanitation present on their reserves. In 2005, the Auditor General of Canada admitted that First Nations communities do not receive the same level of protection as the rest of the Canadian population with respect to drinking water quality (Auditor General of Canada, 2005).

As of February 29, 2012 there were 112 Canadian First Nations communities under a DWA, a rate that is 2.5 times higher than in the rest of Canada (Health Canada, 2012; Patrick, 2011). DWA’s are used to advise the public of confirmed or suspected drinking water contamination in order to protect public health. These advisories include Boil Water Advisories (BWA) that direct people to boil their tap water for any use or consumption and Do Not Drink Advisories that direct the public to use alternative sources of drinking water. Although intended to be temporary and precautionary, DWA’s are arguably being used as a provisional substitute for real action in many First Nations communities (Eggertson, 2008). The mean duration of DWA’s in First Nations communities is 343 days, with a quarter lasting for longer than one year (Health Canada, 2009). DWA’s in First Nations communities typically last longer than in non-First Nation areas and receive less media publicity (Mascarenhas, 2007). The major causes of DWA’s are unacceptable microbiological contamination, inadequate disinfection or disinfectant residuals, source water contamination and equipment malfunction during treatment or distribution (Health Canada, 2009).

According to the National Assessment of Water and Wastewater Systems in First Nations Communities 2003 report, many First Nations communities are at higher risk for health-related water issues than the rest of Canadian citizens because they lack effective treatment, delivery and sanitation infrastructure. In 2007, 65% of First Nations communities had some sort of a water system, 16% used trucked water, 15% had individual wells and 4% used community wells, as seen in Figure 1. When compared to the Canadian population, Aboriginal houses were 90-times more likely
to have no piped water supply and 5-times more likely to have no bathroom facilities (DIAND, 2011).


An INAC assessment on drinking water in First Nations communities revealed that, out of 740 community water systems assessed, 29% were high-risk and 46% were medium-risk for factors that could negatively impact water quality (DIAND, 2011). Approximately 30% of the water systems either occasionally or continuously surpassed the MAC set out by the CDWQG (DIAND, 2011). The six most common deficiencies in drinking water systems that the INAC study identified were: design and treatment technology, operation and maintenance, monitoring, operator status and training, operator equipment dysfunctions, and water source (DIAND, 2011).

Access to safe drinking water in First Nations communities poses many challenges. Remote and isolated reserves located in the Canadian Shield make water services expensive and these communities often lack the electricity, means of source water protection, and funding for proper treatment and distribution of safe drinking water. Furthermore, the accountability and technical standards of safe drinking water for First Nations people are unclear and this ambiguity is a cause of neglect and inaction. Unqualified operators of water treatment plants and rapid population growth that exceeds the capacity of a community’s water services are other frequent challenges. Also,
whereas urban Canadian cities typically use a multiple barrier approach to ensure microbial contaminants are effectively removed, this method is rarely used in rural Canada (Peterson, 2001).

### 2.3 Health Problems Associated with Contaminated Drinking Water

First Nations people have a unique susceptibility to adverse health affects from water pollution because of their strong dependence on natural resources, including water, for traditional, cultural and subsistence uses. As a consequence, First Nations communities often have a greater pollutant exposure from consumption, ingestion, contact and inhalation of environmental contaminants than other Canadian populations (Mascarenhas, 2007). The number of waterborne infections and diseases in First Nations communities is a distressing 26-times greater than in the rest of Canada, and their life expectancy is on average 5-7 years shorter (Patrick, 2010).

The long-term impact of DWAs, including their economic and health consequences, is still unclear. However, several studies have found many adverse health outcomes associated with prolonged DWAs. Patrick (2010) found that one outcome was the public accepting unsafe water as ‘the norm’ and they routinely ingested it or, in other cases, the public became so skeptical of the tap water they became dependent on bottled water, which is very expensive. Even worse, after long periods of unsafe drinking water many First Nations people stopped drinking water altogether and started consuming unhealthy amounts of sugary cola-based drinks contributing to poor health and obesity.

There are several factors that influence the risk of developing an illness or disease from waterborne pathogens including the specific contaminant, the concentration of the contaminant, the route of exposure to the contaminant (oral, dermal, inhalation etc) and individualized susceptibility. Highly susceptible populations include fetuses, infants, elderly, pregnant women and people with pre-existing health problems. Infants can have 1-2 times increased health risks from an infection or disease than other age categories (Peterson, 2001). Rural Canada has a 40% higher infant mortality
rate than the rest of Canada, and there is a possibility of an association between higher infant mortality and poor rural water quality (Peterson, 2001).

The four major groups of water contaminants are listed below. Appendix 2 contains charts of the major waterborne contaminants, their EPA standard levels, and potential chronic health effects.

1. Microbial Pathogens

Microbial pathogens include bacteria, viruses and parasites. They are able to enter drinking water from sewage and animal wastes when surface water is exposed or when wells are incorrectly sealed and/or constructed. Waterborne bacteria can be primary pathogens or opportunistic, and can cause disease by growing and/or releasing toxins in the human body. Waterborne viruses can be divided into two main categories: viruses with low infectivity but severe health effects; for example, echovirus, and viruses with high infectivity but mild health effects; for example, rotavirus (Peterson, 2001). These disease-causing microorganisms commonly cause multiple gastrointestinal symptoms and may cause more severe disease depending the status of the host and/or the virulence factors of the infective organism (Peterson, 2001).

2. Organics

Relatively few organic compounds are monitored by drinking water standards and they include trihalomethanes (THMs), pesticides and volatile organic compounds (VOCs). Organic compounds cause chronic health conditions if routinely ingested, including cancer, central nervous system disorders, liver and kidney damage, reproductive disorders and birth defects (Stewart et al., 1989).

3. Inorganics

Inorganic contaminants include toxic metals that enter water from both natural and industrial sources. Toxic metals such as arsenic, barium, chromium, lead, mercury and silver are
monitored by drinking water guidelines and have the potential to cause acute poisoning, cancer and other varied health effects (Stewart et al., 1989).

4. Radioactive Elements

Radionucleotides can enter water supplies from natural or human processes. The health effects associated with radioactive elements are diverse and include cancer, loss of tissue or organ function, and changes to sensitive biological structures (Stewart et al., 1989).

2.4 Access to Healthcare for First Nations people

Although Canada has a world-renowned healthcare system, access to primary care and resources is unattainable for many First Nations people. This inaccessibility stems from geographic isolation, economic and cultural barriers, and governmental disputes over First Nations healthcare policies, as shown in Figure 2.

<table>
<thead>
<tr>
<th>Barriers related to First Nations-specific needs</th>
<th>Overall (%)</th>
<th>Male (%)</th>
<th>Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chose not to see health professional</td>
<td>12.3</td>
<td>12.8</td>
<td>11.7</td>
</tr>
<tr>
<td>Felt service was not culturally appropriate</td>
<td>15.4</td>
<td>15.4</td>
<td>15.4</td>
</tr>
<tr>
<td>Felt health care provided was inadequate</td>
<td>19.8</td>
<td>18.7</td>
<td>21.4</td>
</tr>
<tr>
<td>Difficulty getting traditional care</td>
<td>13.1</td>
<td>10.7</td>
<td>15.5*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Barriers related to geography and availability of services</th>
<th>Overall (%)</th>
<th>Male (%)</th>
<th>Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health facility not available</td>
<td>11.4</td>
<td>10.2</td>
<td>12.5</td>
</tr>
<tr>
<td>Service was not available in my area</td>
<td>16.1</td>
<td>15.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Doctor or nurse not available in my area</td>
<td>22.6</td>
<td>21.3</td>
<td>23.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economic Barriers</th>
<th>Overall (%)</th>
<th>Male (%)</th>
<th>Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could not afford childcare costs</td>
<td>6.2</td>
<td>5.2</td>
<td>7.3*</td>
</tr>
<tr>
<td>Could not afford direct cost of care, service</td>
<td>16.6</td>
<td>14.8</td>
<td>18.5*</td>
</tr>
<tr>
<td>Could not afford transportation costs</td>
<td>16.6</td>
<td>15.8</td>
<td>17.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systemic Barriers</th>
<th>Overall (%)</th>
<th>Male (%)</th>
<th>Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unable to arrange transportation</td>
<td>17.6</td>
<td>16.4</td>
<td>19.0</td>
</tr>
<tr>
<td>Approval for services under NIHB was denied</td>
<td>15.5</td>
<td>13.2</td>
<td>17.8*</td>
</tr>
<tr>
<td>Not covered by NIHB</td>
<td>20.6</td>
<td>17.0</td>
<td>24.1*</td>
</tr>
<tr>
<td>Waiting list too long</td>
<td>37.6</td>
<td>35.3</td>
<td>42.0*</td>
</tr>
</tbody>
</table>

**Figure 2:** Barriers to First Nations Healthcare Access. Source: The First Nations Information Governance Centre, 2011
In a National Aboriginal Health Organization survey, 35.9% of First Nations people stated that they have less access to healthcare services and providers than other Canadian citizens (Health Council of Canada, 2005). Furthermore, only 43% of First Nations citizens had contact with a general practitioner in the previous year, as compared to 75% of urban and 71% of rural Canadian citizens (Health Council of Canada, 2005). As a result, the health status of First Nations people is significantly lower than other Canadian citizens (Health Council of Canada, 2005).

With respect to waterborne illness, physicians and other healthcare providers play a crucial role in early recognition of illness and disease from water contamination. While many waterborne illnesses resolve on their own, others require medical attention and delayed healthcare access can exacerbate the problem (Copes, 2006). Increasing access to healthcare for people living in remote First Nations communities is important in both raising awareness about waterborne illnesses and providing effective and appropriate treatment.

PART 3.0 – CURRENT WATER QUALITY TREATMENT FRAMEWORK

“In First Nations communities south of 60 degrees parallel the responsibility for clean drinking water is shared between First Nations communities and the Government of Canada.”
– Health Canada, 2011

3.1 Role of the Federal Government

Section 91(24) of the Canadian Constitution Act, 1867, gives the Federal Government power to make and enforce laws concerning ‘Indians, and lands reserved for Indians’ (Swain et al., 2006). The federal government has three departments that look over First Nations water quality and issues: The Department of Indian Affairs and Northern Development (DIAND), Health Canada, and Environment Canada. DIAND provides funding resources, partially through the Indian and Northern Affairs Canada (INAC), for water services including construction, operating and maintenance costs
Health Canada is responsible for water quality testing either directly or through supervision, and Environment Canada plays a role in things like source water protection (Simeone, 2010).

### 3.2 The First Nations Water Management Strategy

The First Nations Water Management Strategy (FNWMS) was developed by INAC and Health Canada in 2003. The FNWMS is a multi-barrier approach to reducing the risk of contaminated drinking water in First Nations communities. It includes three core elements: (1) source water protection, (2) drinking water treatment and (3) drinking water distribution systems (Best, 2010). In 2003, the Federal Government allocated $600 million over 5 years to implement and deliver the elements of this drinking water program, and an additional $330 million over 2 years was given in 2008 and again in 2010 (Best, 2010).

According to Health Canada (2010a), the FNWMS has found four major challenges in providing adequate water for First Nations communities and is working towards fixing them. The first challenge includes monitoring drinking water quality using the official CDWQG. Long-term drinking water advisories and the perception of water quality and safety also continue to be challenges in First Nations communities. Lastly, a stronger regulatory framework between the Federal government and First Nations communities regarding drinking water supply and wastewater needs to be developed and implemented.

Some specific actions that INAC has taken through the FNWMS are: developing some protocols for ensuring clean water in First Nations communities, raising public awareness through workshops, publications and information sessions, helping fund the operation and maintenance components of water treatment plants, creating Regional Water Teams to oversee water and wastewater remedial action plans, and forming the Circuit Rider Training program to provide on-site operator training (DIAND, 2011). Despite ample funding and good ideas, the FNWMS has had little success at actually improving the drinking water quality across First Nations communities in Canada.
3.3 Role of First Nations Communities and Band Councils

Chiefs and their councils are responsible to contribute approximately 20% of the costs related to design, construction, operation and maintenance of their water systems (Simeone, 2010). Furthermore, they are responsible for actually issuing a DWA in their community after being recommended to do so by an Environmental Health Officer.

Section 81 of the Indian Act states that Band Councils have the authority to make by-laws concerning water supplies on their reserve and ensuring that their water and wastewater treatment facilities are in accordance with Federal standards (Swain et al., 2006). However, because the water and wastewater facilities in First Nations communities are primarily funded through DIAND and the FNWMS, there is typically little flexibility for Band Councils to vary the conditions of the programs being implemented to better fit their local needs and concerns. As a result, First Nations governments often struggle to attain the autonomy and power needed to take action in their communities.

3.4 Problems with Current Regulation Framework

The current regulatory framework has been criticized for being ambiguous with respect to who is responsible for the provision of safe drinking water to First Nations communities and what the role of each department/council is. Although there are Federal guidelines for Canadian Drinking Water Quality, they have no binding legislative power for First Nations communities who are excluded from important elements found in Provincial regulatory schemes (Auditor General of Canada, 2005). Currently, there is no First Nations specific legislation set forth by the Federal government regarding water quality and, as a result, they do not benefit from the same quality of water monitoring as communities who are under Provincial regulatory regimes (Swain et al., 2006). For example, INAC has no comprehensive standards for the construction, operation and maintenance of water systems in First Nations communities resulting in preventable operator safety risks, suboptimal treatment regimens and an inability to produce water of acceptable quantity or quality (Auditor General of Canada, 2005). Additionally, there is a big issue of inadequate funding and
support. Funding shortfalls are a major challenge for providing safe drinking water to First Nations communities. Currently, INAC uses an inconsistent and outdated formula to fund operation and maintenance fees for water systems. They only contribute 80% of their estimated costs, which are often underestimates, and the remaining 20% is expected to come from user fees or other sources within the community (Simeone, 2010). As a result, many water and wastewater systems are severely underfunded leading to insufficient resources being used to run and update these facilities.

The Expert Panel on Safe Drinking Water in First Nations report nicely summarizes these broad framework problems:

“The current situation can be described as consisting of a number of parties whose roles and responsibilities are bound by government policies and contribution agreements. These arrangements are neither comprehensive nor easily deciphered; most critically, there are numerous gaps and a lack of uniform standards, as well as enforcement and accountability mechanisms” (Swain et al., 2006).

PART 4.0 – SPECIFIC CASE STUDIES

4.1 Kashechewan First Nations, Ontario

“We were aware of this crisis for some years now, and I thought we had a commitment from government to deal with the crisis, now we are in an emergency situation.”

– Chief Phil Fontaine, Kashechewan First Nations, 2005

4.1.1 Background

Kashechewan is a Cree First Nations community that is located on reserve 67 in the Kenora district of Ontario. Originally, the community was located near the Hudson’s Bay Company post on Albany Island, but due to religious conflict and flooding issues the Anglican band members relocated to the present location of Kashechewan in 1957 (Wakenagun Community Futures Development Corporation, 1999). The 140-square mile reserve is located 10 kilometers upstream of James Bay and is across from Fort Albany on the north side of the Albany River, as seen in Figure 3. Although the Kashechewan residents strongly wanted to build their community on an elevated area that was a
traditional meeting place with spiritual and cultural significance, INAC ignored their request and built the community on the Albany River flood plane (Parliament of Canada, 2005). Seasonal water level fluctuations of 1-2 meters cause recurrent flooding of the community in the springtime. Despite the fact that a long 10-foot high clay and gravel dyke was built around the community in 1997, flooding continues (Wakenagun Community Futures Development Corporation, 1999).

Kashechewan community members have faced an enduring struggle for access to basic human rights, including safe drinking water, healthcare services and adequate housing. In 1999, only 60% of Kashechewan houses were connected to the water and sewage systems and there was a startling 87% unemployment rate in the community (Wakenagun Community Futures Development Corporation, 1999).

![Figure 3: The location of Kashechewan First Nations community and the area surrounding Kashechewan, including the water treatment plant, sewage lagoon and Red Willow Creek. Source: Swain et al., 2006.](image)

4.1.2 Water Quality

*Water Treatment Plant*

Kashechewan First Nations community built a new Water Treatment Plant (WTP) at the west end of the reserve in 1995, shown in Figure 3 above, and it is the primary source of drinking water in the community. Although Kashechewan has a population estimated at 1,900 people, for budgetary concerns INAC has the community listed at 1,100 people (Gosine and Teelucksingh, 2008). Thus,
many people believe the new WTP was built too small to accommodate the growing and larger-than-reported community size, leading to water quantity and quality concerns.

According to the Ontario Ministry of the Environment (2005), the WTP draws its water from the Red Willow Creek, and it initially flows through a coarse screen and then enters a low lift well located in the intake facility. Red Willow Creek contains very low quality drinking water that is essentially classified as swamp water. The water has naturally very high turbidity levels making effective chlorination and treatment of the water challenging. The water then gets pumped from the intake facility into the treatment facility that uses chemically-assisted filtration and chlorine disinfection before being stored in a clearwell. From here, the water is pumped into the distribution system.

**The Crisis**

On October 14, 2005 Kashechewan received a fax from Health Canada stating that their drinking water contained dangerous *E. coli* bacteria (CBC, 2005). For two years prior to this crisis Kashechewan had been on a sustained boil water advisory, and before 2005 they had been on-and-off boil water advisory’s for more than 7 years (Murdocca, 2010).

Despite being a relatively new water treatment facility, the *Technical Report on the Drinking Water System at Kashechewan* compiled after the crisis found many flaws in the design and use of the WTP. These problems include, but are not limited to, a lack of a detailed documented procedure for the disinfection processes, the absence of regular calibration of instruments, the presence of an insecure bypass that allowed for potential mixing of treated and untreated water and having untrained or unqualified operators running the plant (Ontario Ministry of the Environment, 2005). These design and process flaws were well known and documented by Health Canada, yet no action was taken to rectify them.

The sewage treatment plant also suffered from a faulty design and the community’s sewage was likely the source of *E. coli* contamination in Kashechewan’s drinking water. During the 2005
crisis, two-thirds of the sewage lift stations were broken which lowered the sewage collection system storage capacity (Ontario Ministry of the Environment, 2005). This lead to sewage overflowing into the Red Willow Creek at a site less than 140 meters upstream from the WTP intake site. Additionally, fluctuating tides and torrential rainfall pose a threat to water contamination because the sewage overflow sewer is located very close to the Albany River. Furthermore, beaver dams repeatedly clog the sewage lagoon, leading to overflows into the Red Willow Creek. In 2001, INAC acknowledged the issue of sewage overflow in Kashechewan, yet did not take action to fix the problem (Gosine and Teelucksingh, 2008). During the crisis, it was also found that the WTP had a plugged chlorine injector and, consequently, was unable to disinfect the contaminated water (Ontario Ministry of the Environment, 2005). Combined, these factors played a major role in the distribution of unsafe water to Kashechewan residents over a long period of time, culminating in the 2005 crisis.

Seven days after the water tested positive for dangerous *E. coli* bacteria the Indian Affairs Minister, Mr. Ian Scott, announced the federal government would not evacuate the community, but instead they would increase the quantity of bottled water shipped to the community to 1,500 18-L bottles per day (Gosine and Teelucksingh, 2008). Kashechewan gained widespread media attention on October 23, 2005 as the problem remained at a standstill while the provincial and federal governments disputed their responsibilities (CBC, 2005). The provincial government claimed that First Nations affairs are the responsibility of the federal government, and the federal government retaliated by saying the provincial government was responsible for water safety and public health in their province. During this time Dr. Murray Trusler travelled to Kashechewan and documented written and photo evidence of the widespread health crisis occurring. Dr. Trusler subsequently shared his experience and findings with Ontario Premier Dalton McGuinty, whom, on October 25, 2005 declared a ‘state of emergency’ and announced that the sickest people in Kashechewan would be evacuated (CBC, 2005). This turned out to be over 1,000 of Kashechewan’s 1,900 residents, a
proportion greater than 50% of the population (Murdocca, 2010). Almost all residents suffered some adverse health effects.

**Action Following the Crisis**

After the outbreak, there was discussion regarding the relocation of the Kashechewan community. One potential option was to relocate the Kashechewan community to just outside of Timmins. This would help alleviate reoccurring flooding that is devastating the community’s housing infrastructure and contributing to many health issues in the community. This would also move the community much closer to a hospital and improve access to healthcare services, if needed. A second option was to relocate the community to higher-grounds within the current reserve area to avoid the threat for flooding to damage infrastructure and create unhygienic living conditions. In 2007, the community was strongly in favor of this second relocation option, but Jim Prentice, Minister of Indian Affairs, said that this relocation would cost $500 million dollars and be too costly compared to spending $200 million to fix the current infrastructure (CBC, 2007). As a result, current funds are going into building and repairing houses located on the Albany River flood plane, which will inevitably be damaged from flooding events sometime in the near future.

**4.1.3 Health Problems**

Kashechewan has a long history of rampant health problems associated with the community’s impoverished, unhygienic and cramped living conditions. In 2005, the ingestion of contaminated drinking water served to exacerbate many preexisting health conditions, and also contributed to the development of many new and severe health problems in the community.

Following the detection of *E. coli* in the tap water, technicians from Northern Water Works were sent to Kashechewan to quickly fix the problem. They increased the chlorine to five times the normal level which led to “shock” levels of chlorine that aggravated dry skin conditions and endemic levels of eczema present in the community (Dhillon and Young, 2010). This led to excessive itching and scratching, skin burns and lesions that turned into secondary infections including impetigo and
scabies. The infections quickly spread due to unsanitary, cramped housing. It is estimated that two-thirds of Kashechewan residents required healthcare treatment following the *E. coli* outbreak and its associated effects including gastroenteritis, ulcers, stomatitis, impetigo and scabies (Murdocca, 2010).

Gastroenteritis is an infection of the gut that results from water contaminated with bacteria or other microbes, especially in areas of poor sanitation. Its symptoms range from mild to severe and include diarrhea, vomiting, abdominal pain and dehydration (Public Health Agency of Canada, 2010). Impetigo is a bacterial skin disease that causes pustules and blisters (Public Health Agency of Canada, 2010). Scabies is caused by mites and has the potential to quickly spread in crowded conditions, like those present in Kashechewan, and can be very difficult to control and eliminate because mites are so small.

The major health concern in Kashechewan was the presence of *E. coli*, a gram-negative bacteria. Waterborne strains originate from fecal contamination of water and are capable of causing diarrhea, intestinal and urinary tract infections, hemolytic uraemic syndrome and haemorrhagic colitis (Percival *et al.*, 2004). The bacteria can be fatal to children, elderly and immuno-compromised people and has an infectious dose of less than 100 organisms (Percival *et al.*, 2004).

Exacerbating the health problems in Kashechewan is the fact that the reserve is located in such a remote location and residents have limited access to healthcare services. Kashechewan has a health centre with nurses always on-call and various weekly clinics. However, physicians infrequently visit the community, and anybody seeking serious medical attention must travel to a hospital in Timmins, which is 400 kilometers away (Wakenagun Community Futures Development Corporation, 1999).
4.1.4 Recommendations

The Technical Report on the Drinking Water System at Kashechewan First Nation outlines several recommendations for the physical works and treatment processes in Kashechewan as well as the water treatment plant operation and management practices.

**Physical Works and Treatment Processes**

In order to ensure safe and clean drinking water in Kashechewan many changes to the water treatment plant and sewage facility must be made. The biggest priority is to ensure that the system is able to constantly meet the CDWQG standards for all contaminants and meet treated water disinfection standards. This will require upgrading the WTP chemical storage and metering system, continuously monitoring water quality and relocating the water intake pipes to prevent some of the source water contamination (Ontario Ministry of the Environment, 2005). Furthermore, eliminating the potential for cross-contamination of disinfected and raw water within the WTP is essential to ensuring safe drinking water in Kashechewan.

**Management Practices**

Proper operation, upkeep and management of the WTP are also necessary to ensure continued clean water for Kashechewan residents. Suggestions in this area include making comprehensive operations manuals, keeping up-to-date logbooks of water quality, and mandatory/comprehensive operator certification to at least a class II operator level (Ontario Ministry of the Environment, 2005).

Access to healthcare is another serious problem in Kashechewan and needs to be addressed. The Weeneebayko Area Health Authority was created in December 2007 to help increase the delivery of healthcare services to the five First Nations communities in the James Bay area, including Kashechewan. This group is working to integrate services including primary care, nursing, mental health, home and community care, and long-term care as well as to coordinate policies for a single medical records system that would facilitate easier access to healthcare services (Health Canada,
Expansion and continuation of this program as well as increased funding from the Federal and Provincial governments are crucial in its success and ability to improve the health and well-being of Kashechewan residents.

4.1.5 Information Available (sources, quality, gaps)

Following the Kashechewan crisis the Ontario government commissioned the *Technical Report of the Drinking Water System at the Kashechewan First Nation community*. It reported that following analytical tests, water samples collected on October 29 and 30, 2005 in Kashechewan met all provincial water quality standards (Ontario Ministry of the Environment, 2005). Many people are skeptical of these findings and question whether political interests may have influenced the reported results (Timoney, 2007). Thus, the quality and validity of some of the information released following the Kashechewan crisis is questionable, and it may be useful to have an independently funded report commissioned to look at the past and present drinking water quality in Kashechewan and specific disease incidence rates. Additionally, little information is available on the long term health effects Kashechewan residents are experiencing as a result of chronic exposure to poor water quality.

Furthermore, the Victor Diamond Mine is another potential source threatening the water quality in Kashechewan that has been inadequately studied. In 2005, following an environmental assessment conducted by the federal and provincial government, the Victor Diamond Mining Project gained approval for construction in the James Bay lowlands, approximately 140 kilometers away from the Kashechewan reserve (Murdocca, 2010). The open pit mine is the first diamond mine in Ontario and is expected to run for at least 20 years. Currently, the Kashechewan community is conducting an independent survey, funded by the Ontario government, on the environmental and health impacts of the mine on the First Nations community (Murdocca, 2010). It is currently unknown if the mine is contributing to water contamination in Kashechewan or any adverse health effects.
4.2 Yellow Quill First Nations, Saskatchewan

“Yellow Quill had some of the worst raw water in the world… the media came out and basically got involved to say that our water was worse than what they had in Walkerton…”
– Chief Whitehead, Yellow Quill First Nations

4.2.1 Background

Yellow Quill First Nations community is located in northeastern Saskatchewan and has a population of approximately 2,500 people, with 1,000 living on-reserve (Harden and Levalliant, 2008). It is located in the boreal transition eco-region in the Rose Valley area, which is roughly 200 kilometers east of Saskatoon, as seen in Figure 4. Yellow Quill is a unique case, and an interesting community to study because they currently do have access to clean drinking water and thus represent a water transformation success story.

Figure 4: Location of Yellow Quill First Nations. Source: http://www.sitesatlas.com/Maps/Maps/cansk1.gif

4.2.2 Water Quality

The difference in water quality between Yellow Quill First Nations and Saskatoon is remarkable, and highlights the disproportionate access to resources, technology and basic human
rights that remote First Nations communities face as compared to larger, urban centers. Before 2004, the WTP in Yellow Quill was severely outdated, especially when compared to the sophisticated technology being used in Saskatoon. Furthermore, Yellow Quill only had one operator working at any given time, whereas Saskatoon had a team of engineers, technical staff and operators at their water treatment plant (Peterson, 2001). Another discrepancy between these two communities was the source water. Saskatoon received high quality raw water from the Rocky Mountains and Yellow Quill received their water from Pipestone Creek (Harden and Levalliant, 2008). According to Peterson (2001), this water source posed three significant problems: first, an upstream town called Kelvington emptied their sewage lagoon into the Pipestone Creek contaminating the water with pollutants and toxins. Second, the river only flowed for 5-15 days every spring, leading to drastic water shortages. Third, the water contained sewage, high particle levels, high dissolved solids, viruses, bacteria and parasites, most notably including Cryptosporidium and Giardia lamblia.

The raw water from Pipestone Creek had a very high dissolved organic carbon (DOC) level of 15mg/L, and the DOC was only slightly reduced during the chemically assisted filtration water treatment (Peterson, 2001). Adequate chlorination of water with such high DOC levels is not possible without exceeding the trihalomethane guidelines of 100µg/L; Yellow Quill’s water rarely exceeded the trihalomethane guideline level indicating that the water chlorination process was likely insufficient (Peterson, 2001). Yellow Quill’s WTP used an up-flow clarifier and then a mixed media filter; however, because the raw water quality was so poor, the treatment system was often unsuccessful at removing contaminants (Peterson, 2001). For example, in the 2-5µm and 5-10µm particle size fractions, Yellow Quill had one thousand times more particles than Saskatoon, as seen in Figure 5 (Peterson, 2001). These fractions consisted of dissolved solids and pathogenic parasites such as Cryptosporidium and Giardia lamblia. Shockingly, the treated water was of worse quality that the raw water in several particle size fractions because of unsanitary and old distribution lines.
(Peterson, 2001). Although aggressive cleaning of the distribution system and some modifications to the WTP improved the situation slightly, before 2004 Yellow Quill was still receiving unsafe water.

![Figure 5: Particle size distribution comparing Saskatoon City water and water at Yellow Quill First Nations. Source: Peterson, 2001.](image)

In 1995 the water contamination situation in Yellow Quill came to a head and the community was put on a boil-water advisory that lasted 9 years, until 2004. The water treatment plant was cited as having a noxious odour and residents didn’t even turn on their water taps because of the rotten sewage-like stench of the water (Peterson, 2001). For 5 of these years, the Yellow Quill community did not even receive bottled water from the federal government as a short-term solution (Harden and Levalliant, 2008).

In 1999 the Safe Drinking Water Foundation (SDWF) became involved after assessing the water treatment facility and determining that it did not have the capacity to properly treat the poor-quality raw water. The SDWF, the Yellow Quill community and the media all drew attention to the dire need for action to ensure safe drinking water in Yellow Quill. They claimed that the water would
not meet the CDWQG unless a new WTP was built and they argued that the government’s band-aid solutions were ineffective (Couture, 2008). Even though the drinking water situation in Yellow Quill was unacceptable, it still took many years to secure INAC’s funding and support for action.

4.2.3 Health Problems

The raw water flowing into the Yellow Quill Water Treatment Centre had high levels of iron, manganese, arsenic, DOC (excess of 15 mg/L), ammonium and total dissolved solids (1000-fold increase in particles than Saskatoon water) potentially containing Cryptosporidium and Giardia lamblia (Peterson, 2001). In many of these areas, the quality of the treated water was equivalent to the raw water. All of these contaminants had the ability to threaten the health and well-being of the Yellow Quill residents.

Chlorine is used as a disinfectant to reduce the level of DOC in water sources; however, this process also produces a group of compounds called trihalomethanes. Common trihalomethanes include chloroform, bromodichloromethane, dibromochloromethane and bromoform. The MAC for trihalomethanes is 100µg/L because they have both carcinogenic and teratogenic properties, and chronic exposure can result in CNS, liver, heart and kidney damage (Health Canada, 2009). Health Canada claims that the health benefits of chlorination, in terms of inactivation of microorganisms, exceed the health risks posed by trihalomethanes. Nonetheless, having chronically elevated levels of trihalomethanes in drinking water, like in Yellow Quill, is far from optimal.

Cryptosporidiosis is caused by the enteric protozoan Cryptosporidium spp. and causes a gastrointestinal infection with similar symptoms to gastroenteritis (Percival et al., 2004). Cryptosporidium is difficult to inactivate and can cause serious health problems, including death, particularly in the immuno-compromised. Under the CDWQG, there are no clear standards for the MAC of Cryptosporidium and reliable detection of the parasite is very difficult (Peterson, 2001). Giardiasis, also known as Beaver Fever, is caused by the protozoan parasite Giardia lamblia. Giardia is 5-10µm in diameter and is normally found in surface water basins, creeks and lakes
Exposure results in gastroenteritis and is the most common waterborne disease agent in North America (Percival et al., 2004). Again, the CDWQG does not set clear standards for the MAC of *Giardia* and detection is difficult.

### 4.2.4 Recommendations

Yellow Quill is an excellent example of how scientific and engineering solutions can help improve drinking water quality in remote First Nations communities. In 2004, Yellow Quill received a new $6.5 million water biofiltration system designed by Hans Peterson of the SDWF (Peterson et al., 2006). The new plant uses biological filtration to remove minerals by utilizing microbial growth on filter media. After this biological treatment system the water goes through an integrated final membrane processing stage that uses reverse osmosis (Peterson et al., 2006). The WTP was built with a capacity to meet the upcoming needs of the community, as to avoid future drinking water problems. Also, the water is now taken from an underground well and not from Pipestone Creek. This new water source helps to alleviate fluctuations in water levels, concentrations of dissolved solids and other variable factors such as upstream sewage dumping.

The source water change combined with the new water treatment facility has been successful in reducing and/or removing the chemical contaminants, microbes and total dissolved solids from the drinking water (Peterson et al., 2006). Additionally, the water is now biologically stable making the distribution system clean, even with minimal inputs of chlorine. Yellow Quill has also hired qualified staff to operate and monitor the WTP and drinking water quality. Before, Yellow Quill only had one treatment plant operator; today, they have several qualified operators that were trained using the Circuit Rider program launched by INAC (Peterson, 2001).

Importantly, one of the main reasons that the Yellow Quill First Nations community was able to secure INAC’s support and receive a new state-of-the-art water treatment facility was due to media attention. Following the cases of Walkerton in May 2000 and North Battleford in April 2001, the media was paying a lot of attention to water contamination and ensuing health issues. The media
starting highlighting that the water quality in both Walkerton and North Battleford were better than the conditions in Yellow Quill, which helped spark federal government action and funding. Yellow Quill is a success story of a community going from some of the worst water quality in Canada to some of the best. The effective collaboration between the community, engineers and INAC is partially responsible for the success of this project and will serve as an example of how other First Nations communities can attain safe drinking water.

4.2.5 Information Available (sources, quality, gaps)

One information gap with respect to Yellow Quill is that there is no data readily accessible about the prevalence of different diseases and illnesses that residents faced while they endured a 9-year drinking water advisory. Although information is available about the types of waterborne contaminants and diseases/illnesses they caused, there is no information on what proportion of the population was affected and how these incidence rates compare to the greater Canadian population.

Additionally, little to no information is currently available on the present water quality in Yellow Quill. After receiving their new WTP in 2004, articles were released with captions like ‘Clean Water Flowing from Yellow Quill Taps’, but no follow up information has been published on the current conditions. Have local operators been able to successfully manage and run the high-tech reverse-osmosis water treatment plant?

4.3 Fort Chipewyan First Nations, Alberta

“I think our main killer here is our water. That’s what I’ve been trying to tell these reporters... It’s too much chemicals in our water, too much garbage in our water...The air and the water are very important, without that, we’re not going to exist.”

– Big Ray Ladouceur, Fort Chipewyan Resident

4.3.1 Background

The Fort Chipewyan First Nations reserve is located on the southwest end of Lake Athabasca near the intersection of the Peace and Athabasca Rivers, as shown in Figure 6. It is 200 kilometers from Fort McMurray, a core of the Albertan tar sands. Fort Chipewyan has a population of
approximately 1,200 people and draws its drinking water from the Athabasca River (Harden and Levalliant, 2008).

Figure 6: Location of Fort Chipewyan and potential sites of water contamination including abandoned uranium mines and the Athabasca oil sands. Source: Alberta Cancer Board, 2009.

Upstream of Fort Chipewyan, natural resource extraction activities including the oil sands, coal, gold and uranium mining, and large-scale forestry operations, all threaten the source water quality. These industrial developments are known to release pollutants, including wastewater from tailings ponds, pulp and paper effluents and uranium mining byproducts into the Peace and Athabasca Rivers raising health concerns amongst Fort Chipewyan residents (Timoney and Lee, 2009). Despite the fact that natural background levels of some contaminants in the Athabasca River are high enough to cause adverse health outcomes, little has been done to improve water quality. One alleged reason for this inaction is because the agency responsible for public and environmental health
in Fort Chipewyan is the Alberta Government, which has a vested interest in the economic prosperity and development of the oil sands and the natural resource sector (Timoney, 2007).

Historically, there have been many incidents of major oil sands companies leaking toxic tailings waste or oil into the Athabasca River, either by accident or negligence. One example was a Suncor pipeline break on June 6, 1970 that released 3 million litres of oil directly into the Athabasca River towards Lake Athabasca (Timoney and Lee, 2009). The oil slick travelled 240 kilometers to Fort Chipewyan with no effort made by the company or government to stop the downstream flow. No environmental or human health impact studies were ever conducted after the spill. More recently in September 2007, human error at Suncor led to 9.8 million liters of wastewater being released into the Athabasca River creating a sheen on the river (Timoney and Lee, 2009). Again, the chemical composition of the wastewater, and the environmental and health impact of the event have not been reported. It is very difficult to try to obtain information about these leaks and their impacts because of low information transparency, and it is presumed that many additional spills have remained hidden from public knowledge.

4.3.2 Water Quality

The raw water drawn from the Athabasca River has unacceptably high levels of many types of contaminants that pose a broad range of health threats. The chemical constituents found in the water include metals (arsenic, mercury, lead), oil sands pollutants (phenols, dioxins, hydrocarbons) and microbiological contaminants (coliform bacteria).

Arsenic, mercury and lead are toxic heavy metals that, compared to regional levels, were found to be higher and rising near Fort Chipewyan. In 2007, the arsenic levels were 2.6 microgram/liter, which is significantly higher than the CDWQG recommendation of 0.01 microgram/liter (Timoney and Lee, 2009). Arsenic is a known carcinogen associated with bile duct, liver and urinary diseases and prolonged ingestion of water contaminated with arsenic is linked with diarrhea, type II diabetes, and gastrointestinal disorders (Singleton-Polster, 2010).
Health and Wellness estimated that lifelong exposure to the levels of arsenic present in the Athabasca River could cause 17-33 more cancer cases in every 100,000 people; this level is higher than the ‘acceptable’ rate of additional cancers proposed by Alberta Health and Wellness of 1 case in 100,000 people (Timoney, 2007). Mercury levels at the water intake site were 0.00161 microgram/liter (Timoney, 2007). Mercury is a toxic metal that can cause serious neurological and central nervous system disorders that vary depending on the metal speciation and exposure route. People with impaired kidney functioning, from contaminants like lead, are at higher risk for mercury toxicities. Lead is a heavy metal that is known to cause brain and blood disorders, but it has the potential to affect every organ in the body, in particular the kidneys (Singleton-Polster, 2010).

Toxic pollutants that can leak from oil sands activities into the water include phenols, dioxins and hydrocarbons. Phenol, or phenic acid, is a toxic organic compound that can cause central nervous system impairment, liver and kidney damage, and skin or eye irritation (Singleton-Polster, 2010). Dioxins are a group of chemicals that are classified as persistent organic pollutants because of their stability in both the environment and the body. Exposure to dioxins can lead to reproductive and developmental problems, liver damage, immune system damage, hormonal interference and cancers including non-Hodgkin’s lymphoma and rare soft tissue sarcomas (Singleton-Polster, 2010).

Polycyclic Aromatic Hydrocarbons (PAHs) are a group of organic compounds that are generally found in mixtures. PAHs are generated in the oil production process and therefore the Athabasca oil sands site is likely the source of elevated PAHs in Fort Chipewyan. Levels of PAHs in the raw drinking water intake ranged from 0.016-0.034 microgram/liter, which exceeds the human health guideline of 0.0029 microgram/liter (Timoney, 2007). Twenty-six out of twenty-eight PAHs studied from the tar sands increased in concentration as they moved downstream of the oil sands towards Fort Chipewyan (Timoney and Lee, 2009). PAHs are associated with reproductive and birth defects, damage to the immune system and many are known or expected carcinogens (Singleton-Polster, 2010). Furthermore, there appears to be a synergistic relationship between PAHs and arsenic
whereby co-exposure to both contaminants can increase genotoxicity rates to 8-18 times higher than normal (Timoney and Lee, 2009).

In addition to chemical contamination in the water, there is also concern regarding pathogenic microorganisms. In one study, total coliforms were detected at 4-20 colonies/100mL in three water samples; however, coliforms were successfully removed during the water treatment process at Fort Chipewyan and not detected in the tap water (Timoney, 2007). Of concern, however, is an upward trend in the number of total coliform counts during the 12-year period of the Nunee Health Board Society study (Timoney, 2007). The Fort Chipewyan sewage disposal and/or sewage treatment plant are two potential sources for this coliform contamination. The drinking water intake site is normally upstream of the sewage release site, but occasionally the Peace River water levels rise and exceed those at Lake Athabasca. When this happens, a flow reversal occurs in the Peace River and municipal sewage has the potential to contaminate domestic raw water at Fort Chipewyan. Additionally, it is thought that the Fort Chipewyan sewage treatment plant is under-capacity for the community size, which could result in leaks into the source water or groundwater.

4.3.3 Health Problems

Fort Chipewyan First Nations community has many reasons to be concerned over environmental and human health threats due to their close proximity to extensive industrial and natural resource sector activity. Potential sources of pollution in the region range from the massive oil sands development, pulp mills, coal, gold and uranium mines and other industrial sources. Environmental contamination of water, air and soil from these anthropogenic sources are contributing to adverse health outcomes in humans and wildlife. Because First Nations people have a holistic view of health, development and destruction of natural ecosystems and native culture also has a deleterious impact on their health and well-being.

Fort Chipewyan residents have vocalized concerns over their health due to contaminated drinking water for numerous years. Many community members and health officials postulate that the
abnormal rates of cancer, kidney failure and other illnesses are the consequence of drinking contaminated water. In the early 2000s, Dr. Murray O’Connor started treating patients from the Fort Chipewyan community. After noticing abnormal rates of certain rare diseases in the small community he decided to further investigate the situation. In 2006 he voiced concern that the rates of cholangiocarcinoma (a rare liver/bile duct cancer), colon cancers, lymphomas, leukemia, kidney failure, autoimmune diseases and a variety of skin rashes were all unusually high (Timoney, 2007). This was not the first time questions had been raised about the high incidences of these diseases; the head nurse at Fort Chipewyan, Dr. Sauvé (Fort McMurray’s Medical Association President) and the director of the local health board all had similar apprehensions (Singleton-Polster, 2010). His inquiry sparked the Nunee Health Board Society to conduct a study based on a 12-year dataset, which found that the cancer rate in Fort Chipewyan residents was 29% above the Albertan average for non-First Nation people (Timoney, 2007). Also, the frequency of type II diabetes, lupus, renal failure and hypertension were abnormally high (Timoney, 2007). In 2006 the Government of Alberta conducted a health study of Fort Chipewyan in which they reported ‘no difference’ in the incidence of cancer (Alberta Cancer Board, 2009). This study has been highly criticized however, because it used incomplete datasets, displayed information in a confusing way and separated findings into different categories to make the incidence rates appear lower (Timoney, 2007).

The primary health concerns in Fort Chipewyan are listed below:

**Cancer**

The incidence of cholangiocarcinoma, a rare form of liver/bile duct cancer, is elevated 7-fold in Fort Chipewyan (Solomon, 2010). This type of cancer normally affects 1-2 people in 100,000, and in the 1,200 population of Fort Chipewyan two cases have been confirmed by biopsy and three others are suspected (Alberta Cancer Board, 2009). There is also a high incidence of Graves’ disease, an autoimmune disorder that leads to hyperthyroidism and potentially thyroid cancer (Timoney, 2007). Hematopoietics (blood cancers) and leukemia rates were also elevated by a
factor of 3 in Fort Chipewyan (Solomon, 2010). In 2006, 22 people died in Fort Chipewyan, half from cancers (Timoney, 2007). Furthermore, the number of cases of cancer in the region increased between 1995-2000 and 2001-2006 suggesting that the problem is intensifying (Alberta Cancer Board, 2009). There is an interesting connection between the elevated rare forms of cancer and potential contaminants in Fort Chipewyan’s water that have been scientifically linked to chemicals at the oil sands. Bile cancers are linked to petroleum and PAHs, leukemia’s have been linked to PAHs, dioxins and volatile organic compounds, and soft tissue sarcomas have been associated with hydrocarbons and dioxins (Solomon, 2010).

**Kidney (Renal) Failure**

Both Dr. O’Connor and the 2006 Government of Alberta health study found that renal failure in Fort Chipewyan was elevated as compared to provincial averages (Alberta Cancer Board, 2009; Timoney, 2007). Renal failure occurs when the kidney is no longer able to excrete waste products and patients need renal replacement therapy either in the form of dialysis or a kidney transplant. Both hypertension and type II diabetes (see below) are common causes of chronic renal failure.

**Additional Illnesses**

The prevalence of hypertension and type II diabetes were found to be higher than expected in Fort Chipewyan (Timoney, 2007). Left untreated or undiagnosed hypertension can cause stroke, renal disease, blindness, and heart failure. Health complications from type II diabetes include neuropathy, nephropathy, eye damage and cardiovascular problems (Singleton-Polster, 2010).

Access to healthcare resources for Fort Chipewyan residents is also a potential factor in the disproportionate impact of disease in the community. The community has a full-time nursing station with a registered nurse, a community health representative, and a physician visits the community once every two weeks (Alberta Cancer Board, 2009). However, with many of the severe disease states and rare carcinomas experienced by Fort Chipewyan residents, they often require medical attention beyond what is available in their community. The closest hospital is in Fort McMurray,
which is 270 kilometers away and the closest cancer diagnosis and treatment center is 600 kilometers away in Edmonton (Alberta Cancer Board, 2009). The burden of transportation and other travel costs, leaving ones family and taking time off work often deters residents from seeking the medical help they need.

4.3.4 Recommendations

The battle to ensure access to safe drinking water in Fort Chipewyan is primarily associated with mitigating source water contamination from the nearby industrial and natural resource sectors. Pollution from mines, oil sands, agriculture, and pulp and paper factories must be regulated and strictly monitored in order to eliminate the source of contamination. Source water protection programs and planning are essential in Fort Chipewyan and the greater Athabasca region in order to successfully provide residents clean and safe drinking water.

An environmental monitoring program for contaminants in the Athabasca region needs to be created that is free of any vested interests. Ideally, this program would run in association with a local University that would regularly and openly discuss all findings with the residents of Fort Chipewyan. With enhanced knowledge about the pollutants in the raw drinking water, scientists and health officials could work together to design more effective ways of treating the water to remove contaminants that pose significant health threats.

The current Regional Aquatics Monitoring Program (RAMP) has a flawed approach and collects private data that is partial to prejudice. Its approach is analytically inadequate in that it has too short a detection timeline, low statistical power, rarely references accepted scientific literature, and is often inconsistent in how data is measured over time (Timoney, 2007). The new monitoring program must include a comprehensive review of all the environmental and health impacts from the various natural and anthropogenic sources around Fort Chipewyan. From this, analysis of the data will be able to confidently show which contaminants in the water pose the largest health threat and measures can be taken to effectively reduce and remove these dangers. Epidemiologists would be
able to use the study data to control for factors including time living in Fort Chipewyan, diet, water supply and lifestyle to detect expected rates of disease in the community. Toxicologists could quantify the exposure risk to toxicants in the area. Together, this additional information could help create disease and risk prevention programs targeted specifically to Fort Chipewyan. Continued monitoring using transparent and consistent methods as well as open communication to all stakeholders (Government, Health Canada, Fort Chipewyan, Industries) is also necessary to detect any changes in pollutant or health factors.

4.3.5 Information Available (sources, quality, gaps)

Currently, information about the cumulative impact of the oil sands on environmental and human health in Alberta is hard to obtain. Contaminants vary spatially and temporally and therefore much of the pollutant information available is plagued by uncertainty. Furthermore, the majority of oil sand property is privately owned making scientifically independent data difficult to collect (Timoney and Lee, 2009). Many of the studies concerning contaminant concentrations are industry or government funded and are therefore potentially biased in the information they present. Additional challenges to obtaining reliable information are epidemiological in nature. With such a small sample size, the statistics are shifted towards not detecting effects even if they do exist (low statistical power), and expanding the geographic focus of the study would compromise the focus on Fort Chipewyan (Timoney, 2007).

A second information gap concerns the fact that the oil sands are not the only source of water contamination in the Fort Chipewyan community, yet they are the only anthropogenic pollutant source that has been examined with respect to health and water quality issues. Uranium mining around Lake Athabasca during the 1900s has left many abandoned mines and their associated toxic tailings. Between the Lorado Mine, Beaverlodge Mine, and Gunnar Mine there are 11.6 million tonnes of tailings in the Athabasca area, which contain 85% of the original ore radiation including radioactive uranium, radium, polonium and heavy metals such as arsenic, lead and nickel (Alberta
Cancer Board, 2009). This pollution is potentially leaching into surface and groundwater sources, yet the environmental and human health implications from these contaminants remain unexamined. Furthermore, the effect of agriculture, which covers 23% of the lower Athabasca River basin, is not well studied. Between 1995-2002, five pesticides in the Peace and Athabasca River basins upstream of Fort Chipewyan exceeded the water quality guidelines (Timoney, 2007). However, no follow-up health study examined the potential health effects on Fort Chipewyan residents from these agricultural pollutants.

Finally, there is a perception among some that the government is hiding data from the citizens of Alberta, creating gaps in the information available on human health impacts from the oil sands. After a report on “Water quality and quantity, technology, the impact of climate change, Aboriginal issues (health), governance and strategic environmental assessment” was proposed by the federal government, the study was cancelled in 2009 (Singleton-Polster, 2010). All copies of the study were destroyed with no rationale given to the public, leading to fears about lack of government transparency and information disclosure.

PART 5.0 – POTENTIAL SOLUTIONS AND CONCLUSION

“Regulation alone will not be effective in ensuring safe drinking water unless the other requirements – a multiple barrier approach, cautious decision-making and effective management systems – are met.” – Swain et al., 2006, Report of the Expert Panel on Safe Drinking Water for First Nations

5.1 The Multi-BARRIER Approach

The Canadian Council of Ministers of the Environment (CCME) defines the multi-barrier approach as looking at all components of a water system, from source to tap, with an aim to reduce the risk of contaminants in drinking water, to increase the effectiveness of preventative measures and to protect public health (CCME, 2004). As seen in Figure 7, the core components include public awareness, legislative and policy frameworks, guidelines and objectives, and scientific research and technology.
The major components in the multi-barrier approach to providing clean, safe and reliable drinking water to First Nations communities can be broken into three main goals.

1) Management, Legislative and Policy Changes

Co-management between First Nations and government bodies is an effective way to ensure that regulatory changes made are accepted and adopted by the communities they will affect. Paternalistic and unilateral decision-making by national and provincial governments must stop. First Nations people have a wealth of information and expertise to contribute to active participation in water-related regulatory processes and management discussions, and argue that it is time for recognition and integration of their concerns into policy agendas. First Nations communities support co-management as a solution that allows for the cooperation and power sharing of First Nations people with the various levels of government over water-related issues.

Although co-management and decision-making processes need to take place on a specific community basis, there are several fundamental principles that are essential in ensuring the successful partnership of government and First Nations. Firstly, First Nations Band Councils must be
recognized as legitimate and accountable for protection of the health, economic security, and political well-being of their community. Secondly, First Nations must be given an equal opportunity to participate in decision-making processes from early stages of problem identification to late stages of solution implementation. Thirdly, TEK must be respected and considered expert information instead of being discounted as illegitimate and unscientific (White et al., 2006). Therefore, TEK must be integrated into the conceptualization and design of management strategies, and not just haphazardly incorporated into existing frameworks. Lastly, there must be a framework and/or mechanism in place for resolving arguments and differing opinions that contains detailed provisions for disagreement resolution (White et al., 2006).

Finally, to ensure the success of co-management strategies several large-scale changes need to be made to current frameworks. Firstly, as First Nations governments are granted more power and responsibilities over their communities, they must receive more funding to ensure they have the resources necessary to successfully accomplish their roles and duties. Secondly, the division of roles between First Nations communities and different government bodies needs to be clearly outlined in binding legislation so that there is no ambiguity over who is responsible for what. Lastly, regulatory bodies including First Nations Band Councils, Health Canada, Environment Canada and DIAND should be separated from funding agencies. Currently INAC is functioning as both a regulatory and funding body for water quality for First Nations and mandating that certain funds be spent in specific ways. This is reducing the capacity and freedom for other regulatory bodies, particularly First Nations Band Councils, to act in ways that they see to be most beneficial.

2) Scientific-Based Solutions

“The first barrier to the contamination of drinking water involves protecting the sources of drinking water.” – Justice Dennis O’Connor, Walkerton Inquiry
Source Water Protection

Source water protection (SWP) is the most successful method of reducing microbiological contamination in drinking water (Patrick, 2011). Source water includes surface water (rivers and lakes) and groundwater (aquifers) and refers to where we get our raw drinking water. SWP works by establishing watershed management plans and protection zones around the surface water area where drinking water intake occurs. Recently, SWP has been increasingly used to ensure safe drinking water, as no single water treatment process is entirely effective for removing the diverse types of microbiological organisms and physical contaminants in water (Watershed Science Centre, 2007). SWP is the first line of defense against pathogens and toxic chemicals entering drinking water. In essence, SWP is a cure to water pollution instead of a reaction after a disease or health outbreak occurs and is a logical and cost-effective way of protecting human health, especially in remote First Nations communities (Patrick, 2011).

There are many ways that source water can become contaminated including release of wastewater, leakage of septic tanks, runoff of sewage sludge and pesticides, storm water overflows, livestock wastes and many others. For humans, the largest threat to drinking water safety comes from water contaminated with human or livestock wastes that contain harmful microbes (Watershed Science Centre, 2007). There are also temporal variations in water quality and quantity that affect source water. The levels of turbidity, natural organic matter, and fecal coliforms can all naturally change over time. SWP planning can be used to implement stream buffers, reduce impervious surfaces, disinfect wastewater, forbid septic system discharges into the environment and enforce well-head protection programs (Water Quality and Health Council, 2012).

One emerging method of SWP is using microbial source tracking (MST) to identify the source of fecal pollution so that it can be reduced or eliminated. Between 1974 and 2004 waterborne pathogens resulted in over 28 disease outbreaks in Canada and, therefore, minimizing risk of fecal water contamination is essential in securing safe drinking water (Unger, 2011). MST compares the
DNA similarity of microorganisms in the water to microorganisms in nearby potential sources using genetic fingerprinting of pathogens including *E. coli* (Unger, 2011). Once the accurate source of the pollution is clearly determined using MST methods, strategic and cost-effective work to protect source water from the fecal pollution can be taken with highly effective results. Combined use of MST and SWP will help communities meet water quality guidelines and regulations.

SWP has the potential to be highly effective in First Nations communities for three reasons. Firstly, the current strategy of the federal government and INAC to construct expensive WTPs in First Nations communities to minimize water contamination risk has failed. These facilities have high unit costs and only serve a small population, they often have flawed designs, lack trained operators to run them and have high operation and maintenance costs (Patrick, 2011). Secondly, with a limited budget, it is more cost-effective to protect a water source than it is to remediate polluted water, and land acquisition within a watershed is cheaper than investing in physical infrastructure such as large WTPs. Thirdly, SWP has the potential to unite watershed stakeholders including First Nations communities and nearby land managers, while enhancing communication and coordination between these groups. A successful program in British Columbia has given Health Officials (Drinking Water Officers and Medical Health Officers) the legal power to order SWP planning in communities (Patrick, 2011). The result is mandatory communication between all stakeholders, including First Nations communities that are often excluded from decision-making processes, towards land-use planning with the goal of securing safe drinking water.

*Wetlands/ Riparian Zones*

Wetlands and riparian zones are two examples of important ecological services that protect and maintain water quality. A wetland is classified as a swamp, marsh or bog that has either a shallow water covering or a high water-table level. Riparian areas are transition zones between upland areas (fields) and water containing areas (streams, rivers). Both wetlands and riparian areas are highly effective at mitigating the health impacts associated with point and non-point source water
contamination. Wetlands are able to remove pathogens, pharmaceuticals, endocrine disruptors, nitrogen, phosphorous, metals, pesticides, nutrients, mine extraction wastes and many other pollutants from water (Watershed Science Centre, 2007). For example, after 1.5 days in a wetland there is an 84% fecal coliform reduction in the water and that figure increases to 99.6% after 6 days (Watershed Science Centre, 2007). The removal of pollutants in wetlands occurs through UV radiation exposure and breakdown, sedimentation, mechanical filtration, oxidation processes, adsorption and natural die-off (Watershed Science Centre, 2007). Riparian zones are successful at minimizing run-off of pollutants through infiltration, adsorption, and retention.

Other than providing humans ecosystem services, wetlands and riparian zones also improve ecosystem health and provide habitat to local wildlife. The interconnection between water, land and animals is very important in TEK and in maintaining a healthy ecosystem. It has been found that First Nations communities are more willing to work towards a water-based ecosystem management plan that combines TEK with other scientific principles (Chiefs of Ontario, 2007). These ecosystem management plans could work to protect natural wetlands or construct artificial wetlands, which would enhance raw water quality and could even target area-specific pollutants. The result would be using scientific principles in ways that respect TEK and First Nations values, while enhancing drinking water quality and health.

3) Monitoring and Resources

The issue of monitoring and funding water treatment and distribution plants is a third key area in the multi-barrier approach that needs to be addressed in order to improve water quality on First Nations reserves. Proper monitoring entails ensuring trained operators are onsite at all times, having equipment fitted with warning devices and checking that the treatment and distribution systems are functioning properly. Since the publication of O’Connor’s recommendations in the Walkerton Inquiry on a multi-barrier approach to drinking water safety, legislation has been
introduced in Ontario. In the 2002 Safe Drinking Water Act, outlines for water quality standards, operator training and proper facility construction were included.

First Nations communities face a difficult challenge finding and retaining trained operators because, with inadequate funding, Band Councils cannot compensate operators satisfactorily or afford to properly train them. One solution to this problem is the Circuit Rider Training Program (CRTP) created by INAC in the 1990s to train First Nations water and wastewater treatment plant operators how to run and properly maintain their facilities. The CRTP is a 2-3 day program in which Circuit Riders – qualified operators and instructors – travel to different First Nations communities and empower skilled local residents to successfully run their water and wastewater facilities with hands-on training (McGregor and Whitaker, 2001). This is a highly cost-effective approach aimed at quickly, but comprehensively, educating operators in order to mitigate human-associated water contamination problems common in technologically sophisticated or old, run-down facilities present on reserves. The CRTP program is available for First Nations communities all across Canada and recently has expanded to include a 24-hour hotline to answer any operator questions (McGregor and Whitaker, 2001). With more qualified WTP operators, monitoring of water treatment and distribution systems should be more effective and, in the case of an emergency, they will have well thought out and practiced response plans to prevent contaminated water distribution and a public health emergency.

5.2 Increased Access to Healthcare Facilities

Many First Nations communities have poor access to healthcare facilities and, as a result, suffer from avoidable health problems. Increased First Nations participation in local and provincial healthcare planning and delivery mechanisms is necessary to ensure better access to healthcare resources. For example, more culturally and community-relevant services, enhanced coordination of healthcare and referrals, as well as closer services to remote communities could be provided with increased First Nations involvement in healthcare frameworks (Health Canada, 2011).
According to Health Canada (2011) the Aboriginal Health Transition Fund has helped create three key transitions in working towards improving access to healthcare for First Nations people:

1. *New ways of working together in Aboriginal Health*

   The creation of fair and equal partnerships between government and First Nations groups has facilitated mutual commitment towards collaboration in order to effectively address issues pertaining to the access and quality of First Nations health services. For example, the Ontario First Nation Tripartite Public Health Relationship Framework represents a good stepping-stone towards providing better healthcare to First Nations communities. It involves a framework that incorporates a First Nations health management system that is supported by the provincial government and Health Canada. This program allows for participation and inclusion of traditional First Nations approaches to healthcare in public health policies and planning.

2. *New ways of thinking in planning and delivering healthcare services*

   The incorporation of First Nations people into healthcare discussions has enhanced awareness about unique health disparities, social challenges and cultural considerations facing First Nations people. From this, innovative methods of healthcare, adapted for First Nations patient needs, are being increasingly formed and implemented.

3. *New ways to access healthcare services*

   Improved access to healthcare programs has been accomplished by improving awareness of healthcare options, moving healthcare services closer to First Nations communities and catering services to specific First Nations healthcare needs. For example, a Telehealth program in Manitoba is using videoconferencing technology to improve First Nations access to healthcare services. A patient in a remote location can connect with a health specialist in a hospital in Manitoba and get immediate healthcare services without having to travel, leave their family or miss work.
Improving First Nations access to healthcare will help facilitate two positive outcomes. Firstly, it will lead to more timely and effective treatment of serious waterborne or water-related illnesses and diseases. Secondly, it will help raise awareness about different waterborne illnesses, how to detect their signs and symptoms, and how to avoid waterborne sicknesses (Copes, 2006).

5.3 Summary of Key Points

Water Quality and Health States

- The Auditor General of Canada has admitted that First Nations communities do not receive the same level of protection as the rest of the Canadian population with respect to drinking water quality
- 40% of Canada’s First Nations communities are under a DWA, which is 2.5-times higher than the national rate
- An INAC survey found that 75% of First Nations water systems were medium-risk or worse
- Waterborne illnesses and infections are 26-times more common in First Nations communities than the rest of Canada
- First Nations people have a life expectancy 5-7 years shorter than the Canadian average
- 35.9% of First Nations people believe they have less access to healthcare services than other Canadian citizens, and only 43% of First Nations residents visited a physician annually compared to over 71% in the rest of Canada

Case Studies

- The results varied between the case studies based on the type of water contaminants present and where the communities were located. Kashechewan faced disproportionate exposure levels to *E. coli*, Yellow Quill to pathogenic parasites and Fort Chipewyan to carcinogenic agents, heavy metals and oil sand pollutants
Solutions and Recommendations

• Multi-barrier Approach
  o Management, legislative and policy changes
    ▪ Co-management: power sharing and cooperation between First Nations and government
    ▪ Binding legislature with reduced ambiguity and adequate funding
    ▪ Respectful incorporation of TEK into policies and management strategies
  o Scientific-based solutions
    ▪ Source water protection
    ▪ Wetlands/riparian zones
  o Monitoring and Resources
    ▪ Skilled and trained operators

• Access to Healthcare
  o Innovative approach to addressing and providing specific healthcare services to First Nations communities

ACKNOWLEDGEMENTS

I would like to thank many people who made the writing of this report possible while also making it an enjoyable and meaningful learning experience. Firstly, I would like to thank my supervisor, Dr. Anna Majury, for her support, insight and assistance throughout the year as I compiled information for this report. Secondly, I would like to thank my two co-supervisors Dr. Kristan Aronson and Dr. Chris Metcalfe for helping to answer my questions and support me through the writing process. Lastly, I’d like to thank my parents for encouraging me to do an independent research project and supporting me along the way.
REFERENCES


APPENDIX

List of Short Forms

BWA – Boil Water Advisory
CDWQG – Canadian Drinking Water Quality Guidelines
CRTP – Circuit Rider Training Program
DIAND – Department of Indian Affairs and Northern Development
DOC – Dissolved Organic Carbon
DWA – Drinking Water Advisory
FNWMS – First Nations Water Management Strategy
HPC – Heterotrophic plate count
INAC – Indian and Northern Affairs Canada
MAC – Maximum Acceptable Concentration
MST – Microbial Source Tracking
NAHO – National Aboriginal Health Organization
PAHs – Polycyclic Aromatic Hydrocarbons
SDWF – Safe Drinking Water Foundation
SWP – Source Water Protection
TEK – Traditional Ecological Knowledge
THMs – Trihalomethanes
VOCs – Volatile organic compounds
WTP – Water Treatment Plant
### A.1 Guidelines for Canadian Drinking Water Quality Tables


#### Table 1. New and revised guidelines

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Guideline (mg/L)</th>
<th>Previous guideline (mg/L)</th>
<th>CHE approval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Microbiological parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacteriological</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>0 per 100 mL</td>
<td>0 coliforms/100 mL</td>
<td>2006</td>
</tr>
<tr>
<td>Total coliforms</td>
<td>0 per 100 mL</td>
<td></td>
<td>2006</td>
</tr>
<tr>
<td>Heterotrophic plate count</td>
<td>No numerical guideline required</td>
<td></td>
<td>2006</td>
</tr>
<tr>
<td>Emerging pathogens</td>
<td>No numerical guideline required</td>
<td></td>
<td>2006</td>
</tr>
<tr>
<td>Protozoa</td>
<td>No numerical guideline required</td>
<td>None</td>
<td>2004</td>
</tr>
<tr>
<td>Enteric viruses</td>
<td>No numerical guideline required</td>
<td>None</td>
<td>2004</td>
</tr>
<tr>
<td>Turbidity</td>
<td>0.3/1.0/0.1 NTU(^b)</td>
<td>1.0 NTU</td>
<td>2004</td>
</tr>
<tr>
<td><strong>Chemical and physical parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.1/0.2(^c)</td>
<td>None</td>
<td>1999</td>
</tr>
<tr>
<td>Antimony</td>
<td>0.006</td>
<td>None</td>
<td>1997</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.01</td>
<td>0.025</td>
<td>2006</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.005</td>
<td>0.005</td>
<td>2009</td>
</tr>
<tr>
<td>Bromate</td>
<td>0.01</td>
<td>None</td>
<td>1999</td>
</tr>
<tr>
<td>Chlorate</td>
<td>1</td>
<td>None</td>
<td>2008</td>
</tr>
<tr>
<td>Chlorine</td>
<td>No numerical guideline required</td>
<td>None</td>
<td>2009</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td>None</td>
<td>2008</td>
</tr>
<tr>
<td>Cyanobacterial toxins—microcystin-LR</td>
<td>0.0015</td>
<td>None</td>
<td>2002</td>
</tr>
<tr>
<td>Fluoride</td>
<td>1.5</td>
<td>1.5</td>
<td>1996</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>No numerical guideline required</td>
<td>None</td>
<td>1998</td>
</tr>
<tr>
<td>Haloacetic Acids—Total (HAA(s))</td>
<td>0.08</td>
<td>None</td>
<td>2008</td>
</tr>
<tr>
<td>2-Methyl-4-chlorophenoxyacetic acid (MCPA)</td>
<td>0.1</td>
<td>None</td>
<td>2010</td>
</tr>
<tr>
<td>Methyl tertiary-butyl ether (MTBE)</td>
<td>0.015</td>
<td>None</td>
<td>2006</td>
</tr>
<tr>
<td>Trichloroethylene (TCE)</td>
<td>0.005</td>
<td>0.05</td>
<td>2005</td>
</tr>
<tr>
<td>Trihalomethanes—Total (THMs)(^d)</td>
<td>0.1</td>
<td>0.1</td>
<td>2006</td>
</tr>
</tbody>
</table>
A.2 Regulated Drinking Water Contaminants and their Chronic Health Effects

http://water.epa.gov/drink/contaminants/index.cfm

### Microorganisms

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>MCLG (mg/L)</th>
<th>MCL or TT (mg/L)</th>
<th>Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryptosporidium</td>
<td>zero</td>
<td>TT</td>
<td>Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)</td>
</tr>
<tr>
<td>Giardia lamblia</td>
<td>zero</td>
<td>TT</td>
<td>Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)</td>
</tr>
<tr>
<td>Heterotrophic plate count</td>
<td>n/a</td>
<td>TT</td>
<td>HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.</td>
</tr>
<tr>
<td>Legionella</td>
<td>zero</td>
<td>TT</td>
<td>Legionnaire's Disease, a type of pneumonia</td>
</tr>
<tr>
<td>Total Coliforms (including fecal coliform and E. Coli)</td>
<td>zero</td>
<td>5.0%</td>
<td>Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present</td>
</tr>
<tr>
<td>Turbidity</td>
<td>n/a</td>
<td>TT</td>
<td>Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels</td>
</tr>
</tbody>
</table>
are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.

### Organic Chemicals

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>MCLG (mg/L)</th>
<th>MCL or TT (mg/L)</th>
<th>Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylamide</td>
<td>zero</td>
<td>TT</td>
<td>Nervous system or blood problems; increased risk of cancer</td>
</tr>
<tr>
<td>Alachlor</td>
<td>zero</td>
<td>0.002</td>
<td>Eye, liver, kidney or spleen problems; anemia; increased risk of cancer</td>
</tr>
<tr>
<td>Atrazine</td>
<td>0.003</td>
<td>0.003</td>
<td>Cardiovascular system or reproductive problems</td>
</tr>
<tr>
<td>Benzene</td>
<td>zero</td>
<td>0.005</td>
<td>Anemia; decrease in blood platelets; increased risk of cancer</td>
</tr>
<tr>
<td>Benzo(a)pyrene (PAHs)</td>
<td>zero</td>
<td>0.0002</td>
<td>Reproductive difficulties; increased risk of cancer</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>0.04</td>
<td>0.04</td>
<td>Problems with blood, nervous system, or reproductive system</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>zero</td>
<td>0.005</td>
<td>Liver problems; increased risk of cancer</td>
</tr>
<tr>
<td>Chlordane</td>
<td>zero</td>
<td>0.002</td>
<td>Liver or nervous system problems; increased risk of cancer</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>0.1</td>
<td>0.1</td>
<td>Liver or kidney problems</td>
</tr>
<tr>
<td>2,4-D</td>
<td>0.07</td>
<td>0.07</td>
<td>Kidney, liver, or adrenal gland problems</td>
</tr>
<tr>
<td>Chemical</td>
<td>IF</td>
<td>SI</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Dalapon</td>
<td>0.2</td>
<td>0.2</td>
<td>Minor kidney changes</td>
</tr>
<tr>
<td>1,2-Dibromo-3-chloropropane (DBCP)</td>
<td>0.0002</td>
<td></td>
<td>Reproductive difficulties; increased risk of cancer</td>
</tr>
<tr>
<td>o-Dichlorobenzene</td>
<td>0.6</td>
<td>0.6</td>
<td>Liver, kidney, or circulatory system problems</td>
</tr>
<tr>
<td>p-Dichlorobenzene</td>
<td>0.075</td>
<td>0.075</td>
<td>Anemia; liver, kidney or spleen damage; changes in blood</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>0.005</td>
<td></td>
<td>Increased risk of cancer</td>
</tr>
<tr>
<td>1,1-Dichloroethylene</td>
<td>0.007</td>
<td>0.007</td>
<td>Liver problems</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethylene</td>
<td>0.07</td>
<td>0.07</td>
<td>Liver problems</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethylene</td>
<td>0.1</td>
<td>0.1</td>
<td>Liver problems</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>0.005</td>
<td></td>
<td>Liver problems; increased risk of cancer</td>
</tr>
<tr>
<td>1,2-Dichloropropane</td>
<td>0.005</td>
<td></td>
<td>Increased risk of cancer</td>
</tr>
<tr>
<td>Di(2-ethylhexyl) adipate</td>
<td>0.4</td>
<td>0.4</td>
<td>Weight loss, liver problems, or possible reproductive difficulties.</td>
</tr>
<tr>
<td>Di(2-ethylhexyl) phthalate</td>
<td>0.006</td>
<td></td>
<td>Reproductive difficulties; liver problems; increased risk of cancer</td>
</tr>
<tr>
<td>Dinoseb</td>
<td>0.007</td>
<td>0.007</td>
<td>Reproductive difficulties</td>
</tr>
<tr>
<td>Dioxin (2,3,7,8-TCDD)</td>
<td>0.00000003</td>
<td></td>
<td>Reproductive difficulties; increased risk of cancer</td>
</tr>
<tr>
<td>Diquat</td>
<td>0.02</td>
<td>0.02</td>
<td>Cataracts</td>
</tr>
<tr>
<td>Endothall</td>
<td>0.1</td>
<td>0.1</td>
<td>Stomach and intestinal problems</td>
</tr>
<tr>
<td>Chemical Name</td>
<td>Concentration (p.p.b.)</td>
<td>TT Level (p.p.b.)</td>
<td>Health Effects</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------</td>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Endrin</td>
<td>0.002</td>
<td>0.002</td>
<td>Liver problems</td>
</tr>
<tr>
<td>Epichlorohydrin</td>
<td>zero</td>
<td>TT</td>
<td>Increased cancer risk, and over a long period of time, stomach problems</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.7</td>
<td>0.7</td>
<td>Liver or kidneys problems</td>
</tr>
<tr>
<td>Ethylene dibromide</td>
<td>zero</td>
<td>0.00005</td>
<td>Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>0.7</td>
<td>0.7</td>
<td>Kidney problems; reproductive difficulties</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>zero</td>
<td>0.0004</td>
<td>Liver damage; increased risk of cancer</td>
</tr>
<tr>
<td>Heptachlor epoxide</td>
<td>zero</td>
<td>0.0002</td>
<td>Liver damage; increased risk of cancer</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>zero</td>
<td>0.001</td>
<td>Liver or kidney problems; reproductive difficulties; increased risk of cancer</td>
</tr>
<tr>
<td>Hexachlorocycloptadiene</td>
<td>0.05</td>
<td>0.05</td>
<td>Kidney or stomach problems</td>
</tr>
<tr>
<td>Lindane</td>
<td>0.0002</td>
<td>0.0002</td>
<td>Liver or kidney problems</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>0.04</td>
<td>0.04</td>
<td>Reproductive difficulties</td>
</tr>
<tr>
<td>Oxamyl (Vydate)</td>
<td>0.2</td>
<td>0.2</td>
<td>Slight nervous system effects</td>
</tr>
<tr>
<td>Polychlorinated biphenyls (PCBs)</td>
<td>zero</td>
<td>0.0005</td>
<td>Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>zero</td>
<td>0.001</td>
<td>Liver or kidney problems; increased cancer risk</td>
</tr>
<tr>
<td>Contaminant</td>
<td>MCLG (mg/L)</td>
<td>MCL or TT (mg/L)</td>
<td>Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term)</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------</td>
<td>------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Antimony</td>
<td>0.006</td>
<td>0.006</td>
<td>Increase in blood cholesterol; decrease in blood sugar</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.007</td>
<td>0.010 as of</td>
<td>Skin damage or problems with circulatory systems, and may have...</td>
</tr>
<tr>
<td>Substance</td>
<td>Current Value</td>
<td>Action Level</td>
<td>Health Effect</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------</td>
<td>--------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Asbestos (fiber &gt;10 micrometers)</td>
<td>7 million fibers per liter</td>
<td>7 MFL</td>
<td>Increased risk of developing benign intestinal polyps</td>
</tr>
<tr>
<td>Barium</td>
<td>2</td>
<td>2</td>
<td>Increase in blood pressure</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.004</td>
<td>0.004</td>
<td>Intestinal lesions</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.005</td>
<td>0.005</td>
<td>Kidney damage</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>0.1</td>
<td>0.1</td>
<td>Allergic dermatitis</td>
</tr>
<tr>
<td>Copper</td>
<td>1.3</td>
<td>Action Level=1.3</td>
<td>Short term exposure: Gastrointestinal distress</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Long term exposure: Liver or kidney damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level</td>
</tr>
<tr>
<td>Cyanide (as free cyanide)</td>
<td>0.2</td>
<td>0.2</td>
<td>Nerve damage or thyroid problems</td>
</tr>
<tr>
<td>Fluoride</td>
<td>4.0</td>
<td>4.0</td>
<td>Bone disease (pain and tenderness of the bones); Children may get mottled teeth</td>
</tr>
<tr>
<td>Lead</td>
<td>zero</td>
<td>Action Level=0.015</td>
<td>Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adults: Kidney problems; high blood pressure</td>
</tr>
<tr>
<td>Mercury (inorganic)</td>
<td>0.002</td>
<td>0.002</td>
<td>Kidney damage</td>
</tr>
<tr>
<td>Nitrate (measured as)</td>
<td>10</td>
<td>10</td>
<td>Infants below the age of six months who drink water containing</td>
</tr>
</tbody>
</table>
Nitrogen) nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.

| Nitrite (measured as Nitrogen) | 1 | 1 | Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. |
| Selenium | 0.05 | 0.05 | Hair or fingernail loss; numbness in fingers or toes; circulatory problems |
| Thallium | 0.0005 | 0.002 | Hair loss; changes in blood; kidney, intestine, or liver problems |

### Radionuclides

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>MCLG (mg/L)</th>
<th>MCL or TT (mg/L)</th>
<th>Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha particles</td>
<td>None zero</td>
<td>15 picocuries per Liter (pCi/L)</td>
<td>Increased risk of cancer</td>
</tr>
<tr>
<td>Beta particles and photon emitters</td>
<td>None zero</td>
<td>4 millirems per year</td>
<td>Increased risk of cancer</td>
</tr>
<tr>
<td>Radium 226 and Radium 228 (combined)</td>
<td>None zero</td>
<td>5 pCi/L</td>
<td>Increased risk of cancer</td>
</tr>
<tr>
<td>Uranium</td>
<td>zero</td>
<td>30 ug/L as of 12/08/03</td>
<td>Increased risk of cancer, kidney toxicity</td>
</tr>
</tbody>
</table>