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Source Water Protection Planning and Management in Metropolitan Canada: A Preliminary Assessment

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Abstract: Source Water Protection (SWP) is the process of protecting a drinking water source through land use planning policies and land management activities. The risk of source water contamination is a human health concern even in developed countries such as Canada. Much of the existing SWP literature in the more developed world is centred on small and rural water systems with a focus on capacity needs to support SWP activities and planning. These capacity needs tend to centre on five key elements: political, financial, human, technical and legal. While these contributions have added value to the water resource planning literature in rural areas, there remains a noticeable gap in the literature with respect to SWP activities in metropolitan areas. The purpose of this paper is twofold: first, to report the kinds of source water threats facing metropolitan water systems in Canada; and, second, to explore the utility of the capacity literature with respect to SWP planning in metropolitan Canada.

Keywords: source water protection; Canada; metropolitan; capacity-building

1. Introduction

Safe drinking water is a basic human necessity. However, water contamination remains a serious global issue. In developing countries, millions of people annually succumb to serious, life threatening, illnesses from the consumption of contaminated drinking water [1]. It is estimated that 90,000 illness and deaths occur globally every day due to contaminated drinking water [2]. In developed countries, such as Canada, drinking water contamination incidents regularly occur, albeit to a lesser extent than in developing countries. For example, the water contamination event in 2000 at Walkerton, Ontario, resulted in seven deaths and 2300 illnesses. Other water contamination events resulting in illness and medical health treatment are well documented in urban Canada [3]. Many drinking water contamination events can be avoided through greater attention to land use practices aimed at the protection of public water supplies [4–6]. Source Water Protection (SWP) is recognized as the first barrier in the multi-barrier approach to reduce the risk of drinking water contamination. In Canada, jurisdiction over water management falls mainly to provincial government authority. As such, there is highly uneven approach to water management across the 10 provinces and three territorial governments. In many provincial jurisdictions, water is managed on a watershed scale to include both small communities and larger cities. This decentralized approach to water management may contribute to an uneven application of SWP planning and implementation across provincial and territorial jurisdictions. Such unevenness raises questions regarding the capacity of large metropolitan areas within Canada to undertake SWP planning. Here, capacity refers to human and financial resources, technical capability, and legal and political capacity to take action.

The capacity "gap" affecting rural and small communities is well documented in the water resources literature with much less attention to urban, or metropolitan, regions. The assumption is that

metropolitan regions with higher land values and taxation rates, greater numbers of highly qualified people and more access to technical hardware will be immune to capacity gaps affecting rural and small town areas. This study seeks to test that assumption.

The concept of "capacity" and "capacity-building" can be traced to various professional and academic fields, including public sector agencies and institutions, local economic development, local environmental management, and public health [7,8]. Capacity in this context refers to the capability of an organization or group to undertake action to bring about meaningful change [9]. The five types of capacity referenced in this study will be briefly introduced: Human capacity refers to the knowledge, experience and readiness of individuals to engage in water resource planning and management. Key components include training, communication and cooperation between and among individuals and institutional organizations. Financial capacity is the ability to generate and access funding, the presence of adequate resources to meet operating expenses and manage water supplies, the sustainable and prudent use of financial resources including the use of market mechanisms, and financial flexibility [8]. Technical capacity includes commitment to, and communication of, provincial and municipal monitoring programs, data collection through risk assessment to inventory human activities, natural cases of water quality contaminations, and cooperation with scientific and research groups to collect data and information for monitoring programs. Legal capacity refers to jurisdictional control and authority to take action. Political capacity includes provincial regulations and initiatives, local control over land use activities, and local leadership with responsibility to conduct SWP implementation and other water management procedures.

Much of the SWP literature is focused on capacity needs of small and rural water operators to protect sources of drinking water, both surface and groundwater [5,10]. In this paper, we investigate the utility of the capacity-building literature with respect to SWP in metropolitan Canada. The study examined four cities from different regions of Canada: Victoria, British Columbia; Saskatoon, Saskatchewan; Toronto, Ontario; and Halifax, Nova Scotia. The research approach employs qualitative mixed-methods including document review and a questionnaire instrument. The results show variability in approach and uptake of SWP planning as well as variability in scale of approach toward SWP implementation across metropolitan Canada. The results also reveal the utility of the capacity literature in understanding the limitations and opportunities for the implementation of SWP planning in metropolitan areas. The results of this research contribute to the knowledge and understanding of SWP particularly as applied to capacity needs in metropolitan regions.

2. Method

This research undertakes a case study analysis into SWP planning and management in four Canadian metropolitan regions: Victoria, British Columbia; Saskatoon, Saskatchewan; Toronto, Ontario; and Halifax, Nova Scotia. These four cities (see Figure 1) were chosen because each has a different approach to drinking water protection. In addition, the four case studies represent distinct regions of Canada, making this a pan-Canadian study.

In Halifax, Nova Scotia, SWP plans, managed locally by Halifax Water, have been in place since 2009 under the requirements of provincial law in Nova Scotia. Provincial law requires SWP plans to be developed at the municipal scale across Nova Scotia. By contrast, in Saskatoon, Saskatchewan, the South Saskatchewan River Source Water Protection Plan is regulated through a provincial agency and administered at the watershed scale by a watershed coordinator in consultation with the city of Saskatoon. In Victoria, British Columbia, the local municipal water department owns almost 90% of the watershed of the drinking water supply, putting that city in a unique position of controlling land use within its water supply. In Toronto, Ontario, the largest city in Canada by population, SWP planning falls under provincial authority where watershed-based conservation districts are charged with developing SWP plans. The Credit Valley, Toronto and Region, and Central Ontario Region (CTC) have joined to complete a single SWP plan for the greater Toronto region. These four metropolitan

case studies collectively represent the uneven scale of application of SWP planning across provincial jurisdictions in Canada (see Figure 1).

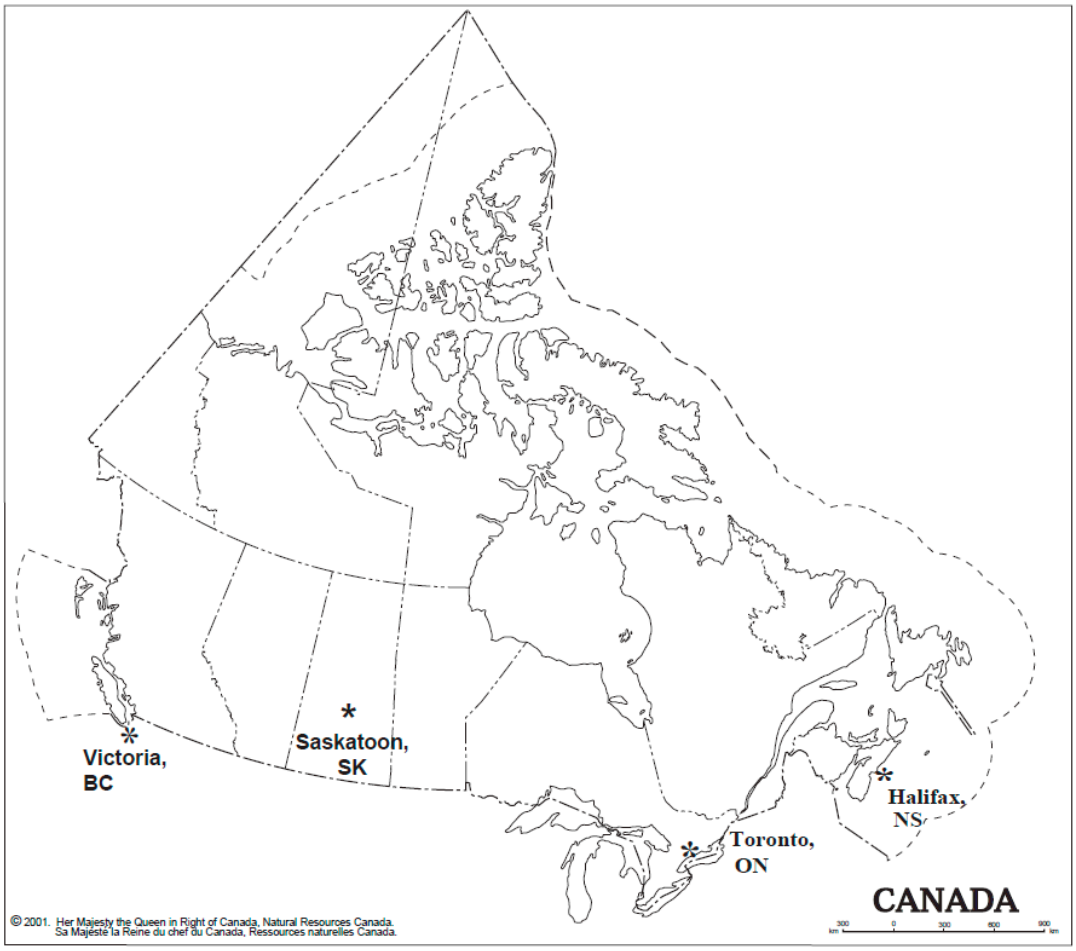

Figure 1. Metropolitan case study areas (Victoria, Saskatoon, Toronto and Halifax, Canada).

An extensive document analysis was undertaken of public access government documents. Selected documents ranged from provincial-scale water policy strategies to local planning and policy statements for each case study. A questionnaire instrument was also developed and sent to key informants across all four case studies. The questionnaire sought responses relating to capacity needs to support SWP planning and management. Emphasis was placed on the five capacity categories (human, financial, technical, legal and political) taken from the water resource literature pertaining to the operation, planning and management of public water supply systems. To obtain the most knowledgeable responses, participants were selected based on their job descriptions; preference was given to senior-level officials whose job responsibilities included city planning and watershed management. A total of nine local governmental employees participated in this research, including watershed managers, a source water protection planner, senior watershed planning coordinators, senior managers, and a water quality laboratory manager.

2.1. Case Study Areas

Four cities from different Canadian provinces and regions were selected for this research (see Figure 1). Each city can be taken as representative of the respective city's provincial legislation including SWP planning and management frameworks. Specific characteristics of each city relating to SWP planning and management will now be discussed (see Table 1).

Table 1. Case study characteristics.

City	SWP Plan (Date)	Water Source	Water Utility	Provincial or Local SWP Plan
Victoria	n/a	Surface	Capital Regional District	n/a
Saskatoon	South Saskatchewan River Watershed Source Water Protection Plan	Surface	City of Saskatoon	Provincial Watershed area
Toronto	Credit Valley, Toronto and Region and Central Lake Ontario Source Protection Plan	Groundwater	City of Toronto	Provincial Watershed area
Halifax	Pockwock Lake and Tomahawk Lake Watersheds Source Water Protection Plan	Surface & Groundwater	Halifax Water	Metropolitan reservoirs

2.1.1. City of Victoria

Drinking water service in Greater Victoria, British Columbia, is managed by the Greater Victoria Water Supply System (GVWSS). The main source of supply is the Sooke Reservoir, located in the Sooke Hills, the primary water source supplying approximately 98% of Greater Victoria's drinking water [11]. The reservoir, like much of the land in the source water area, is owned and managed by the Capital Regional District (CRD), a local government department responsible for over 200 local, regional and sub-regional services for residents of the region, including 13 municipalities and three electoral areas on southern Vancouver Island and the Gulf Islands. The CRD provides drinking water for residential, commercial, institutional, and agricultural uses, serving a total population of about 340,000 people on the southeast corner of Vancouver Island, British Columbia [12].

Forest fires in the Greater Victoria Water Supply Area are a significant risk to water quality. A large-scale fire has potential to increase the adverse effects at water quality such as increasing the amount of surface erosion and nutrients entering the reservoir. In addition, the erosion and movement of sediments is another significant factor of risk to raw water quality. Sediment, dissolved minerals, and organic material eroded from the land surface, or from stream channels, may be carried to the reservoir or into a water intake causing elevated turbidity of the raw water. Additionally, waterborne pathogens in surface water supplies include parasites, viruses, bacteria, and protozoan pathogens such as *Giardia* and *Cryptosporidium* which cause diarrhoea, gastro-intestinal problems, and numerous public human health issues [11].

2.1.2. City of Saskatoon

The City of Saskatoon, Saskatchewan, utilizes the South Saskatchewan River as its main source of drinking water. The South Saskatchewan River receives predominantly Rocky Mountain runoff from a land area covering 120,000 square kilometers. The linear expanse of the South Saskatchewan River is over 700 kilometers; in Saskatchewan, the total drainage is 35,000 square kilometers.

The South Saskatchewan River offers the opportunity for a variety of human activities bringing economic and social benefits. The South Saskatchewan River is the largest single source of drinking water for Saskatchewan's population supplying approximately one third of the people of Saskatchewan's daily drinking water needs. The river is used for irrigation, thermal cooling, power generation, industrial activity, and recreation [13]. These uses of water have potential adverse effects on the natural water quality through contaminated runoff and increased concentrations of nutrients such as nitrogen and phosphate. Upstream land use activities in Alberta include intensive feedlots, animal grazing and agriculture. Runoff from these activities cumulates in the South Saskatchewan.

In 2007, a SWP plan was completed for the South Saskatchewan River by the then Provincial Watershed Authority to include all towns and cities, including Saskatoon, the largest city by population in Saskatchewan. Implementation of this plan, and other similar watershed-scale plans in Saskatchewan, is coordinated through a local watershed organization with a manager and modest budget provided by the provincial government.

In 2012, the Government of Saskatchewan developed a 25-Year Saskatchewan Water Security Plan to protect and manage source water quality [14]. The Water Security Agency was created in 2012 to bring multiple provincial responsibilities for water together for effective management, and it is tasked with leading implementation of the 25-Year Saskatchewan Water Security Plan and improving water management to ensure water supplies support economic growth, quality of life, and environmental well-being. The responsibility for programs related to municipal drinking water, wastewater management, and the protection of surface and ground water were transferred from the Ministry of Environment to the new Water Security Agency [15].

2.1.3. City of Toronto

Lake Ontario is the source of drinking water for approximately six million Canadians including the people of Toronto, Ontario. Conservation Authorities play a key role in managing watershed quality and quantity in Ontario and have full responsibility to conduct SWP activities under provincial regulations and legislation. Conservation Authorities were created in Ontario as early as 1947 under the *Ontario Conservation Authorities Act*.

Recently, the results of water quality data analysis show a correlation to upstream levels of urbanization. In Toronto, water quality continues to be impacted by a non-point source of contamination caused by urbanization effects such as sediment, nutrients and chemicals. Water quality in the Greater Toronto Areas is threatened by point sources of contamination such as discharge from wastewater treatment plants and various industries [16].

The *Ontario Clean Water Act, 2006* and associated regulations came into force in 2006. In response to the new Act, Source Protection Areas, Source Protection Regions (SPR) and the 19 corresponding Source Protection Committees (SPC) were established. Source Protection Regions were initially established using the existing Conservation Authority boundaries as outlined under the Conservation Authorities Act, 1990. Three of these conservation districts joined to produce a single source water protection region (and plan) for the Toronto metropolitan area, Credit Valley CD, Toronto Region CD and the Central Valley CD. This combined region is known as the Credit-Toronto-Central (CTC) Source Protection Region.

The CTC Source Protection Region contains 25 large and small watersheds and spans over 10,000 square kilometres from the Oak Ridges Moraine in the north to Lake Ontario in the south. The region contains portions of the Niagara Escarpment, Oak Ridges Moraine, Greenbelt, Lake Ontario. The CTC Source Protection Region includes 25 local municipalities and eight single tier, regional or county municipalities, 66 municipal supply wells, and 16 municipal surface water intakes on Lake Ontario.

2.1.4. City of Halifax, Nova Scotia

In 2009, Halifax Water developed source water protection plans to manage water quality of eight watersheds (Pockwock Lake, Tomahawk Lake, Lake Major, Bennery Lake, Chain Lake and Lake Lamont, Lake Flecher, and the Musquodoboit River), and three ground water supplies providing over 79,000 customers in the Halifax Regional Municipality [17]. Approximately 75% of the Halifax source water areas are forested. Forestry activities are considered a key risk to water quality by Halifax Water. To reduce and minimize the risk of forestry activities around watershed areas, protect water quality, and the conservation of the forest ecosystem, Halifax Water manages these forested areas.

Under the *Nova Scotia Environment Act*, the watershed around these lakes has been designated as protected areas. Pockwock Lake provides the greatest volume of water for Halifax Water serving the communities of Halifax, Bedford, Sackville, Beaverbrook and Timberlea.

3. Results

The results of the research are presented in this section and are organized by city. The results show two types of data: the first indicates the main risk to the respective city's water supply with the purpose

to identify the main actions or activities that could help mitigate those risks; second, to report the degree to which capacity factors found in the water resources literature apply to metropolitan SWP planning.

3.1. Victoria, British Columbia

The water management division of Greater Victoria's local government, the Capital Regional District (CRD) Water Department manages land-use activities and controls the potential effects of human activity through ownership of land contained within their drinking water supply watershed. Watershed ownership in Greater Victoria enhances the opportunity for long-term water quality security and protection. In addition, the CRD Water Department develops water plans, policy, regulations, bylaws, and standards that collectively aim to reduce or eliminate all risks associated with the water source. The three study participants from Victoria had the same opinion regarding the main risk to the region's water sources—all citing natural events such as wildfires in watershed areas, with soil erosion, climate change, and ash loading listed as secondary risks. In his response, the CRD's manager of resource planning for watershed protection explained the risk of forest fire in regards to water quality:

> *The primary risk to water quality is a large scale wildfire in the forested water supply lands. There is the potential for substantial inputs of ash, sediment, and nutrients entering the reservoir from such an event. Since we have no filtration plant, this would be a major issue.*

Capacity Factors

In spite of there being no official SWP plan for the Greater Victoria water system, existing provincial regulations and initiatives play a key role in facilitating and fulfilling the task of protecting water quality at the source. As required by provincial drinking water regulations, Victoria's water supply—which provides safe drinking water to approximately 350,000 customers—falls under the requirements of the *BC Drinking Water Protection Act (2001).* The manager of resource planning for watershed protection in the CRD indicated that provincial acts are the main factors that facilitate the protection of drinking water quality in Greater Victoria:

> *The most important factor was the BC Drinking Water Protection Act (2001). Importantly, the provisions of this Act were also incorporated into a Capital Regional District bylaw. This Act was generated by the dissolution of the Greater Victoria Water District (the water supplier since 1949) and the transfer of the water supply function to the Capital Regional District to improve political representation and accountability.*

This change clarified the roles and responsibilities for managing and protecting drinking water quality from natural events and human activity, in addition to developing water management plans to understand the effects of land-use activities on water quality. The cooperative approach to managing water resources and controlling land-use activities in Greater Victoria is centralized under a single leading authority (the CRD Water Department), which facilitates the improvement of water management policies and strategies.

The Sooke Hills Protection Act requires the CRD Water Department to prepare a strategic plan for the watershed areas focused on the next 20 years. The vision statement of the strategic plan emphasizes the primary goal, which is ensuring high quality drinking water at the source. The strategic plan also highlights the importance of SWP as the first barrier in the multi-barrier approach to safe drinking water. The strategic plan fulfills the goal of SWP by integrating a risk management framework with adaptive management. The adaptive management approach aims to improve the understanding of the overall results from hydrological, ecological, and geological processes on the quality of water sources [12,18]. This approach helps to develop options in decision-making to reduce the impact of land activities near watershed areas.

The participants all agreed that this strategy was not an official SWP plan, but could fulfill the goal of one. The need for a SWP plan was considered a low priority, as the manager of resource planning for watershed protection explained:

> *Although the Strategic Plan is not considered a drinking water protection plan under the specific requirements of the BC Drinking Water Protection Act, it does fulfill this general purpose. Due to the dedicated purpose of the land to supplying high-quality drinking water, I do not see a need for a source water protection plan.*

The other critical element that facilitates the protection of the watershed drinking water quality in Greater Victoria is the integration of both land use and water management through the jurisdiction of the CRD Water Department. According to the manager of resource planning for watershed protection, the Watershed Protection Division manages the 20,000 hectares of CRD-owned land in the existing and future water supply catchments for the Greater Victoria Water Supply System (GVWSS):

> *Within this area, no public access, commercial logging, farming, mining or recreation is permitted and no use of herbicides, pesticides, or fertilizers is allowed. This source water protection barrier eliminates many organic and inorganic chemicals that can contaminate the source water and virtually eliminates the potential for human disease agents being present.*

The CRD's ownership of water supply land facilitates risk assessment operations, ecological inventories and analysis, and wildlife management. The CRD's senior manager of watershed protection and integrated water service considered the CRD's land ownership to be an opportunity to ensure a supply of high-quality drinking water for the city of Victoria in the long term.

As the manager and services planner in the CRD stated, owning catchment and non-catchment lands for risk reduction and protection promotes watershed quality through prevention:

> *We are in a unique position where the Region owns 90% of the watershed land base and public/industrial access is restricted.*

This is done by the control of public access to water supply lands, careful land stewardship, wildfire prevention and suppression programs, water quality monitoring, watershed security programs, ecological restoration of disturbed areas, and risk reduction activities targeted at the greatest threats to source water quality.

Despite political support for managing watershed quality and implementing watershed management actions and policies, the participants indicated that a lack of financial resources to continue to implement these policies and actions will actually restrict the improvement of the water system in Greater Victoria. Protecting water quality at the source and preventing contamination risks from land-use activities and other natural processes will require a flexible annual budget. When asked to describe the constraining factors that stand in the way of improving the protection program in Greater Victoria, the manager for watershed protection mentioned the tight deadline for preparing the strategic plan as well as:

> *The need to operate within a set annual operational budget and a five-year capital budget. Implementation actions are prioritized and set out in a three-year Service Plan.*

3.2. Saskatoon, Saskatchewan

The South Saskatchewan River supplies the city of Saskatoon with its drinking water. The watershed supports various land-use activities such as agriculture, irrigation, industrial activities and urban development. According to the South Saskatchewan River Watershed Stewards Inc. (SSRWSI), the activity that uses the largest portion of South Saskatchewan River water is agricultural irrigation [13]. The two participants in Saskatoon agreed with issues regarding the impacts of agriculture. These were noted as the main risks, according to the SSRWSI:

> *Mercury is perhaps the most significant risk to water quality, as the flooding of Lake Diefenbaker upstream of the Gardiner Dam dissolved natural mercury in what was previously agricultural land, pasture, or native vegetation. Algae blooms in Lake Diefenbaker are another reoccurring problem, as many of the upland agricultural areas drain into the lake, causing problems with nitrogen concentrations.*

The Watershed Coordinator of the (SSRWSI) mentioned that different land use activities, in both Alberta and Saskatchewan, impact water quality. These activities include feedlots, agricultural activities and other industrial activities such as mining and oil and gas activities. The cumulative effect of these activities is not well monitored or understood. The drinking water intake is located in the South Saskatchewan River and directly upstream of the city of Saskatoon.

Capacity Factors

After the North Battleford, SK, water contamination inquiry in 2002, the Saskatchewan Watershed Authority (renamed the Water Security Agency in 2012) was created by the provincial government with the task of developing watershed-specific SWP plans. The 25-Year Saskatchewan Water Security Plan [14] expanded the scope of watershed planning and management to include actions and arrangements for long-term watershed management plans to ensure safety of watershed quality for water conservation, flood protection and water quality management. Starting in 2007, the SWP plans were developed largely through local watershed groups with technical and financial support from the provincial Watershed Authority. This legal arrangement would ensure SWP plan development on a watershed scale with the goal of drawing together the many diverse actors, stakeholders and rights-holders (Indigenous groups) within the watershed.

While watershed-based SWP plans soon became a water management priority of government, support by legislation, the practicality of plan implementation remains problematic. Good communication, sharing of responsibilities, and a commitment to financial and social support are necessary components for SWP implementation [4]. In the case of Saskatoon, the senior watershed planning coordinator indicated a lack of commitment to cost-sharing, indicating that responsibilities, at both the provincial and local government level, are restricted in regards to implementing the SWP plan in Saskatoon. He explained his concern as:

> *Development of the plan is not normally difficult; lack of implementation is the greatest barrier to success and this is directly influenced by commitments of both resources and money from federal, provincial, [and] municipal governments and First Nations and Métis people and stakeholders. Everyone can agree on what [is needed] the argument is always on who pays.*

This comment suggests that both human and financial capacities are essential to the implementation of the South Saskatchewan SWP Plan. This observation calls for additional research looking at different aspects of SWP planning from plan development to plan implementation.

3.3. Toronto

A broad range of natural and human factors threaten the quality and quantity of Lake Ontario's water. A senior water manager for the City of Toronto working to assess and protect the city's groundwater resources indicated that urban land development in Toronto is one of the most significant factors affecting raw water quality. Based on the approved assessment report in the Toronto and Region Source Protection Area [19], there are several potential sources of fecal contamination that could increase the amount of waterborne pathogens in Lake Ontario. These sources of contamination include river and stream discharge, sewage treatment plant waste, and other shoreline sources ranging from wildlife to diverse urban and agricultural runoff activities [19]. The inventory and assessment of natural and human factors on Lake Ontario through monitoring and assessment programs are key to controlling and protecting water quality, ensuring public safety, and maintaining water quality for current and future generations.

Capacity Factors

Over half a century ago the Government of Ontario developed conservation authorities. These are public sector organizations that develop and deliver resource management programs to safeguard watersheds [20]. Improving and remediating water quality through watershed plans and policies is a

goal of the Toronto Region Conservation Authority (TRCA). In the aftermath of the Walkerton, Ontario, *E. coli* contamination tragedy in 2000, which resulted in seven deaths and damaged public trust in the municipal water supply, the Government of Ontario intensified its technical and institutional efforts to assess the factors that threaten local water sources (ground and surface waters) to help ensure the safety of drinking water quality. The senior water manager for Toronto referred to the TRCA's role in facilitating development of Toronto's proposed SWP plan on a technical level. In partnership with government agencies, watershed councils, and member municipalities, the TRCA has helped establish monitoring programs at the province-wide level. At the groundwater level, the TRCA, in partnership with the Ministry of the Environment, developed a monitoring network to gather and analyze data from well water, providing an early-warning system for changes in water quality influenced by climate conditions and human uses [21].

The TRCA's Regional Watershed Monitoring Program (RWMP), in partnership with the Ontario Ministry of the Environment (OMOE), has been monitoring surface water quality since 2002 with a program that spans nine watersheds. Surface water quality data is tested and analyzed based on a standard set of water quality parameters such as levels of nutrients, bacteria, and heavy metals [22].

The *Clean Water Act 2006* (CWA) introduced the first set of regulations for drinking water source protection and requires that municipalities develop their own SWP plans. The CWA advocates for a science-based, multi-stakeholder process to establish the Toronto and Region Source Protection Authority within the Credit Valley, Toronto and Region and Central Lake Ontario region [23]. Under the requirement of the CWA and Ontario regulations, an assessment report based on technical studies done in the Toronto Region Source Protection Area (TRSPA) was approved by the Ontario Ministry of Environment in 2011. The assessment report provided information on vulnerable areas as well as detailing significant natural events (such as climate change) and human uses such as agriculture and urban development that negatively influence the quality of ground and surface water. The CTC SWP Plan was completed in 2015, a SWP plan covering the largest area by population in Canada.

In spite of the technical tools and institutional support to protect municipal waters, the financial resources for CTC plan implementation are limited and uncertain into the future. For example, the senior water manager referred to two actions requiring external funds that would improve the current level of SWP implementation in Toronto. It was noted that additional funds are required to implement social and educational programs to promote stewardship, outreach, and threat verification:

> *Local people in Toronto must be knowledgeable and aware of their responsibility for effective land-use practices that will help to manage and protect their water sources. Social investment in training and education will increase the city's capacity to implement its SWP plan.*

Second, it was reported that additional financial resources were needed to compensate landowners for property taken under TRCA control. The examples from Halifax and Victoria have shown that placing tracts of land under the jurisdiction of water agencies can achieve and maintain long-term water quality protection. The costs of stewarding water sources and implementing water protection can be prohibitively expensive for landowners in some cases; consequently, cooperation agreements between local government and landowners is necessary for guiding land use and human activity in accordance with best practices. In Toronto, the absence of financial compensations for landowners may reduce landowner desire to comply with government regulations to protect sources of drinking water.

3.4. Halifax, Nova Scotia

The Halifax Water Agency (Halifax Water) manages the city's municipal drinking water supply including the main watershed areas, groundwater supplies, and small water systems within the city. In their responses to the questionnaire, Halifax Water participants emphasized the risks to municipal water supplies in Halifax were due to the threat of forest wildfire and nearby land use activities. A senior manager of water services revealed that recreational water activities are the main issues potentially affecting raw water quality in Halifax. Recreational activities such as swimming, camping,

boating, and fishing have potential to negatively affect water quality. For example, swimming activities have the potential to spread bacterial pathogens to the local drinking water supply. Activities related to expanded urban development, such as road maintenance and associated activities, have caused water quality deterioration; road salt and hazardous materials carried by vehicles along roadways were cited as another potential risk to water quality. A water planner at Halifax Water emphasized how municipal land use activities can affect the local water supply:

> *For surface water supply source areas, which are more remote and contained within wooded areas, the main risk is a forest fire. For other water supply areas, including surface and groundwater supplies that are impacted by residential areas without municipal sewer services, the risks include on-site septic systems and storm water runoff, which carries all sorts of pollution, and recreational activities including boating and off-highway vehicle use; and especially for those that are not provincially designated, the main risk is the lack of regulations and municipal by-laws to help protect the water supplies from land use planning and development activities.*

Natural catastrophic events such as fires, native and invasive forest insects such as Brown Spruce Longhorn Beetles (BSLBs), and wind storms at the main watersheds—Pockwock, Major, and Bennery—could impact water quality, according to the Halifax watershed manager. Halifax Water cooperates with other government bodies to improve and maintain water quality; one such cooperative project occurred in 2009 to limit infestation by the brown spruce longhorn beetle (BSLB) through forest management in the Lake Major watershed area [17].

Capacity Factors

The Province of Nova Scotia's Drinking Water Strategy is based on the recommendations of the Walkerton inquiry and serves as a provincial initiative promoting the protection of water supplies at the municipal level. New regulations have been put in place that require regular testing of all public drinking water supplies; in addition, land-use bylaws require officials to address local water issues and develop sensible solutions for the protection of drinking water supplies. The strategy consists of several initiatives, which include actions, tools, education programs, and the promotion of human resource expertise. These initiatives are intended to work collectively to protect and manage municipal drinking water supplies. The strategy stresses communication between parties to ensure the sustainability of the source water protection plan. The strategy clarifies the roles and responsibilities in the integrated work among multiple government levels, businesses, and other stakeholders.

At the municipal level, the most important political factor facilitating development of the source water protection plan for Halifax is ownership of vulnerable lands by an autonomous utility. The Water Agency's land acquisition program has secured 84% of the three main protected water areas, a total of 13,230 hectares. According to the director of water services, this is the most important factor that facilitated the development of a source water protection plan in Halifax:

> *Because we are an autonomous utility, and we control most of the land, technical factors such as identifying risks, emergency response, etc., are the most important factors.*

Acquisition of the land base allows an organization to manage the use of chemicals, limit access to water supplies, and control or restrict land use activities that have cumulative effects on water quality. In addition, management activities needed to maintain high drinking water quality, such as risk assessment, regular monitoring, and emergency response, can be carried out more easily through a land acquisition program. Recently, Halifax Water started managing the forested land around the watersheds and operating a water-crossing inspection program. This program requires inspection every five years for all water crossing structures (such as bridges) to identify the areas that need repair [17].

Financial support was reported to be a key factor facilitating SWP implementation, assessments, monitoring, and other expenses. The watershed manager referred to an annual budget of

approximately $300,000 to conduct SWP activities. The operating budget comes from a variety of sources, including water rates, property taxes, and sewers and water service fees.

In evaluating the status of the SWP plan in Halifax, this study finds that the plan has been implemented effectively. Two participants indicated that insufficient funding could be limiting the effectiveness of the SWP plan. The SWP process is a long-term commitment, and thus it needs to address the cost of regular monitoring, maintenance and replacement of infrastructure, and periodic hydrological studies and technical assessments. In addition, the plan must address the cost of employing external expertise and training staff to ensure that the plan is running smoothly while addressing new issues that might adversely affect local water quality. A senior manager of water services noted the need for financial resources to cover the external needs of the SWP plan:

> *We do not have the financial resources to do everything we would like to do, but we are in a good position overall.*

A source water protection program can be difficult to develop and implement given that any consensus-based approach requires a long-term commitment and cooperation among multiple stakeholders and provincial and local governments. The watershed manager concluded that the political parties at both the municipal and provincial levels need to support the SWP plan. This was identified as a significant political factor that currently limits the improvement and upgrade of the SWP plans in Halifax.

When asked to describe the main barrier to SWP planning and management in Halifax, all participants cited the lack of watershed regulations to control land-use activities; this lack of legal authority limits the efficacy of the SWP plans. The participants' points of view seem to be consistent regarding the need to ensure that adequate watershed legislation and municipal bylaws minimize risk to source water areas. The senior watershed manager explained that the risk to small systems and areas was not considered in the watershed regulations:

> *Customers with no specific watershed regulations are located in developed areas and one in an agricultural area. Problems range from nutrient loading to storm water run-off.*

Capacity needs for the four metropolitan case study areas are shown in Table 2.

Table 2. Case study capacity needs for SWP planning.

City	Main Treats to Source Water	Capacity Gaps Facing SWP	Capacity Strengths Supporting SWP
Victoria	Natural events: wildfire; soil erosion; climate change; ash loading	Lack of financial resources (capacity) to implement all the policies and management actions. Lack of human capacity to prepare and implement plans.	Political and legal capacity through the *BC Drinking Water Protection Act (2001).* Integrated strategic plan of the CRD. CRD owns much of the watershed area.
Saskatoon	Agricultural nutrients; mercury from the Gardener Dam; upstream activities pose cumulative effect	Financial and human capacity to support SWP plan implementation.	Political and legal arrangement of Water Security Agency to develop SWP plans is the more populated southern watersheds.
Toronto	Urban land development impacting groundwater sources. Discharge of coliforms into Lake Ontario from sewage plants, urban development, agriculture, wildlife	Financial capacity for plan implementation appears to be limited. Financial support needed for education, outreach and for compensation to land owners.	Technical support of the Conservation Authorities. Political and legal support from MoE to the Conservation Authorities to produce SWP plans. Science based, multi-stakeholder approach.
Halifax	Threat of forest fires on surface water sources. Land use activities on and around the reservoirs/lakes, including recreation, urban development and roadway maintenance	Financial resources may be a limiting factor in plan implementation, education programs, monitoring. Fixed budget may be insufficient.	Political and legal capacity to own land and control land uses in source water areas.

4. Discussion

All participants in this research strongly identify the critical role of provincial governments to support SWP planning and management through legislation, strategies and policies. The extent to which political capacity is present to facilitate development of a SWP plan is considered the most significant of the five capacity areas. Additionally, all participants suggested that the requirements of provincial regulations including tools such as safe drinking water strategies and the requirements of drinking water legislation have played a significant role in supporting effective SWP activities. At the metropolitan scale, delegated authority from the provincial government to the local scale to control land use activities will not necessarily protect water supplies. Conflicting interests of metropolitan governments between resource extraction (e.g., forest harvesting) and source water protection may jeopardize long term water quality conditions. A mandatory requirement from more senior government to produce SWP plans, such as what exists in both Ontario and Nova Scotia will more positively result in effective SWP planning and management. The importance of autonomy over land use decisions through watershed ownership for the protection of drinking water supplies will enable the restriction of public access to the benefit of source protection planning. This is the case for Victoria and Halifax. However, metropolitan-scale ownership of drinking water sources is much more the exception than the norm in Canada where provincially-owned ("Crown") land is subject to multiple forms of resource extraction including forestry, oil exploration and transportation, and mining all to the potential detriment of source water.

Next, a stable and long-term budget is important and a requisite to facilitate SWP planning. Watershed management generally and SWP specifically require long-term financial commitment and support. In the results of this study, similar to other studies in rural and small communities, participants consistently expressed concern over the need for adequate and sustained funding to both develop and implement SWP plans. Furthermore, additional funding is needed to increase local awareness of SWP planning through public education and outreach programs.

In this research, we found a lack of human capacity to support SWP implementation. Some metropolitan staff working in the field of water management acknowledged they had insufficient training and knowledge in source water protection planning and management. Long term commitment to planning requires a commitment to plan implementation. Having adequately trained personnel in place is critical to long term plan implementation.

5. Conclusions

This qualitative case study identifies typical threats to metropolitan drinking water sources and the associated management actions to reduce those threats. In addition, the utility of the capacity-building literature was examined with respect to SWP in metropolitan areas. Based on the results, political capacity was the most significant capacity-related factor to influence SWP planning and management. Technical capacity was the second most significant capacity-related factor identified in the research.

Similar to rural and small communities, this research has shown the important of capacity as a necessary requirement to advance SWP planning and management. Additionally, an equally important discovery draws attention to the issue of scale. The case studies in this paper represent two distinct scales of authority, one local, or metropolitan, and the other provincial. At the local, or metropolitan scale, both Victoria and Halifax exercise direct authority over SWP planning and management. In the case of Victoria, metropolitan ownership of the watershed enables direct control over land use planning and all land- and water-based activities. In the case of Halifax, a similar arrangement of land ownership enables control over land use practices. In both cases, responsibility for SWP planning and management is vested with the metropolitan water district. By contrast, responsibility over SWP planning and management for both Toronto and Saskatoon are vested with provincial agencies. In the case of Toronto, a consortium of conservation districts administers a regional SWP plan that includes the Greater Toronto Area. In the case of Saskatoon, a provincial water agency established a watershed-based plan that includes the City of Saskatoon.

At both the local and provincial scale, there are likely to be advantages and disadvantages for effective SWP planning and management. It was not the purpose of this study to make that determination although further investigation into this topic is encouraged.

The results of this study underscore the critical importance of protecting metropolitan drinking water sources in Canada. To date, the emphasis in metropolitan Canada has been on the advancement of water treatment technology to "fix" any drinking water quality problems. While such an approach is prudent, so too is the protection of drinking water sources, an area of study receiving much less attention. The scale at which metropolitan SWP occurs is perhaps less important than the need for a commitment from metropolitan governments to undertake capacity-building for the purpose of supporting SWP planning. Political and technical capacity appeared to overshadow other forms of capacity in this single study. It is recommended that further research into the capacity-building needs to support metropolitan SWP planning be undertaken in Canada.

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