Government of Canada Policy Research Initiative
Gouvernement du Canada Projet de recherche sur les politiques

WORKING PAPER SERIES 028

SUSTAINABLE DEVELOPMENT

The Canadian Water Sustainability Index (CWSI) Case Study Report

Centre for Indigenous Environmental Resources

and

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August 2006

Canada

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PRI Project
Sustainable Development

Policy Research Initiative Working Paper Series

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Série de documents de travail du Projet de recherche sur les politiques

La série de documents de travail présente les travaux d'analyses en cours réalisés dans le cadre des projets horizontaux du PRP. Les articles sont présentés uniquement dans la langue dans laquelle ils ont été rédigés, avec un résumé dans les deux langues officielles. Ils ne reflètent pas l'opinion définitive du Projet de recherche sur les politiques du gouvernement du Canada.

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The Canadian Water Sustainability Index (CWSI) Case Study Report

Abstract

The Policy Research Initiative (PRI) Sustainable Development Team began working on the Canadian Water Sustainability Index (CWSI) in the summer of 2005[1] as part of a broader project on freshwater[2]. Inspired by the Water Poverty Index[3], the PRI developed a draft framework[4] for a composite water index that could be used to assess various elements of water well-being in Canadian communities. This draft CWSI framework provided the basis for a data review and an expert workshop. Outcomes from the data review and the workshop, as well as additional consultation and information sources, were used to further refine the index framework and develop an evaluation methodology that could be tested in the field. This working paper presents the results of the field testing exercise. Despite a number of data gaps, several indicator scores were determined for the six participating communities. Overall the index was well received and the communities felt that, with some improvement, a tool like the CWSI would be useful.

Résumé

L'équipe du développement durable du Projet de recherche sur les politiques (PRP) a commencé des travaux sur l'Indice canadien de la durabilité des ressources hydriques (ICDRH) durant l'été 2005[5] dans le cadre de son projet sur l'eau douce[6]. En s'inspirant de l'Indice de pauvreté en eau[7], le PRP a élaboré un cadre provisoire[8] d'indice composé sur les ressources hydriques qui servirait à évaluer les différents éléments liés à l'état général de l'eau douce dans les collectivités canadiennes. L'ébauche de ce cadre a jeté les bases d'un examen des données et d'un atelier d'experts. Les résultats de l'atelier et de l'examen des données – de même que des renseignements provenant de consultations et de diverses sources – ont été utilisés pour préciser le cadre de l'indice composé et évaluer la méthodologie qui pourrait être mise à l'essai sur le terrain. Le présent document de travail énonce les résultats d'essais accomplis sur le terrain. Malgré certains écarts entre les données, on a pu attribuer une note à plusieurs indicateurs dans les six collectivités participantes. Dans l'ensemble, l'ICDRH a été bien accueilli et les collectivités étaient d'avis qu'avec un peu d'amélioration, l'ICDRH serait utile.

Preface

The Policy Research Initiative (PRI) Sustainable Development Team began working on the Canadian Water Sustainability Index (CWSI) in the summer of 2005[9] as part of a broader project on freshwater[10]. Inspired by the Water Poverty Index[11], the PRI developed a draft framework[12] for a composite water index that could be used to assess various elements of water well-being in Canadian communities. This draft CWSI framework provided the basis for a data review and an expert workshop. The data review was a study of existing water related data that was prepared by Tri-Star Environmental Consulting[13]. The study presents a compilation of primarily national datasets for a number of potential CWSI indicators. The data study also identified thematic and geographical data gaps.

The workshop was held in November to discuss the development of the CWSI. Key water policy and indicator experts from Canada and abroad attended. Outcomes from the data review and the workshop along with additional consultation and information sources were used to further refine the index framework and develop an evaluation methodology that could be tested in the field. This working paper presents the results of the field testing exercise.

Introduction

In February 2006, the PRI contacted the Centre for Indigenous Environmental Resources (CIER) to conduct a field test of the CWSI with six communities in Canada using the evaluation framework and methodology that had been developed by the PRI. This working paper contains portions of a broader case study report and presents the results of the field testing. It also describes the methodology conducted to acquire the case studies and Index scores of the six participating communities as well as an analysis of the Index based on our use of the tool, feedback from the participating communities and discussions with governmental personnel.

The CWSI is a composite water index developed by the PRI that provides a measure of community well-being with respect to freshwater. The index incorporates a range of water related data into a standardized evaluation framework and consists of fifteen indicators that are organized into five policy relevant components (*Table 1*). The indicators and components allow for specific freshwater issues and themes to be explored. When aggregated, they can provide a comprehensive and simple community profile reflecting the integrated nature of our freshwater resources.

The CWSI evaluation methodology provided in Appendix 1 outlines the calculations required for determining the 15 indicator scores and in turn the component and final index scores. The final CWSI score for a community is on a scale of 0 to 100. The higher the score, the greater is the water well-being in the community with respect to the state of the water resources, services and ecosystems, and the ability of the community to be effective water stewards.

Table 1 - Canadian Water Sustainability Index Framework

	Component	Indicator	Description
Canadian Water Sustainability Index	Resource	Availability	The amount of renewable freshwater that is available per person
		Supply	The vulnerability of the supply as caused by seasonal variations and/or depleting groundwater resources
		Demand	The level of demand for water use based on water license allocations.
	Ecosystem Health	Stress	The amount of water that is removed from the ecosystem
		Quality	The Water Quality Index score for the protection of aquatic life
		Native Fish	Population trends for economically and culturally significant fish species
	Infrastructure	Demand	How long before the capacity of water and wastewater services will be exceeded due to population growth
		Condition	The physical condition of water mains and sewers as reflected by system losses
		Treatment	The level of wastewater treatment
	Human Health	Access	The amount of potable water that is accessible per person
		Reliability	The number of service disruption days per person
		Impact	The number of waterborne illness incidences
	Capacity	Financial	The financial capacity of the community to manage water resources and respond to local challenges
		Education	The human capacity of the community to manage water resources and address local water issues
		Training	The level of training that water and wastewater operators have received.

Indicator, component and final composite scores were derived for six case study communities. Component and indicator scores ranged from 0 to100 with final composite scores ranging from 52.9 to 87.4. For all of the communities data did not exist or were commonly unavailable for several indicators. Overall, indicator scores that could be derived accurately reflected the community's status on the respective indicator at that point in time. However, given the data gaps, many component scores could not be considered accurate representations of the community's status regarding that component.

During follow-up interviews, participants noted that their results could be drawn upon to inform planning activities relating to water and wastewater infrastructure and to support the need for research studies, training, and funding. They also noted that the Index could be extremely useful if applied by communities within the same region or communities that rely upon the same water body or source. Used in this way, communities could compare their scores while simultaneously acquiring a general understanding of both the state of their area and their collective ability on a regional level to address water sustainability.

Acknowledgements

This project required the cooperation and assistance of numerous individuals. CIER would like to extend its sincerest thanks to these individuals for their commitment and willingness to participate in this project.

For their assistance with the Chetwynd community case study, our thanks extend to:

- R.M. Chetwynd: Gord Gosse, Engineering Technician; Rob Crisfield, Deputy Director of Engineering and Public Works; and
- Government of British Columbia: Ministry of Environment: Bruce Carmichael, Impact Assessment Biologist; James Jacklin, Water Technician; Cory Williamson, Fish Biologist; Tom Muirhead, Water Technical Officer.

For their assistance with the Tsuu T'ina First Nation and Three Hills community case studies, our thanks extend to:

- R.M. Three Hills: Len Dyck, Operator; Jack Ramsden, CAO;
- Tsuu T'ina First Nation: Lee Crowchild, Infrastructure Manager and Acting Band Administrator;
- Government of Alberta, Environment: Dave Cable, Groundwater Technologist; Brian Free, Environmental Reporting Coordinator; Chacko Abraham, Water Quantity Technologist; Karl Runions, Water Quantity Technologist; Sean Douglas, Hydrologist;
- Government of Alberta, Sustainable Resource Development: Jim Wagner, Provincial Fish Culture Specialist; Michael Sullivan, Provincial Fisheries Science Specialist;
- Indian and Northern Affairs, First Nations Relations, Treaty 7: Shannon Pagotta, Environmental Officer; and

- Environment Canada, Water Survey, Alberta: Tim Davis, Supervisor, Hydrological Services.

For their assistance with the Pelican Lake First Nation case study, our thanks extend to:

- Pelican Lake First Nation: Chief Peter Bill; Band Councilors Willie Thomas, David Thomas, Pete Sakebow, Romeo Thomas, Dennis Lewis, Frederick Whitehead; Herb Fiddler, Band Administrator; Hector Beeds, Director of Operations and Land Management; Wane Bill, Water Truck Operator; Darren Mosquito, Operator;
- Agency Chiefs Tribal Council: Glen Hartz, Technical Services Manager; Brian Lewis, Water Quality Technician;
- Government of Saskatchewan, Environment: Ken Armstrong, Conservation Officer, Chitek Lake;
- Government of Saskatchewan, Saskatchewan Watershed Authority: Curtis Paterson, Senior Technician; Al Keller, Technician, Regional Operations; Cas Rogal, Coordinator, Ground Water Approvals; Dalvin Euteneier, Manager, River Forecast Centre;
- Environment Canada, Water Survey, Regina: Scott Hill, Hydrometric Technologist; and
- Statistics Canada: Lorenzo Corea, Account Executive.

For their assistance with the Gimli case study, our thanks extend to:

- R.M. Gimli: Jack Feschuk, Supervisor; Operators Tom Kmet, Richard Bezdietny, and Ovide Ouellette;
- Government of Manitoba, Water Stewardship: Robert Betcher, Manager; Walt Lysack, Fisheries Assessment Biologist; Robert Matthews, Manager, Water Licensing Branch; Joe O'Connor, Director; Don Rocan, Manager; Ed Chorniuk, Data Management; and
- Government of Manitoba, Conservation: Bruce Webb, Water Development and Control Assessment Officer.

For their assistance with the Moose Cree First Nation case study, our thanks extend to:

- Moose Cree First Nation: Chief Patricia Faries; Jean Sayers, CEO; John Turner, Forestry Liaison; Howard MacDonald, Senior Operator; Karen Weistche, Office Manager, Health Department;
- Health Canada: Gilles St. Pierre, Environmental Health Officer;
- Government of Ontario, Environment: David Hollinger, Supervisor, Water Resources; Jacinth Gilliam-Price, Permits To Take Water (PTTW) Coordinator;
- Government of Ontario, Natural Resources: Ken Corston, Fire/Flood Technician; Christopher Chenier, Area Biologist; and
- Weeneebayko General Hospital: Derrick Gourley, Director of Support Services.

In addition, we would like to thank the Policy Research Initiative for the opportunity to work on this exciting project and Anne Morin for her guidance throughout the project.

Case Study Methodology

A case study methodology was chosen by the client, the PRI, to field-test the Index. In total six communities from throughout Canada participated in the project. The following outlines the research methods involved in the five phases of the project.

Phase 1: Community Selection and Request for Participation

The PRI provided CIER with a list of criteria to use to identify communities to invite to participate in the study. To participate in the project communities must have met the following criteria:

- Is First Nations or non-Aboriginal;
- Exists in rural and/or remote locations;
- Has a population between 1,000 and 5,000;
- Has a primary, identifiable form of economic development such as agriculture, resource-based industry (forestry, mining, oil and gas) or other economic activity (tourism);and;
- Is experiencing a water challenge perceived by the community related to water quality and/or quantity.

When identifying communities for participation in this project, CIER also strived to account for geographical and cultural diversity, particularly for the participation of First Nations. For example, CIER requested and secured the participation of First Nations from various cultural backgrounds such as the Cree and Sarcee.

In total sixteen communities were contacted and eleven invited to participate in the project. Six of these communities were confirmed for participation. The other five communities declined participation, did not respond to the invitation, or responded to CIER after the deadline for response had passed.

The following table identifies and briefly characterizes the six participating communities:

	Agricultural	Resource-Based	Other
First Nation	Pelican Lake First Nation, Saskatchewan Rural community Population: ~2200 Hay crops, bison and cattle ranching Water issue: water quality	Tsuu T'ina Nation, Alberta Rural, but adjacent to Calgary Population: ~1900 Gas development Water issue: water quality and quantity	Moose Cree, Ontario Remote Population: ~1700 Tourism and ecotourism Water issue: water quantity, jurisdictional issues related to water responsibility
Non-Aboriginal	Three Hills, Alberta Rural community Population: ~3500 Primary industry is agriculture, followed by oil and gas production Water issue: water quantity	Chetwynd, British Columbia Rural community Population: ~2800 Numerous industries as the area is rich in oil, gas, coal and timber Water issue: water quality	Gimli, Manitoba Rural community Population : ~3500 Tourism Water issue : water quality

CIER contacted each community by telephone. For the First Nations, the first point of contact by CIER was the Chief and Council, followed by individuals working as federal government Environmental Health Officers or in First Nation government departments dealing with water and wastewater treatment. For the non-Aboriginal communities, the first point of contact was the Mayor, followed by individuals working in the municipal office, specifically the public works department.

A script was developed and used by CIER Project Team members to guide them during the initial telephone call. The following points were discussed during the initial approach to communities:

- Background on the Centre for Indigenous Environmental Resources (CIER);
- Purpose of the call: to invite their community to participate in Canadian Water Sustainability Index Case Studies project;
- Description of the project;
- Reason(s) that their community was being invited;
- Participation requirements (e.g., number of interviews, time required for interviews, etc.); and
- Anticipated costs and benefits to the community.

Following each telephone call, CIER sent the community a Request for Participation document. This document was written using accessible language in order to reach a diverse audience. It provided the same information discussed during the telephone call, included the PRI's CWSI table identifying the components and indicators of the tool, and described its data requirements. This document was provided as a discussion piece for communities to use in deciding whether or not to participate in the study.

A follow-up call was made to each community to confirm their participation a few days after sending the Request for Participation document.

Phase 2: Data Collection

A variety of data on various aspects of water quality and quantity was required by the PRI to determine the Index score for each community. CIER's task was to gather this data from a variety of sources such as the case study communities, all levels of government, and non-government bodies.

Community Survey and Interviews

A survey was developed to acquire the data necessary for the index scores. Subsequent interviews were held with representatives of each case study community. The majority of the questions in the survey sought quantitative data for the Index however several questions included sought qualitative information. These questions were included to provide interviewees with opportunities to share information that would provide CIER and, subsequently, the PRI with valuable information about the realities and concerns of the communities relating to water sustainability.

Conversations with Federal and Provincial Government Personnel

To fulfill community survey requirements, project team members also contacted federal and provincial government personnel in attempts to acquire data.

Searching Online Governmental Databases

Online searches of existing government databases were conducted. Often these sources were recommended by government personnel as authoritative sources for the data required.

Phase 3: Calculation of CWSI Indicators and Final Index Score

All data gathered during the data collections phase was synthesized into a master file. All community scores were calculated using the evaluation framework provided to CIER by Anne Morin (*Appendix 1*). When all data requirements were available, an indicator score was derived. However, given some of the data gaps, some indicator scores could not be derived for each participating community. Component scores were derived through averaging its three indicator scores and were calculated even when some of its indicator scores were not calculable.

Phase 4: Analysis of Results

Results of the indicator and component scores were analyzed for each community. Further comparative analyses were conducted between the First Nations and non-Aboriginal communities and between the various communities related to their primary form of economic development. In addition a broad analysis was conducted of the utility, applicability, and relevance of the Index.

Phase 5: Follow-up Interviews

Follow-up interviews were conducted with the participating communities via conference call from April 18-25, 2006. Prior to each interview, communities were provided with a community profile drafted by CIER and based on information the communities provided during their initial interviews. Each profile provided descriptive information about the community population, geographic location, primary form of economic development, perceived water issue(s), and water and wastewater infrastructures. Finally the community profiles outlined each community's CWSI scores for each indicator and component, as well as its final composite score.

The purpose of the interviews was two-fold: to receive feedback from the participating communities on their score and the CWSI tool, and, wherever possible, to assist them with its interpretation. CIER asked participants the following questions during the follow-up interview:

- What are your thoughts on how we have described your community, including the water and wastewater systems? Is this an accurate description?
- What thoughts do you have about your community's Index score? In your view, does it accurately reflect your community's situation and represent the sustainability of the water?
- What thoughts do you have about your community's individual indicator scores?
- Based on the information that you have about the Index and your community's score, what do you identify as the strengths and weaknesses of the Index?
- What uses will this information (the Index score) have in your community?
- Would you use this tool to calculate the score for your community?

Each interview was audio taped to allow CIER to revisit the responses during the final analysis. The results have been incorporated in *Section 7.5: Feedback from the Communities – Follow-Up Interviews.*

Case Study Results and Analysis

The following section provides the case study for each community that participated in the project. Each case study provides a brief description of the community, including information about its demographics, water and wastewater infrastructures, capacity to address water and wastewater issues, and its final composite index score which was calculated using the methodology presented in Appendix 1.

Tsuu T'ina First Nation, Alberta

Tsuu T'ina First Nation is located in southern Alberta. The traditional territory of the Nation includes the majority of southwestern Alberta. Calgary, the closest major urban centre to the community, is located on the eastern boundary of the reserve. According to Statistics Canada Census 2001, Tsuu T'ina First Nation has a population of 1,982, an increase from its 1996 population of 1,509.[14] The majority of its population is between the ages of 5 to 14 and 25 to 44, a relatively young population.[15]

Tsuu T'ina First Nation is engaged in a number of economic development activities, primarily oil and gas exploration and development. In addition, the community owns and operates several businesses such as Redwood Meadows Golf and Country Club, Wolf's Flat Ordnance Disposal Corporation that addresses the clean-up of military explosive ordnance contamination on Nation lands, Sarcee Gravel, and Tsuu T'ina Gas Stop.[16]

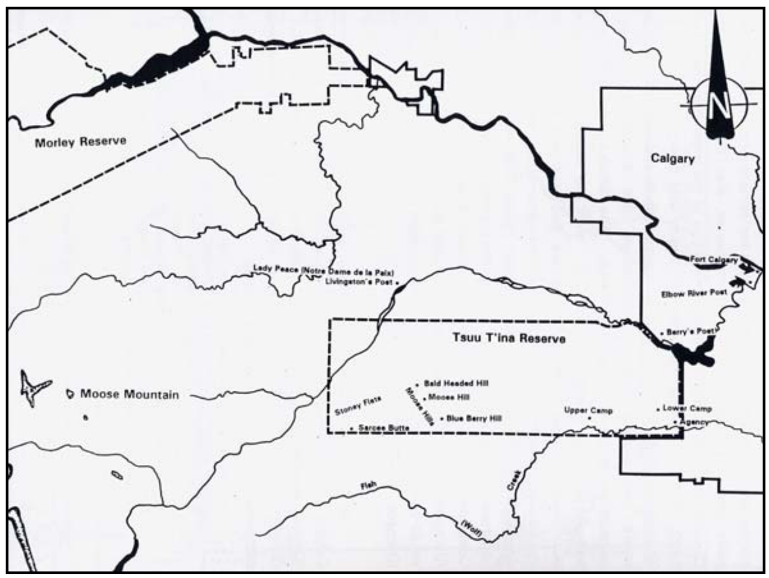

***Figure 1: Tsuu T'ina Reserve**. Source: Tsuu T'ina Nation web site: http://www.tsuutina.ca/page.aspx?pageID=1-3*

Water Supply, Collection, Treatment and Distribution System

The community acquires its water from both groundwater and surface water sources, the Elbow River. Though the majority of homes in the community are serviced by domestic wells, some receive treated water through an agreement with the City of Calgary, the community's water truck hauling service, or via a distribution pump.[17] The water that is hauled and/or distributed through the distribution pump is obtained from a drilled well in the community that pumps the water to the Fire Hall water treatment plant.[18] Prior to distribution throughout the community, the water is filtered through iron filters and chlorine is added.

The community believes that the frequent seismic activities occurring in the area are negatively impacting the water quality though no formal testing has been conducted to confirm or corroborate this belief.[19] The drought-like conditions in the southern part of

Alberta have resulted in water quantity issues. Tsuu T'ina has experienced wells drying up and has needed to drill new wells in response to meet its water needs.

Wastewater Collection and Treatment

The majority of the homes in Tsuu T'ina are serviced by septic tanks.[20] However piped wastewater collection does occur for a small number of the homes in the community as well as for its elementary and junior high schools. This wastewater flows to two lift stations that pump it into the community's two-celled lagoon. After the requisite amount of time in the lagoon, the treated effluent is discharged to the ground and either percolates into the ground or flows to a small slough nearby.

Canadian Water Sustainability Index Score and Analysis

Data gathering for Tsuu T'ina First Nation was challenging, given that the individual interviewed from the community was serving in two roles: Manager of Infrastructure and Acting Band Administrator. As he was extremely busy, he was unable to acquire several of the data pieces to populate the Index despite excellent efforts to do so. Similar time constraints existed to some extent in all of the communities. The workload of the water and wastewater treatment staff CIER met with was extremely heavy, making it difficult for people to allocate time toward this project. Though Tsuu T'ina First Nation willingly provided CIER with all of the information readily accessible to them, 50 % of the data requirements were either not available or not provided.

Due to time constraints, Tsuu T'ina First Nation was unable to participate in the follow-up interview. Therefore, this brief analysis is based on CIER's perspective of the results and has not been confirmed by the community.

Tsuu T'ina First Nation's final composite score was 52.9. *Component 1: Freshwater Resources* received a score of 50.0 indicating that, while freshwater resources are available, the supply to the community is vulnerable (*Indicators 1: Availability* and *2: Supply*). However as data on water demand (*Indicator 3: Demand*) was not available, the score for this component is not complete. As with the other participating communities, insufficient data was available to assess *Component 2: Ecosystem Health.* For *Component 3: Infrastructure* the low score of 11.7 resulted for two reasons. First, with their current rate of population growth, Tsuu T'ina First Nation's infrastructure might not be able to address demand for water services in the relatively near future (*Indicator 7: Demand*). Second, given that less than one third of the population is connected to the secondary sewage treatment system, since the majority has septic tanks, the score for wastewater treatment was low (*Indicator 9: Treatment)*. *Component 4: Human Health and Well-Being* received a high score of 100 but it is questionable given that a score for *Indicator 10: Access* was not available. For *Component 5: Community Capacity*, a score of 50.0 was derived, which accurately reflected that the community has an educated population, but their operators have not generally obtained adequate training in the areas of water and wastewater treatment *(Indicators 14: Education* and *15: Training)*. As with all of the communities, an indicator score could not be derived for *Indicator 13: Financial Capacity.*

The table that follows provides Tsuu T'ina First Nation's score for each indicator and component of the Index as well as the community's final composite score.

TSUU T'INA FIRST NATION		
Component and Indicators	**Indicator Score**	**Component Score**
Component 1: Freshwater Resources		
Indicator 1: Freshwater availability per person	100	**50.0**
Indicator 2: Freshwater vulnerability	0	
Indicator 3: Freshwater allocations	No data	
Component 2: Ecosystem Health		
Indicator 4: Ecosystem stress	No data	**Not calculable**
Indicator 5: Water quality	No data	
Indicator 6: Native fish population	No data	
Component 3: Infrastructure		
Indicator 7: Demand for water services	8.8	**11.7**
Indicator 8: Condition of infrastructure	No data	
Indicator 9: Wastewater treatment	14.7	
Component 4: Human Health and Well-Being		
Indicator 10: Access to potable water	No data	**100.0**
Indicator 11: Drinking water reliability	100	
Indicator 12: Waterborne illness	100	
Component 5: Community Capacity		
Indicator 13: Financial Capacity	No data	**50.0**
Indicator 14: Work force education	100	
Indicator 15: Treatment plant operator training	0	
Canadian Water Sustainability Index Composite Score		**52.9**

Pelican Lake First Nation, Saskatchewan

Pelican Lake First Nation is located along the shores of Chitek Lake, approximately 200 kilometres northwest of Prince Albert. Pelican Lake First Nation has a population of approximately 1,241 individuals.[21]

The primary form of economic development for the community is agriculture, specifically hay production and bison and cattle ranching. Pelican Lake First Nation owns and operates numerous businesses, including the Pelican Lake Store, Pelican Lake Mall, Chamakese Resort, Spruce Creek Bison Ranch, Junor Farms, Pelican Lake Bingo Hall, Pelican Lake Heavy Equipment, and Golden Eagle Leathercraft.

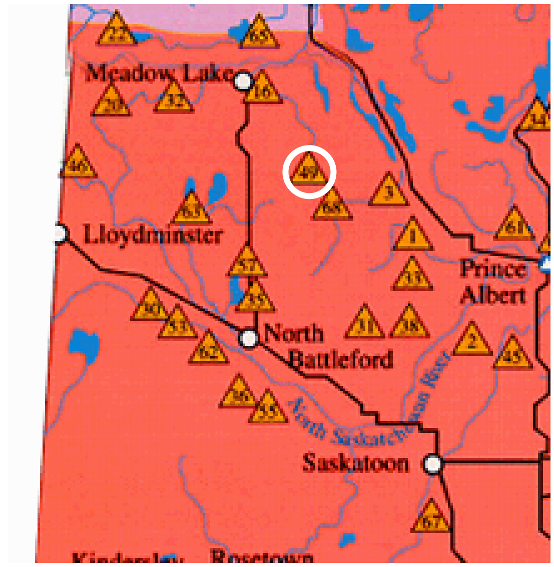

Figure 2: Pelican Lake First Nation (circled area)*. Source: Indian and Northern Affairs Canada website - http://www.ainc-inac.gc.ca/sk/fnmap_e.html*

The main water issue for the community is quality, although community members have been advised to ration water during periods when water delivery is hampered, during winter months when roads and other factors slow the delivery process.[22] Interviewees noted that community members are concerned about water quality, surface water contamination resulting from the extensive farming activities, forestry operations and increased tourism in the area.

Water Supply, Collection, Treatment and Distribution System

The community acquires most of its water from Chitek Lake through a direct, low pressure line and the community water hauling service. It also receives some water from four wells located within the reserve boundaries. Recently the community moved from a groundwater to a surface water treatment system. The water made available through the community water line and water trucks receives treatment for pre-chlorination, coagulation, sand and gravel filtration, ultraviolet filtration, aeration, and post-chlorination, followed by settling and a final chlorination process.

Water testing occurs bi-weekly at the household level with weekly testing occurring at the water treatment plant. The water trucks and the water plant are thoroughly cleaned once each year.

Wastewater Collection and Treatment

The community has three sewage lagoons, one of which was added to an existing lagoon in 2005.[23] The lagoons are treated with a deodorizer, with degreasing occurring at the three community lift stations. After the requisite amount of time in the lagoon, the wastewater is tested and subsequently released into a nearby marsh.

Canadian Water Sustainability Index Score

Pelican Lake First Nation's overall score was 64.3. A score of 100 for *Component 1: Freshwater Resources* indicates that the community has a sufficient supply of water (*Indicator 2: Supply)* though data for *Indicators 1: Freshwater Availability* and *3: Freshwater Allocations* was unavailable. These indicators in addition to *Indicator 4: Ecosystem Stress* require streamflow and run-off data but no federal water monitoring station exists near the community to record streamflow and surface water run-off existing in that area. Though two provincial monitoring stations exist that could more accurately record the water situation in that area, the data from one station was compromised and the data from the other station had not yet been processed. Pelican Lake First Nation acquires their water from Chitek Lake. However the Index does not include a calculation for water that is acquired from a lake source. It utilizes stream flow data only. This has implications for the accuracy of the Index score for these communities.

As with the other participating communities, insufficient data was available to assess *Component 2: Ecosystem Health*. For *Component 3: Infrastructure*, Two of the data pieces were not available (*Indicators 7: Demand* and *8: Condition*). Although the community had a score of 66.7 for this component attributed to their entire population being connected to a secondary wastewater treatment system, the overall component score is not comprehensive.

A score of 65.3 was derived for *Component 4: Human Health and Well-Being*. The majority of the points deducted related to *Indicator 12: Impact*. The community received a score of "0" for this indicator as it had experienced an incidence of waterborne illness wherein 10 people were affected. For *Component 5: Community Capacity*, a score of 25.0 was derived, accurately reflecting the human capacity limitations faced by the community (*Indicator 14: Education*). Points received for this component recognized that the current operators have received training for water and wastewater treatment (*Indicator 15: Training*). As with all of the communities, an indicator score could not be derived for *Indicator 13: Financial Capacity*.

In total, 53 % of the data requirements for Pelican Lake First Nation were not available or not provided, resulting in a score that appears average in comparison with the other participating communities but is not necessarily accurate overall given the data gaps.

The following table provides Pelican Lake First Nation's score for each indicator and component of the Index as well as the community's overall score.

PELICAN LAKE FIRST NATION		
Component and Indicators	**Indicator Score**	**Component Score**
Component 1: Freshwater Resources		
Indicator 1: Freshwater availability per person	No data	**100.0**
Indicator 2: Freshwater vulnerability	100	
Indicator 3: Freshwater allocations	No data	
Component 2: Ecosystem Health		
Indicator 4: Ecosystem stress	No data	**Not calculable**
Indicator 5: Water quality	No data	
Indicator 6: Native fish population	No data	
Component 3: Infrastructure		
Indicator 7: Demand for water services	No data	**66.7**
Indicator 8: Condition of infrastructure	No data	
Indicator 9: Wastewater treatment	66.7	
Component 4: Human Health and Well-Being		
Indicator 10: Access to potable water	100	**65.3**
Indicator 11: Drinking water reliability	96	
Indicator 12: Waterborne illness	0	
Component 5: Community Capacity		
Indicator 13: Financial Capacity	No data	**25.0**
Indicator 14: Work force education	0	
Indicator 15: Operator training	50	
Canadian Water Sustainability Index Composite Score		**64.3**

Moose Cree First Nation, Ontario

Moose Cree First Nation is located near the mouth of the Moose River on Moose Factory Island, 12 kilometers south of the southern tip of James Bay.[24] The closest urban centre to the community is Timmins, Ontario. The neighbouring community is the town of Moosonee, located on the mainland approximately three kilometers from Moose Cree First Nation.

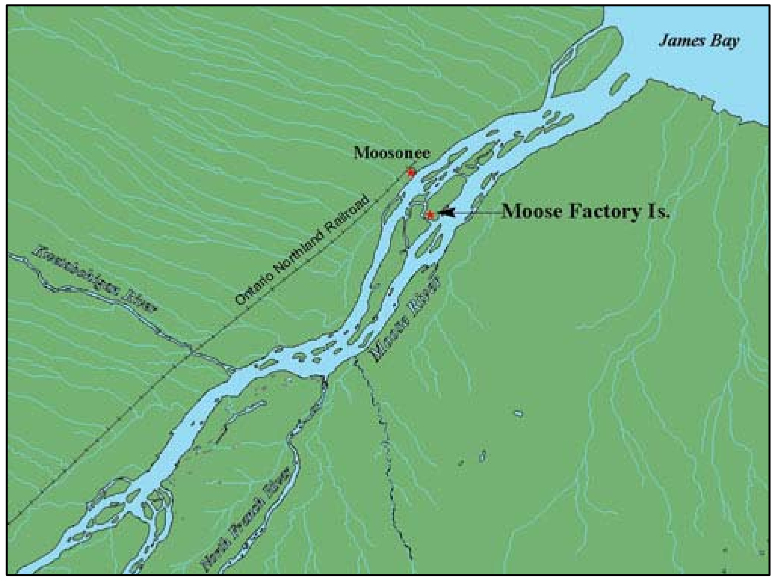

Figure 3: Moose Cree First Nation. *Source: Moose Cree First Nation website - http://www.moosecree.com/community-profile/geography.html#island-size*

As of 2005, the on-reserve population of Moose Cree First Nation was 1,714 individuals.[25] The primary form of economic development for the community is through tourism initiatives. Moose Cree currently owns and operates the Tidewater Goose Camp, Cree Cultural Interpretive Centre, Kesagami Lake Fishing Lodge (40 % ownership), and Moose Cree Outdoor Discoveries and Adventures. Planning is currently underway for the establishment of the Washow James Bay Wilderness Centre.

Water quantity has been an issue for the community. Until recently the water was shut off nightly from midnight to 5:00 a.m. to ensure adequate amounts of drinking water for community members during the day. Interviewees noted that, if a fire were to occur in the community, putting it out would likely deplete the water stores available, leaving no water available to the community until the system was replenished and the water treated. However, due to system upgrades, the water is no longer turned off during the evening.

Water Supply, Collection, Treatment and Distribution System

The community acquires its water from the Moose River and water is distributed to community members through a main water line.[26] The history of the water treatment plant in Moose Cree is unique. The island is divided into three jurisdictions: First Nation, a municipal area, and a federal area. Two water treatment plants exist in the area: one plant approximately fifty years old and the other approximately fifteen years old. Both treatment systems are in housed within the Weeneebayko General Hospital on federal land.

Though the water treatment plant is owned by the hospital, it has been managed and operated by Moose Cree First Nation and overseen remotely by a local authority, the Ontario Clean Water Agency (OCWA). Control over the management and operation of the water treatment system was transferred from the Weeneebayko General Hospital to the Moose Cree First Nation approximately five years ago. To optimize operations, within the next six to nine months OCWA will assume the management of the plant with Moose Cree First Nation retaining its operational responsibility.

Currently, both water treatment plants are at full capacity. Though the systems could produce more treated water, particularly the newer system, there is inadequate storage capacity available to hold the water until its distribution thus limiting treatment plant capacity.

Wastewater Collection and Treatment

The community has one sewage lagoon with three aerated cells. Wastewater is pumped through sewage pipes to the lagoon where it remains for the requisite amount of time. After this period, it is discharged into the Moose River.

Canadian Water Sustainability Index Score

Moose Cree First Nation's overall score was 65.7. A score of 33.3 for *Component 1: Freshwater Resources* indicates that a sufficient amount of water resources are available per person but freshwater supply is vulnerable and is 100 % allocated through water permits (*Indicators 1: Availability*, *2: Supply* and *3: Demand*). The score for demand is not accurate however as the amount of water allocated includes groundwater. Groundwater data was not available when calculating availability (total renewable resources) thus the true percentage of total resources that is allocated for use is unknown. As with the other participating communities, insufficient data was available to assess *Component 2: Ecosystem Health.* Nonetheless, the community did receive a score of 99.9 for *Indicator 4: Ecosystem stress* as stress on the system appears minimal based on the community's water consumption. This score is, however, based on consumption within Moose Cree First Nation as opposed to consumption within the basin. The true score is likely to be a bit lower.

For *Component 3: Infrastructure*, the community received a score of 55.6 that accurately reflected the need for improved infrastructure. However a couple of the indicators within this component were questionable. For example, *Indicator 7: Demand for Water Services* received a problematic score of 100. Moose Cree First Nation received a score of 100 as their population is decreasing while demand on the water treatment system is not. The community's water storage facilities have been insufficient. As a result, until very recently the community implemented nightly water rationing to ensure community demand for water was adequately met during the day. Regarding *Indicator 9: Wastewater Treatment*, the wastewater treatment facility serves more than Moose Cree First Nation's population. Because it is used by the hospital as well, it serves approximately 203 % of the population. Three Hills and Gimli also share water and/or wastewater services with other communities. As currently constructed, this reality is not factored into the Index scoring framework.

Component 4: Human Health and Well-being, received a score of 59.5. Though data was not available for *Indicator 12: Waterborne Illness*, the other two indicators of this component appeared to be an accurate reflection of the community's current situation (*Indicators 10: Access* and *11: Reliability*).

For *Component 5: Community Capacity*, a component score of 80.0 was derived that is not an accurate representation of the community's overall capacity given the data gaps for *Indicators 13: Financial Capacity* and *14: Work Force Education*. However the score does reflect that the community's treatment plant operators are certified to operate the plant (*Indicator 15: Training*).

The following table provides Moose Cree First Nation's score for each indicator and component of the Index as well as the community's overall score.

MOOSE CREE FIRST NATION		
Component and Indicators	**Indicator Score**	**Component Score**
Component 1: Freshwater Resources		
Indicator 1: Freshwater availability per person	100	**33.3**
Indicator 2: Freshwater vulnerability	0	
Indicator 3: Freshwater allocations	0	
Component 2: Ecosystem Health		
Indicator 4: Ecosystem stress	99.9	**99.9**
Indicator 5: Water quality	No data	
Indicator 6: Native fish population	No data	
Component 3: Infrastructure		
Indicator 7: Demand for water services	100	**55.6**
Indicator 8: Condition of infrastructure	0	
Indicator 9: Wastewater treatment	66.7	
Component 4: Human Health and Well-Being		
Indicator 10: Access to potable water	100	**59.5**
Indicator 11: Drinking water reliability	19	
Indicator 12: Waterborne illness	No data	
Component 5: Community Capacity		
Indicator 13: Financial Capacity	No data	**80.0**
Indicator 14: Work force education	No data	
Indicator 15: Treatment plant operator training	80	
Canadian Water Sustainability Index Composite Score		**65.7**

Chetwynd, British Columbia

The District of Chetwynd is located in northeastern British Columbia in the foothills of the Rocky Mountains. This region is rich in oil and gas, timber, and coal resources and Chetwynd is actively involved in gas development, forestry, and mining activities.[27]

Figure 4: Chetwynd (see red circle). *Source: Wikipedia - http://en.wikipedia.org/wiki/Image:Chetwynd%2C_British_Columbia_Location.png*

According to the community's current statistics, Chetwynd has a population of 2,842 that continues to grow. Chetwynd is a young community with approximately 25 % of the population under the age of 15.

Water quality has been an issue for the community and is closely monitored. In 2000 there was a crude oil spill of approximately 1,000,000 litres into the Pine River approximately 65 kilometers upstream of the community's water intake.[28] The spill resulted fron a ruptured pipeline.[29] In addition to concerns about spills, the community is also concerned about water quality impacts from cattle being watered in the river, animal waste run-off, and mining and forestry activities.

Water Supply, Collection, Treatment and Distribution System

The District of Chetwynd obtains their water from the Pine River. After the oil spill in 2000 the community temporarily relied on the Jackfish aquifer for their water before resuming their use of the Pine River. The water from the Pine River flows into a concrete inlet structure located near the shore. It is then piped into the onshore low lift pump station. One to two lift pumps, depending upon load, then pump the water into the community's three raw water reservoirs for settling of sediment. Following this, the raw water is pumped to the water treatment plant.[30] After settling occurs the water is treated with a coagulant, passed through sand and charcoal filters and injected with a sodium hypochlorite solution.[31] The water is then pumped into two storage reservoirs that are located on hills near the community. The community is currently in the process of installing an ultraviolet system as a safety measure to sterilize any Giardia or Cryptosporidium found in the water.[32]

Wastewater Collection and Treatment

Chetwynd's sewage is collected through sanitary sewers with the raw sewage subsequently processed by a six-cell lagoon.[33] Prior to being released into the Pine River the effluent is processed through two primary lagoons, three aerated lagoons, and a final polishing pond.

Chetwynd's overall score was 78.8. A score of 66.6 for *Component 1: Freshwater Resources* indicates that the community has a sufficient amount of water that is being allocated in a sustainable manner (*Indicators 1: Availability* and *3: Demand*). However the overall supply of freshwater is vulnerable (*Indicator 2: Supply*). As with the other participating communities, insufficient data was available to assess *Component 2: Ecosystem Health.* However the community did receive a score of 99.9 for *Indicator 4: Ecosystem Stress* as stress on the ecosystem appears minimal based on the community's water consumption.

For *Component 3: Infrastructure*, the community received a score of 86.3, indicating that their infrastructure is in good condition and has a number of years before it will reach 100 % operating capacity (*Indicators 7: Demand* and *8: Condition*). The score for this component indicated that all of its population is connected to the community's secondary wastewater treatment system (*Indicator 9: Treatment*). Chetwynd received a score of 100.0 for *Component 4: Human Health and Well-being*, supporting that its members have access to at least 150L/cap/day of water and have not recently experienced any incidences of waterborne illness (*Indicators 10: Access* and *12: Impact*). However given the lack of data for *Indicator 11: Drinking Water Reliability*, this component inadequately reflects human health and well-being as measured by the Index.

Component 5: Community Capacity received a score of 40.9 based on the scores for *Indicators 14: Education* and *15: Operator Training.* No score could be derived for *Indicator 13: Financial Capacity*. Though the score for *Indicator 14: Work Force Education* accurately reflected that 70.9 % of the population aged 20 to 64 had obtained a high school level of education or higher, the score for *Indicator 15: Operator Training* was questioned by the community during the follow-up interviews. Interviewees identified that Chetwynd's operators have met the training requirements set out by its health authority. Therefore they believed that their indicator score should be higher. The community highlighted that each province has its own training requirements for operators and suggested that this differentiation be factored into the Index to improve its accuracy.

The following table provides Chetwynd's score for each indicator and component of the Index as well as the community's overall score.

CHETWYND		
Component and Indicators	**Indicator Score**	**Component Score**
Component 1: Freshwater Resources		
Indicator 1: Freshwater availability per person	100	**66.6**
Indicator 2: Freshwater vulnerability	0	
Indicator 3: Freshwater allocations	99.9	
Component 2: Ecosystem Health		
Indicator 4: Ecosystem stress	99.9	**99.9**
Indicator 5: Water quality	No data	
Indicator 6: Native fish population	No data	
Component 3: Infrastructure		
Indicator 7: Demand for water services	100	**86.3**
Indicator 8: Condition of infrastructure	92	
Indicator 9: Wastewater treatment	67	
Component 4: Human Health and Well-Being		
Indicator 10: Access to potable water	100	**100.0**
Indicator 11: Drinking water reliability	No data	
Indicator 12: Waterborne illness	100	
Component 5: Community Capacity		
Indicator 13: Financial Capacity	No data	**40.9**
Indicator 14: Work force education	48.6	
Indicator 15: Operator Training	33.25	
Canadian Water Sustainability Index Composite Score		**78.8**

Three Hills, Alberta

Three Hills is situated in southern Alberta, southeast of Red Deer. Located in an agricultural district, agriculture has become Three Hill's primary form of economic development.[34] More recently oil and gas production has also become part of its industrial activity. According to Alberta Municipal Affairs, the population of Three Hills was 3,554 in 2004, an increase from its 2001 population of 3,375.[35] However discrepancies appear to exist between this data and Statistics Canada Census 2001 data, which identified a population of 2,900 in 2001. Though Three Hills does have a relatively young population, the majority of its residents are between the ages of 35 to 54.

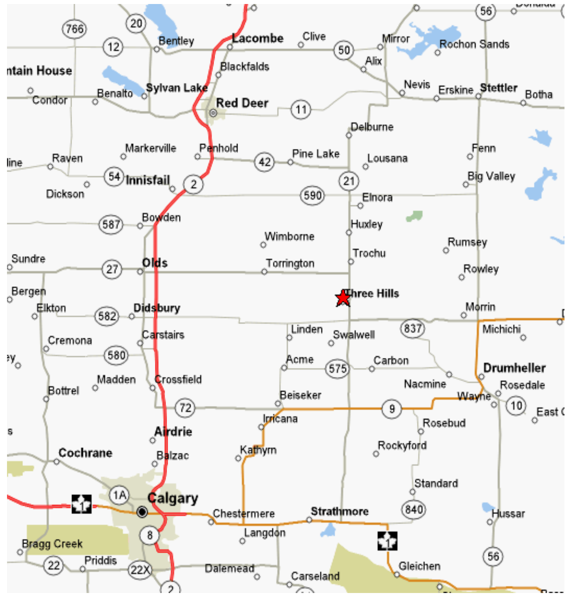

***Figure 5: Three Hills**. Source: MapQuest - http://www.mapquest.com/*

The main water issue facing Three Hills relates to water quantity resulting from the drought-like conditions of southern Alberta and the increased demand for water caused by population increases.

Water Supply, Collection, Treatment and Distribution System

Three Hills obtains its water from the Red Deer River. In addition to servicing the town's needs, Three Hills also provides water to some outlying areas connected to Three Hills' distribution system. These include the Town of Trochu and the rural areas of Kubinec, Pipeline, Equity, and Mt. Vernon. Water is collected from the Red Deer River and piped into holding cells.[36] After settling occurs, the water is injected with a coagulant of alum and potassium, passed through a coal and sand filter and chlorinated with chlorine gas. The water is then sent via pipe 18 kilometres into the town. Prior to distribution, the water is treated with a final round of chlorination and is then distributed to the town members through a main water line.

Wastewater Collection and Treatment

Three Hills pumps its wastewater into a three-celled sewage lagoon system.[37] The lagoon system, built approximately 35 years ago on a hillside, has berms to contain the effluent. The wastewater remains in the lagoon for a total of 320 days after which it is released into a drainage course near the town that ultimately leads to the Red Deer River. Concern was expressed about the lagoon system, specifically its leaking berms. Currently the community is conducting some repairs on the system and is in the process of planning for more comprehensive repairs and/or a new system.

Canadian Water Sustainability Index Score

Three Hills' final composite score 87.4. A score of 66.6 for *Component 1: Freshwater Resources* indicates that the community has a sufficient amount of water that is being allocated in a sustainable manner through water licenses (*Indicators 1: Availability* and

3: Demand). However freshwater supply (evaluated based on the variability of surface flows) is vulnerable (*Indicator 2: Supply*). As with the other participating communities, insufficient data was available to assess *Component 2: Ecosystem Health* though the community did receive a score of 99.9 for *Indicator 4: Ecosystem stress* as stress on the ecosystem appears minimal based on the community's water consumption.

For *Component 3: Infrastructure*, the community received a score of 70.3, indicating that its infrastructure could meet demand based on the current rate of population growth and that all of its population is connected to the community's secondary wastewater treatment system (*Indicators 7: Demand* and 9*: Treatment*). However the score for *Indicator 7: Demand for Water Services* is questionable given contradictory data on the community's population change. For consistency, Statistics Canada data was used for this calculation as it would have been problematic to derive the rate of population growth using two different bodies of data: Statistics Canada and Alberta Municipal Affairs data. Statistics Canada data identified Three Hills' population as decreasing however Alberta Municipal Affairs data identified Three Hills' population as increasing. Three Hills' score for this component was lowered due to their score of 44.0 for *Indicator 8: Condition of Infrastructure*, reflecting the 14 % system losses the community experienced in the past year.

Three Hills received a score of 100.0 for *Component 4: Human Health and Well-being*, reflecting that community members have access to at least 150L/cap/day of water and that this supply is reliable (*Indicators 10: Access* and *11: Reliability*). As data was not available for *Indicator 12: Waterborne illness*, this component does not comprehensively reflect human health and well-being as measured by the Index.

Component 5: Community Capacity received a score of 100.0 indicating that the community has the human capacity to be effective water stewards (*Indicators 14: Education* and *15: Training*). As with all of the other participating communities, Three Hills did not receive a score for *Indicator 13: Financial Capacity* given a gap in the data.

The following table provides Three Hills' score for each indicator and component of the Index as well as the community's overall score.

THREE HILLS		
Component and Indicators	**Indicator Score**	**Component Score**
Component 1: Freshwater Resources		
Indicator 1: Freshwater availability per person	100	**66.6**
Indicator 2: Freshwater vulnerability	0	
Indicator 3: Demand for freshwater	99.9	
Component 2: Ecosystem Health		
Indicator 4: Ecosystem stress	99.9	**99.9**
Indicator 5: Water quality	No data	
Indicator 6: Native fish population	No data	
Component 3: Infrastructure		
Indicator 7: Demand for water services	100	**70.3**
Indicator 8: Condition of infrastructure	44	
Indicator 9: Wastewater treatment	67	
Component 4: Human Health and Well-Being		
Indicator 10: Access to potable water	100	**100.0**
Indicator 11: Drinking water reliability	100	
Indicator 12: Waterborne illness	No data	
Component 5: Community Capacity		
Indicator 13: Financial Capacity	No data	**100.0**
Indicator 14: Work force education	100	
Indicator 15: Operator Training	100	
Canadian Water Sustainability Index Composite Score		**87.4**

Gimli, Manitoba

The Rural Municipality of Gimli is located on the southwestern shores of Lake Winnipeg, northwest of Winnipeg, Manitoba. Gimli has a permanent resident population of approximately 5,158 people.[38] However, as a tourist area known for its recreation, Icelandic Festival and beach, the population levels fluctuate with the addition of 10,000 cottagers in the summer months and over 100,000 visitors annually.[39]

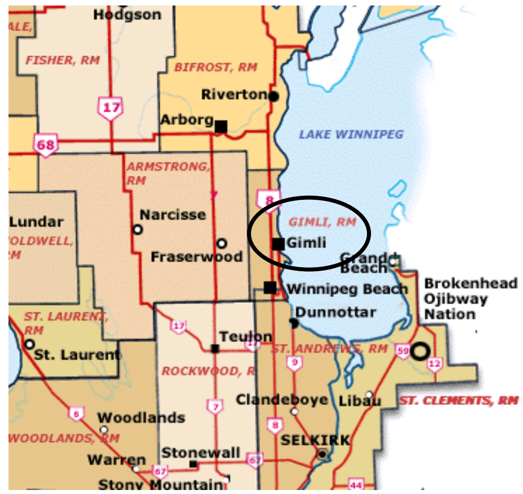

Figure 6: Gimli. *Source: Government of Manitoba website - http://www.communityprofiles.mb.ca/maps/regional/interlake.html*

Gimli has an abundance of water perceived by the community to be of good quality. The area has experienced periodic flooding resulting from overloaded storm drain systems and high lake levels, but indicated to CIER that their experiences of flooding are not nearly as severe or frequent as those experienced in other areas in Manitoba. The community's primary area of concern relates to its inadequate wastewater treatment capacity that is currently being addressed through Gimli's efforts to build a new wastewater treatment plant.

Water Supply, Collection, Treatment and Distribution System

Gimli obtains its water from groundwater resources, specifically the Carbonate aquifer. The community has artesian wells, some of which need to be capped to prevent the water from overflowing. Water quality is not monitored as it is perceived to be of pristine quality. The water is softened and fluoride and chlorine are added prior to use for domestic purposes.

Wastewater Collection and Treatment

Gimli has two wastewater treatment systems: a four-celled lagoon system and a wastewater treatment plant.[40] The lagoon treats the wastewater from the former Town of Gimli and the treated effluent is discharged into a wetland area. The wastewater treatment plant treats the wastewater from the areas connected to the sewage system as well as the truck haul wastewater from some nearby communities such as the Rural Municipality of Armstrong. The treated effluent is then discharged into Lake Winnipeg.

Due to the dramatic increase in Gimli's population during the summer months from tourism activities, the community has needed to export their wastewater to surrounding communities, such as Arborg and Teulon, for processing.[41]

In 2002, Gimli applied for a license to build and operate a new wastewater treatment plant.[42] This new system would replace the existing Rural Municipality of Gimli wastewater treatment plant and Town of Gimli wastewater treatment lagoon. The license was approved in 2003 and work on this new system is currently underway.

Canadian Water Sustainability Index Score

Gimli's final composite score was 79.8. *Component 1: Freshwater Resources* received a score of 100.0 indicating that the community has a sufficient amount of water available per person (*Indicator 1: Availability*). As data was not available for *Indicators 2: Vulnerability of Freshwater* and *3: Freshwater Allocations* the score for this component does not comprehensively reflect the status of freshwater resources as measured by the Index.

As with the other participating communities, insufficient data was available to assess *Component 2: Ecosystem Health*.

For *Component 3: Infrastructure*, the community received a score of 52.1, reflecting that its water infrastructure has a couple of decades before 100 % system capacity is reached and that most of its population is connected to the community's secondary wastewater treatment system (*Indicators 7: Demand* and *9: Treatment*). However data was unavailable for *Indicator 8: Condition of Infrastructure*.

Gimli received a score of 100.0 for *Component 4: Human Health and Well-being*. Its members have access to at least 150L/cap/day of water and its drinking water supply is reliable (*Indicators 10: Access* and *11: Reliability*). As data was not available for *Indicator 12: Waterborne Illness* this component does not comprehensively reflect human health and well-being as measured by the Index.

A score of 67.0 was derived for *Component 5: Community Capacity* reflecting that 67.3 % of the community aged 20 to 64 has a grade 12 or higher level of education and there is a high level of training in their water and wastewater treatment plant operators (*Indicators 14: Education* and *15: Training*). Therefore Gimli has the human capacity to be an effective water steward. As with the other participating communities, a score for *Indicator 13: Financial Capacity* could not be derived due to a gap in data.

The following table provides Gimli's score for each indicator and component of the Index as well as the community's overall score.

GIMLI		
Component and Indicators	**Indicator Score**	**Component Score**
Component 1: Freshwater Resources		
Sufficient amount of water	100	**100.0**
Water is obtained through groundwater sources and the data provided for yield was too broad for the calculation	No data	
Indicator 3: Demand for freshwater	No data	
Component 2: Ecosystem Health		
Indicator 4: Ecosystem stress	Not applicable	**N/A**
Indicator 5: Water quality	No data	
Indicator 6: Native fish population	No data	
Component 3: Infrastructure		
Indicator 7: Demand for water services	47.2	**52.1**
Indicator 8: Condition of infrastructure	No data	
Indicator 9: Wastewater treatment	57	
Component 4: Human Health and Well-Being		
Indicator 10: Access to potable water	100	**100.0**
Indicator 11: Drinking water reliability	100	
Indicator 12: Waterborne illness	No data	
Component 5: Community Capacity		
Indicator 13: Financial Capacity	No data	**67.0**
Indicator 14: Work force education	33.9	
Indicator 15: Operator training	100	
Canadian Water Sustainability Index Composite Score		**79.8**

Comparative Analysis of Case Study Communities

The following section provides a comparison of the participating communities' component and final composite scores within economic (agricultural, resource-based or other) and ethnic (First Nations or non-Aboriginal) contexts. Given that the participating communities differed significantly from each other geographically, culturally, economically and socially, this comparative analysis can at best provide some general insights into usefulness of the Index. More communities with definite geographic, cultural, economic, social or other similarities would need to be studied and compared as a group for an in-depth analysis of the Index.

The final composite scores for the communities ranged from 52.9 to 87.4. Given the gaps in data (see *Section 7.1: Data Requirements, Availability and Quality* for more information), communities' scores were likely lower than they would have been had these gaps, consistent for all of the communities, been excluded from the weighting or given less weight in the final composite score.

Comparison of First Nations and Non-Aboriginal Community Scores

The average score for the three participating First Nations was 58.3 compared with 63.6 for the non-Aboriginal communities. The following table identifies the average component scores for the First Nations and non-Aboriginal communities including the difference between the two groups per component.

Component	First Nations	Non-Aboriginal	Difference
Component 1: Freshwater Resources	61.1	77.7	-16.6
Component 2: Ecosystem Health	99.9	99.9	0.0
Component 3: Infrastructure	44.6	69.5	-24.9
Component 4: Human Health and Well-Being	74.9	100.0	-25.1
Component 5: Community Capacity	51.6	69.3	-17.7
Average Score (all components)	66.4	83.3	-16.9

Overall, the First Nations communities ranked lower than the non-Aboriginal communities in all components except *Component 2: Ecosystem Health*. As no data was available or scores could not be derived for any of the communities for *Indicators 5: Water Quality* and *6: Native Fish*, this component score focuses on *Indicator 4: Ecosystem Stress*. A similar score between the First Nations and non-Aboriginal communities indicates that all participating communities have a minimal water consumption rate. For *Components 3: Infrastructure* and *5: Community Capacity*, the non-Aboriginal communities' average ranged from 24.9 and 17.7 respectively higher than the First Nations. These figures suggest that the First Nations have a lower level or condition of infrastructure and less capacity, whether financial and/or human resources, to deal with water and wastewater in the community. It is therefore not surprising that the First Nations average score for *Component 4: Human Health and Well-Being* was also lower than the non-Aboriginal communities' average score (-25.1) as human health and well-being related to water is dependent on sound water and wastewater infrastructure and treatment and adequate financial and human resources.

These results could be used by First Nations to support a decision to access more funding and/or supports to achieve at least an equivalent level of water sustainability and human health as the non-Aboriginal communities. At the same time, the overall average score for both First Nations and the non-Aboriginal communities could be improved (64.4 and 83.3 respectively), highlighting the need for more supports and/or better systems and/or greater promotion of sustainable water use for all of the participating communities.

Comparison of Community Scores according to Economic Development Activities

The communities participating in the case studies project were involved in various types of economic development: agricultural, resource-based, and other such as tourism. One First Nations and one non-Aboriginal community were involved in each type of development. This section compares the average scores of the First Nations and non-Aboriginal communities for each economic development type, for example between agricultural versus resource-based. The following table identifies the average scores for the types of economic development represented in the project. The percentages were obtained by averaging the component scores of the First Nation and non-Aboriginal community involved in resource-based economic development, agriculture, and other such as tourism.

Component	**Resource-Based**	**Agricultural**	**Other**
Component 1: Freshwater Resources	58.3	83.3	66.7
Component 2: Ecosystem Health	99.9	99.9	99.9
Component 3: Infrastructure	49.0	68.5	53.9
Component 4: Human Health and Well-Being	100	82.7	79.8
Component 5: Community Capacity	45.5	62.5	73.5
Average Score (all components)	70.5	79.4	74.8

It should be noted that averaging the scores of a First Nation and non-Aboriginal community involved in agricultural development or another economic development activity and comparing those scores with the average scores of a First Nation and non-Aboriginal community involved in another form of economic development is somewhat problematic. First Nations and non Aboriginal communities exist in very different realities and legal frameworks that have definite implications for all aspects of life including economic development. CIER recommends that the reader consider that the analysis cannot accurately represent the full scope and complexity of water sustainability issues or capacity of communities engaged in a primary form of economic development to address water sustainability. Further, though a primary form of economic development did exist for all of these communities, their economies were also engaged in other forms of development. Therefore, to conclude, for example, that resource-based economies tend to exhibit higher levels of human health and well-being than communities engaged in other economic development activities would be an over-simplification.

The communities had differing scores for *Component 1: Freshwater Resources* indicating that the communities have varying levels of access to water and varying degrees of vulnerability regarding the supply of freshwater. However it was somewhat surprising to find that the agricultural communities had the highest score for this component given that these communities likely place the greatest demand on their freshwater resources.

All of the communities shared the same average score for *Component 2: Ecosystem Health*. Because scores could not be derived for any of the communities for *Indicators 5: Water Quality* and *6: Native Fish*, this component score is based on *Indicator 4: Ecosystem Stress*. Regardless of economic development activity engagement, a score of 99.9 was derived for all of the communities. This indicates that all of the communities have a water consumption rate that is greater or equal to 40 %.

For *Component 3: Infrastructure* and *Component 5: Community Capacity*, the agricultural-based communities had the highest average. For *Component 4: Human Health and Well-Being*, the resource-based communities ranked the highest. It is reasonable to assume that the better the infrastructure and community capacity to deal with water and wastewater, the greater the likelihood that human health and well-being would also be higher. If this correlation could be made, it would seem that the agriculture-based communities would exhibit a higher level of health and well-being. However, when referring back to the individual communities' scores, this is not the case.

Overall, communities engaged in resource-based types of economic development fared lower than their agricultural and other counterparts. It would require further research to determine whether this could accurately be attributed to benefits flowing from or the nature of the primary form of economic development, that is resulting in reduced access to financial resources or need for water and wastewater systems for example.

Analysis of the CWSI: Utility, Applicability and Relevance

The following section provides an analysis of the utility of the CWSI generally and identifies areas of concern regarding specific indicators. This analysis is based on CIER project team members' experiences working with the Index, on feedback provided by communities through the follow-up interviews and conversations with government personnel during the data gathering process.

Data Requirements, Availability and Quality

To calculate the Index, a number of data pieces are required; approximately 60 pieces in total. At a minimum, 46 % of the data requirements were available for all of the communities, which was encouraging. A substantial amount of this data was available in the communities, which is very positive given that the Index is intended for use at local levels. However the majority of the data pieces required for the Index were challenging to find when not readily available in the community and the information that did exist, regardless of whether it was obtained from the community or a government source, was not housed in a central location. CIER contacted a minimum of two and a maximum of seven individuals from each of the First Nations, municipalities, provincial governments, and/or federal governments to fulfill each data requirement.

The complexities of data gathering were compounded by differences between provincial government processes for managing, monitoring or otherwise dealing with water and wastewater. For example, the Government of Ontario has one department that deals with *water permits*, whereas in Alberta and Saskatchewan, there are two separate divisions within a department that deal with *water licenses*, one for surface water, the other for groundwater. If communities are unaware of how the subjects of water and wastewater are referred to and addressed by their respective governments, they may very easily fail to acquire all of the information that they need to calculate particular scores.

Data gaps consistently existed for *Component 2: Ecosystem Health*. Specifically, data for *Indicator 4: Ecosystem Stress* was only available for half of the communities and no data existed for *Indicators 5: Water Quality* and *6: Native Fish*. In relation to *Indicator 5: Water Quality*, all of the communities did conduct water quality tests, however none of the communities test for at least four of the parameters required to calculate the Water Quality Index (WQI). Further, it was found that the communities' water quality tests are frequently conducted on treated, not raw, water, posing another challenge if the WQI requires data from raw water quality tests. In relation to *Indicator 6: Native Fish*, insufficient quantitative data existed on the percentages of increasing or stable fish populations though anecdotal information was available.

Indicator 12: Waterborne Illness, specifically the incidence of waterborne illness in the community, was also frequently unavailable. Given that most of the communities are not legally required to report waterborne illness, they do not keep track of its occurrence. *Indicator 13: Financial Capacity* could not be derived for any of the communities as data on local government revenues and expenditures at the rural municipality or First Nations community levels was not available from Statistics Canada. This information was not requested during the interviews as it was identified as being available from Statistics Canada.

Generally, the rural municipalities had easier access to the required pieces of data whereas it was more challenging to acquire this information in the First Nations where the data did not often exist.

Overall, the breadth of the data required for the calculations was not clear from the Index documents provided by the PRI. For example, regarding *Component 1: Indicator – Supply*, well water levels can be used as a general indicator of groundwater conditions, whether rising, declining or stable but, given their fluctuation, point-in-time changes are not particularly relevant. This issue was also presented regarding data requirements related to fish populations, incidents of waterborne diseases, numbers of service disruptions, and others. For some of these data requirements, a minimum of five years' worth of data would be required in order to adequately reflect or identify trends.

Data Quality

The data gathered were authoritative, however CIER did receive conflicting data between communities and governmental sources. Whenever possible, the project team used the community data for conducting the calculations (e.g., community population data was assumed to be more accurate and current), but it might be useful to clarify what sources are preferred in subsequent iterations of the Index documents.

Time Requirements

The data gathering process was quite time consuming, particularly when attempting to gather information from the government departments. However this limitation could be attributed to the fact that CIER, as an external research body, was conducting the Index testing and that government bodies were not obligated to provide the data, an obligation that they would have to fulfill if the information requests came from communities. A community would therefore likely acquire the data required more quickly as it knows where its own data is stored and would receive a quicker response from government departments. Despite this, the reality faced by many communities is that there are limited financial and human resources available to assume additional tasks. A similar reality also exists within government departments. As an example, for one government department there was one individual who had all of the technical data required but did not have additional time to allocate to provide the project team with this data. The result was a data gap.

Each community interview lasted between three to eight hours. In addition the communities spent time preparing for the interview, following-up with the project team on data pieces that were unavailable during the interviews and engaging in a follow-up interview. Engaging in the Index calculations internally would likely require a similar amount of time in addition to the hours for data collection.

The time needed to fulfill the requirements of the Index needs to be given serious consideration. If a community requires a substantial amount of time to acquire the information, it might be deterred from using the Index. For example, a maximum of a week would likely be considered a reasonable amount of time to dedicate to this.

Furthermore, government departments will need to be informed in advance about the potential for increased information requests and prepare accordingly. Over time, if the Index was integrated into the work of communities and governments, these data tasks and capacity to address the data requirements could become streamlined, and therefore, more efficient.

Feedback from Case Study Communities: Follow-Up Interviews

As identified in the Case Study Methodology, follow-up interviews were conducted with the participating communities. During these interviews, participants were requested to provide their feedback on their community score and the Index and provide recommendations for consideration by the PRI. Given that the communities were not involved extensively in the data gathering process and did not undertake the data analysis component, it was challenging for them to speak in much depth to the utility of the tool or its relevance to them. Though only a cursory analysis of the tool was possible for the communities, they were able to provide some very useful feedback and recommendations.

Overall, communities were very receptive to the Index. The participants indicated that their indicator scores generally reflected their community's reality in relation to the focus of the relevant indicator. However, they were concerned about their component and final composite scores given the gaps in data.

Communities identified that their results could be drawn upon to inform planning activities relating to water and wastewater infrastructure and support the need for research studies, such as conducting a study on a local fish population, training, and funding. They also felt that the Index could be extremely useful if applied by communities either within the same region or relying on the same water body or source. If used in this way, communities could compare their scores while simultaneously acquiring a general understanding of the state of their area and their collective ability to address water sustainability on a regional level.

Communities also noted that Index was too general. One community noted that the American Waterworks Association's (AWWA) QualServ Benchmarking Program was a similar tool but provided much more detailed results, AWWA's QualServ Benchmarking program site can be found at <http://www.awwa.org/science/benchmarking/>. The community noted that, given the lack of detail, the Index did not provide them with sufficient information on where to act or make decisions. Nonetheless, if refined and broken down into finer points/areas, the community felt that the Index could be greatly enhanced and clearly highlight areas for improvement.

Communities provided the following specific suggestions for the Index to improve its overall relevancy and applicability to their communities and to a larger audience:

The tool should be more locally specific. The first two components of the Index focus on assessing the categories, such as freshwater resources and ecosystem health. on a broad scale, for example at the river basin level. Although communities recognized the importance of knowing the stress on the ecosystem and the amount of freshwater resources available at this level, they felt that it would be more informative and more useful if the Index sought information that provided more insights into their local situation.

Water and wastewater systems should be addressed separately throughout the Index and accounted for separately as well. For example, *Component 3: Infrastructure, Indicator 7: Demand for Water Services* provides directions to calculate the t_{100} value for both water and wastewater systems and chooses the lowest score. Communities expressed the view that it would be more informative for them to know the demand being placed on both of their systems.

Component 2: Ecosystem Health should include an indicator relating to the method and quality of wastewater discharge. Wastewater discharge can cause stress to the ecosystem and participants indicated that they felt it should be factored into the Index.

The PRI should offer educational support, for example an introductory workshop to the tool, assistance with calculating the Index and accessible documentation.

Conclusion

The CWSI was well received by the participating communities and many of its data requirements are available. Therefore it has the potential to be a useful and informative tool for communities to gauge their well-being with respect to freshwater resources. However, as currently constructed, the tool is somewhat cumbersome and requires a fair amount of interpretation to derive scores. The Index could be implemented by a diverse range of communities with some minor modifications, access to user-friendly documentation and supports such as an online program, and addition of components or indicators that would explore issues in a more locally specific way. The implementation of the Index would allow for better understanding and decision-making on water sustainability both locally and across Canada.

Notes

[1] The PRI's partners for this initiative include Health Canada, Environment Canada, Indian and Northern Affairs Canada, and the Prairie Farm Rehabilitation Agency.

[2] Visit <www.policyresearch.gc.ca> to view the PRI's freshwater publications.

[3] Sullivan, C. (2002). Calculating a Water Poverty Index. *World Development*. Vol. 30, No.7, pp.1195-1210.

[4] The Canadian Water Sustainability Index (CWSI) (*Working Paper Series #011*), authored by Anne Morin, PRI in November 2005

[5] Le PRP compte sur plusieurs partenaires pour cette initiative, dont Santé Canada, Environnement Canada, Affaires indiennes et du Nord Canada ainsi que la Prairie Farm Rehabilitation Agency.

[6] Voir le site <www.recherchepolitique.gc.ca> pour consulter les publications du PRP sur l'eau douce.

[7] Sullivan, C. « Calculating a Water Poverty Index », *World Development*, vol. 30, nº 7 (2002), p.1195-1210.

[8] *Indice canadien de la durabilité des ressources hydriques* (ICDRH), Série de documents de travail du PRP (*011*), Anne Morin, novembre 2005.

[9] The PRI's partners for this initiative include Health Canada, Environment Canada, Indian and Northern Affairs Canada, and the Prairie Farm Rehabilitation Agency.

[10] Visit <www.policyresearch.gc.ca> to view the PRI's freshwater publications.

[11] Sullivan, C.(2002). Calculating a Water Poverty Index. *World Development*. Vol. 30, No.7, pp.1195-1210.

[12] The Canadian Water Sustainability Index (CWSI) (*Working Paper Series #011*), authored by Anne Morin, PRI in November 2005

[13] The Canadian Water Sustainability Index (CWSI): Data Study (*Working Paper Series #013*), conducted by Tri-Star Environmental Consulting in February 2006

[14] Government of Canada, Statistics Canada, 2001 Community Profiles. 30 Mar. 2006 <http://www12.statcan.ca/english/profil01/CP01/Index.cfm?Lang=E>.

[15] Ibid.

[16] Tsuu T'ina Nation web site. 27 Mar. 2006 < http://www.tsuutina.ca/>.

[17] Crowchild, Lee. Personal Interview. 6 Mar. 2006.
Government of Canada. Indian and Northern Affairs Canada: Alberta Region. Tsuu T'ina First Nation: Assessment Study of Water and Wastewater Systems and Associated Water Management Practices. February 2002. 1-2/1-3.

[18] Government of Canada. Indian and Northern Affairs Canada: Alberta Region. Tsuu T'ina First Nation: Assessment Study of Water and Wastewater Systems and Associated Water Management Practices. February 2002. 1-2/1-3.

[19] Crowchild, Lee. Personal Interview. 6 Mar. 2006.

[20] All of the information in this paragraph was obtained from the following source: Government of Canada. Indian and Northern Affairs Canada: Alberta Region. Tsuu T'ina First Nation: Assessment Study of Water and Wastewater Systems and Associated Water Management Practices. February 2002. 2-1.

[21] Beeds, Hector. Follow-up Interview. 25 Apr. 2006.

[22] Pelican Lake First Nation. *Pelican Lake News* 1.1 (2004): 12.

[23] Hartz, Glen R. "Re: Pelican Lake First Nation." E-mail to Reegan D. Breu. 29 Mar. 2006.

[24] Sutherland Sr., Phillip. Follow-up Interview. 25 Apr. 2006.

[25] Turner, John. Personal Interview. 17 Mar. 2006.

[26] The information contained in the following two paragraphs were obtained through the community interview process and a discussion with Derrick Gourley, Weeneebayko General Hospital.

[27] District of Chetwynd. 30 Mar. 2006 <http://www.gochetwynd.com/siteengine/activepage.asp?bhcp=1>.

[28] Gosse, Gord and Rob Crisfield. Personal Interview. 18 Apr. 2006.

[29] Wikipedia, The Free Encyclopedia. "Chetwynd, British Columbia." 15 Mar. 2006 <http://en.wikipedia.org/wiki/Chetwynd,_British_Columbia>.

[30] Dobson Engineering Ltd. District of Chetwynd Watershed Source Protection Plan – Pine River Watershed. March 2006. 19 Apr. 2006 <http://www.dobsoneng.com/Report/Report.pdf>.

[31] Government of British Columbia, Ministry of the Environment. "Assessment of the District of Chetwynd Drinking Water Supply (Pine River): Source Water Characteristics." By James Jacklin. n.d.:4.
Gosse, Gord. Personal Interview. 3 Mar. 2006.

[32] Gosse, Gord. Personal Interview. 11 Apr. 2006.

[33] Wikipedia, The Free Encyclopedia. “Chetwynd, British Columbia.” 15 Mar. 2006 <http://en.wikipedia.org/wiki/Chetwynd,_British_Columbia>.

[34] Except where otherwise noted, all of the information in this paragraph was obtained from the following electronic resource: Alberta First. “Profile of Three Hills.” 17 Mar. 2006 <http://www.albertafirst.com/profiles/statspack/20474.html>.

[35] Alberta Municipal Affairs. “Town of Three Hills.” 15 Mar. 2006 http://www.municipalaffairs.gov.ab.ca/mahome/cfml/profiles/index.cfm

[36] All of the information relating to water and wastewater was obtained during the personal interview conducted with Len Dyck and Jack Ramsden on March 7, 2006.

[37] All of the information in this paragraph was received during the personal interview conducted with Len Dyck and Jack Ramsden on March 7, 2006.

[38] King, Joanne. Personal Interview. 18 Apr. 2006.

[39] R.M. of Gimli. “About the RM of Gimli.” 15 Mar. 2006 <http://www.rmgimli.com/about_us.asp>.

[40] Except where otherwise cited, all of the information contained in the following paragraphs was received during interviews with Jack Feschuk and several of Gimli’s operators on March 9, 2006, and an interview held with Joanne King on April 18, 2006.

[41] Coward, John. “Gimli’s Sewage Rerouted to Arborg.” The Interlake Spectator June 10, 2005. <http://www.interlakespectator.com/story.php?id=166152>.

[42] Government of Manitoba. Manitoba Conservation. “Summary Report.” 13 Mar. 2006 <http://www.gov.mb.ca/conservation/envapprovals/archive/archive02/summaries/4814.html>.

Appendix 1

CWSI Evaluation Framework

The CWSI is based on a standardized evaluation framework wherein scores ranging from 0 to 100 are calculated for each individual indicator. The method used to arrive at the indicator scores is presented in the following sections organized by component. Five components make up the index:

- Resource
- Ecosystem Health
- Infrastructure
- Human Health
- Capacity

Once the indicator scores are calculated, component-level scores are determined by taking the average score of the three indicators that make up that component. The final index score for a given community is then determined using the following equation:

$$CWSI = \frac{\sum_{i=1}^{N} w_i X_i}{\sum_{i=1}^{N} w_i}$$

Where X_i refers to component i of the index for a particular community
w_i is the weight applied to that component.

In the standardized evaluation of the CWSI, each component will be weighted equally and will therefore be equal to the average of all fifteen indicators. Should a community decide that one component is more important that another, weights can be adjusted accordingly for internal analysis although such results would not be used for inter-community comparisons.

Resource

The Resource component is evaluated at the scale of the river basin and will score the natural endowment of freshwater in terms of whether or not the resource can reliably meet the needs of the community. The three indicators will assess the amount of renewable freshwater available (AVAILABILITY), how variable the supply is (SUPPLY), and the current level of demand for the resource (DEMAND). Both surface water and groundwater can be considered depending on the sources of water that are used or could be used in serving the community. For the resource component, variables will be measured at the river basin scale.

Indicator 1 - Availability

This indicator will look at the annual amount of renewable freshwater that is available on a per capita basis (m^3/cap/yr). Depending on the community, renewable water can be measured using the average annual stream flow and/or the sustainable ground water yield. The Falkenmark water stress indicator will be used as a benchmark for whether the domestic, economic and ecosystem water needs can be met from a quantitative perspective.

According to Falkenmark (year), 1700 m^3/cap/yr can meet the water requirements of the community whereas anything less than this amount can cause problems in terms of reliability, economic development, and meeting basic human needs as seen below:

> 1700	Water shortages occur only irregularly or locally
1000 – 1700	Water stress appears regularly
500- 1000	Water scarcity is a limitation to economic development and human health and well-being
< 500	Water availability is a main constraint to life

The parameters outlined by Falkenmark will be used as benchmarks for evaluating the availability of renewable freshwater where a score of 100 will be assigned to any value over 1700m^3/cap/yr and a score of 0 will be assigned to any value below 500 m^3/cap/yr. A community score for this indicator (R_A) will thus be calculated using the following equation:

Indicator Score (R_A):

$$R_A = \frac{(T_{cap} - 500)}{(1700 - 500)} \times 100$$

Where: T_{cap} = total renewable water resources per capita (m^3/cap/year)
If $x > 1700$, then $R_A = 100$
If $x < 500$, then $R_A = 0$

To determine the total renewable water resource, use the average annual streamflow, the sustainable groundwater yield or both depending on the water resources within the river basin.

Indicator 2 - Supply

This indicator will serve as a proxy for the vulnerability of the freshwater supply to the community by looking at the variability of surface water flows and/or the trends in groundwater reserves. Highly variable surface flows can have implications for the reliability of the water supply for both economic and domestic uses. Gleick (1990) established the water runoff ratio to assess the extent to which surface flows vary. This ratio can also act as an indication of the community's vulnerability to drought and flood. The ratio can be calculated by dividing the runoff that is exceeded 5 % of the year by the run-off exceeded 95 % of the year. The lower the ratio, the less variability there is in surface flows. According to Gleick, a value greater than 3 indicates vulnerability. To evaluate surface flow variability (R_{SS}) for the CWSI, a runoff ratio (x) of 1 will be equal to a score of 100, 3 will be equal to a score of 50, and 5 will be equal to a score of 0. The community's score can be calculated using the following equation:

$$R_{SS} = 1 - \frac{(x-1)}{(5-1)} \times 100$$

Where x = run-off ratio
If $x < 1$, then $R_{SS} = 100$
If $x > 5$, then $R_{SS} = 0$
If $5 > x > 1$, then calculate R_{SS} using above formula

If runoff data is unavailable, stream flow data can be used as a surrogate.

The vulnerability of the groundwater supply (R_{SG}) is based on the general trends observed in community wells. The Government of Alberta uses groundwater trends as a water indicator by determining how many wells are exhibiting rising levels, how many are exhibiting no changes, and how many wells are exhibiting declining levels[43]. The same approach will be used for the CWSI and to calculate a score, factors of 1, 0.5 and 0 will be assigned to rising, no change, and declining observations respectively using the following equation:

$$R_{SG} = (1r + 0.5n) \times 100$$

Where r = % of wells that have rising water levels
n = % of wells with no change in water level

Water levels will change from day to day, however this equation should consider the overall trend over a period of a year or longer.

If a community depends entirely or primarily on surface water or groundwater, then R_{SS} or R_{SG} can be used as a resource indicator for supply. If both sources of water are important, then a weighted average can be used to arrive at a final score based on the percentage of supply derived from surface or groundwater sources. For example if 60 % of a community's water supply is from surface water and the rest is from groundwater then the supply score (R_S) can be calculated as follows:

$$R_S = 0.6R_{SS} + 0.4R_{SG}$$

Indicator 3 - Demand

This indicator assesses the demand for water that exists in the river basin by looking at the amount of water that is allocated through water licenses. Water licenses are issued for a variety of water uses including irrigation, industrial processing, and municipal uses. The amount of allocated water is the maximum amount of water that can be used but does not necessarily reflect the actual amount of water use. High levels of demand can have implications for the sustainable use of water for economic purposes and use in growing municipalities.

To evaluate the demand on the resource (R_D), the amount of water that is annually allocated is evaluated relative to the total amount of renewable freshwater (T), where 100 % allocation is equal to a score of 0, and 0 % allocation is equal to a score of 100. The following equation can therefore be used to calculate R_D:

$$R_D = \left(1 - \frac{a}{T}\right) \times 100$$

Where: a = amount of water that is allocated (m^3/year)
T = total renewable water resources (m^3/year)
If a/T = 100, then RD = 0
If a/T = 0, then RD = 100

If T consists of both surface and groundwater, then allocations of both surface and groundwater should be considered. If information is only available for surface water or groundwater allocations, then T should only consider surface water or groundwater.

Ecosystem Health

This component is evaluated at the river basin scale and examines the health of the river basin's aquatic ecosystems with indicators of the pressures imposed on the ecosystem (STRESS), its current condition for the protection of aquatic life (QUALITY), and the resulting impacts, if any, on the fish species that are economically and/or culturally important to the community (FISH).

Indicator 4 – Ecosystem Stress

The stress indicator is intended to reflect the types of pressures that are imposed on the ecosystem. An ecosystem can become stressed from pollution as well as excessive water use. The QUALITY indicator addressed below measures the state of the water quality thus this indicator will focus on water quantity by measuring the amount of surface water removed from the system and consumed.

To score this indicator, the annual amount of water consumed will be assessed relative to the total annual renewable surface flows. According to the OECD, 60 % of renewable water flows is required to maintain a healthy, functioning ecosystem thus in scoring this ecosystem stress indicator (E_S), a rate of consumption greater or equal to 40 % will be assigned a score of 0.

$$E_S = \frac{0.4 - c/Tsur}{0.4} \times 100$$

Where: c = annual amount of water consumed (m^3.year)
T_{sur} = total annual renewable surface flow (m^3/year)
If $c/T_{sur} > 0.4$, then $E_S = 0$
If $c/T_{sur} = 0$, then $E_S = 100$
If $0.4 > c/T_{sur} > 0$, then use the above equation to solve for E_S

This indicator is not only relevant for the health of the ecosystem but for the sustainable use of water in the community.

Indicator 5 – Water Quality

For this indicator, the CWSI will rely on an existing tool that assesses the quality of the water with respect to the protection of aquatic life: the Water Quality Index (WQI). The WQI assesses surface water quality based on the scope, frequency and amplitude of water quality observations relative to the guidelines for protecting aquatic life. Quality guidelines for a range of nutrients, metals, physical characteristics, ions and organic compounds are incorporated into the WQI calculations.

The WQI has been calculated for 345 sites, 19 on lakes, 326 on rivers, across the country where extensive water quality monitoring occurs. More monitoring sites are to be added over the next four years to generate the data that is necessary for determining the WQI. The WQI is quantified on a scale of 0 (poor quality) to 100 (excellent quality) and thus the WQI results can be directly integrated into the CWSI scoring scheme. Please refer to Canadian Council of Ministers of the Environment web site for information on the WQI[44].

Indicator 6 – Fish Population

Many Canadian communities are engaged in fishing activities, whether for commercial sales, recreation or subsistence. Such activities are highly dependent on a healthy ecosystem that can support strong fish populations. This indicator will therefore reflect the health of the native fish species that are economically and culturally important to a community. Thus those species that are commercially harvested, fished recreationally, and/or represent a significant portion of a traditional diet will be accounted.

Not only could this indicator reflect ecosystem health, but also the sustainability of the fishing activities. For example, if the STRESS and QUALITY scores are high yet fish populations are declining, then the problems may be associated with poor stock management.

The score for this indicator (E_F) can be calculated by assigning factors of 1, 0.5 or 0 to the percentage of economic and/or culturally significant species whose populations are believed to be increasing, stable or declining respectively. Exact population numbers are not required for this indicator. Anecdotal observations are sufficient.

$$E_F = (1i + 0.5s) \times 100$$

Where i = % of culturally or economically significant fish populations that are increasing
S = % of culturally or economically significant fish populations that are stable

Infrastructure

The infrastructure component will look at the state of the water and wastewater infrastructure that exists within the community by measuring its ability to meet future demand (DEMAND), its condition (CONDITION), and the level of treatment it provides (TREATMENT).

Indicator 7 - Demand

This indicator will assess the ability of the community's water infrastructure to meet future demand by measuring the number of years before 100 % system capacity is reached (t_{100}). A change in demand is an important consideration as it can provide an indication of when, and if, system upgrades or new facilities are needed. To solve for t_{100}, the following equation can be used:

$$t_{100} = \frac{\log FV - \log PV}{\log(1+r)}$$

Where FV = number of people that can be served at 100% capacity of existing system*
PV = number of people currently being served by existing system
r = annual rate of population growth

**constant per capita water use is assumed, however, significant trends, if known, can be factored in.*

The value of t_{100} is calculated for both the water and wastewater systems and the lowest score of the two is used. If population growth is negative, the score for infrastructure demand (I_D) will be 100, as the demand on the system will be decreasing. When population growth is positive, any community that has a value for t_{100} that is equal to or greater than 50 (i.e. 50 or more years until 100 % capacity is reached) will have a score of 100, and a community with a t_{100} of 0 (i.e. system is already operating at 100 % capacity) will receive a score of 0. The following equation can therefore be used to calculate I_D:

$$I_D = \frac{t_{100}}{50} \times 100$$

If, $t_{100} > 50$, then $I_D = 100$
If, $t_{100} = 0$, then $I_D = 0$
If $50 > t_{100} > 0$, then calculate I_D using the above equation

Indicator 8 - Condition

This indicator will measure the condition of the water and wastewater infrastructure by looking at the percentage of system losses in the water and/or wastewater mains. This not only provides a measure of system inefficiencies but an indication of the level of repair that is needed and, in the case of wastewater losses, the extent to which untreated effluent is released to the environment.

The following equation can be used to calculate a score for the infrastructure condition indicator (I_C), where 25 % system loss or greater will receive a score of 0, and 0 % system loss will receive a score of 100[45].

$$I_C = 100 - \left(\frac{L}{25} \times 100 \right)$$

Where: L = % system losses
If L >= 25, then $I_C = 0$
If L = 0, then $I_C = 100$

System losses (L) are determined for both water mains and sewers. The system with the highest percentage of losses is used to calculate I_C.

Indicator 9 - Treatment

The treatment indicator will focus solely on wastewater treatment plants as the quality of drinking water is addressed in the Human Health component. The degree to which wastewater will affect receiving waters will depend on the level of treatment it receives prior to discharge. There are three levels of wastewater treatment: primary, secondary and tertiary. Primary treatment only removes insoluble matter whereas secondary treatment removes insoluble matter and biological impurities. Tertiary treatment is the highest level of treatment where nutrients and chemical contaminants are removed after secondary treatment.

To determine a score for the infrastructure treatment indicator (I_T), the population connected to municipal sewers will be assessed depending on the level of wastewater treatment they receive. The percentage of the population that is serviced by sewers without treatment, primary treatment, secondary treatment, or tertiary treatment will be multiplied by the following factors:

None	0
Primary	1/3
Secondary*	2/3
Tertiary	1

**Waste stabilization ponds and sewage lagoons fall into this category as well.*

The equation below can therefore be used to determine a community's I_T score:

$$I_T = (1/3P + 2/3S + 1T) \times 100$$

Where: P equals % of population connected to sewers that receive primary treatment
S equals % of population connected to sewers that receive secondary treatment
T equals % of population connected to sewers that receive tertiary treatment

Those people that use septic tanks or are otherwise not serviced by municipal sewers are not accounted in this measure.

Human Health

The human health component of the CWSI will look at three issues that are directly related to the health and wellbeing of Canadians. Specifically, the component will look at the amount of potable water that is available per person (ACCESS), how reliable the water supply is (RELIABILITY), and to what extent the health of Canadians is compromised by poor drinking water quality (IMPACT).

Indicator 10 - Access

This indicator looks at how much potable water is normally available, with the exception of service disruptions, per person as a measure of whether or not basic domestic needs are being met. The amount of potable water to which people have access to provides an indicator of how much water is available for potential use, whereas actual use is, in many cases, dependant on behaviour and can capture uses that are wasteful and in excess of basic human needs. Water supplied by municipal infrastructure, water trucks and domestic wells can be included.

There are several assessments in the literature regarding adequate amounts of water for daily personal use, all of which fall well below the average daily water use for Canada. Nevertheless, there are some Canadian communities that record average daily uses that are below some of the recognized benchmarks.

According to Shiklomanov (1997), 150-250L a day will satisfy all personal requirements such as drinking, cleaning, bathing, etc. This benchmark, which is one of the highest, will be used here as it represents a range that complements Canada's position as a developed nation with a high quality of life. Thus, to evaluate the access indicator (H_A), the amount of accessible potable water that is available for domestic use will be compared to this benchmark, wherein those communities that have access to at least 150L/cap/day will receive score of 100. At the lower end, anything equal to or below 50L/cap/day will receive a score of 0. The following equation can therefore be used to calculate H_A:

$$H_A = 100 - \left(\frac{150 - y}{150 - 50} \times 100 \right)$$

Where: y = amount of accessible potable water that is available per person per day (L/cap/day)
If $y >= 150$, then $H_A = 100$
If $y <= 50$, then $H_A = 0$
If $150 > y > 50$, the calculate H_A using the above equation

Indicator 11 - Reliability

When a community is subject to service disruptions the supply is considered to be unreliable. This indicator is intended to reflect the reliability of a community's water supply by looking at the number of days that water service is interrupted by a loss of service, a boil water advisory or other forms of drinking water bans or warnings. Loss of service, boil water advisories or other drinking water warnings are typically issued when there is a concern about water quality that could be brought on by any number of reasons including contamination, infrastructure problems or even human error.

To determine a score for this indicator, the number of service disruption days per capita per year will be assessed. The total number of service disruption days (SDD) per capita can be calculated using the following equation where the maximum value for SDD is 365, which occurs when every person in the community is subject to a service disruption for the entire year.

$$SDD = \frac{\sum_{i=1}^{N}(p_i \times d_i)}{pop}$$

Where: SDD = service disruption days measured per capita
N = number of service disruptions experienced in a year
p_i = the number of people affected by service disruption i
d_i = the duration of the service disruption i in days
pop = total population

To arrive at a score for the reliability indicator (H_R), the following equation will be used:

$$H_R = \left(1 - \frac{SDD}{365}\right)^3 \times 100$$

Although 365 is the maximum value for SDD, 50 service disruption days, for example, is still considered to be a very significant problem despite having 315 days with reliable water. For this reason, the inverse percentage is cubed so that SDD values that pose a significant concern are not rewarded with high scores.

Indicator 12 - Impacts

This indicator will assess the health impacts that are associated with insufficient water quality and/or quantity. Waterborne diseases such as Giardiasis, Campylobacteriosis, Shigellosis, and illnesses caused by *Escherichia coli*, affect thousands of Canadians each year. To evaluate this human health impact indicator (H_I), the number of reported cases of waterborne diseases and illnesses (w) will be used.

To determine an H_I score, the number of water disease and illness incidents per 1000 people is factored into the following equation where a score of 100 will correspond to 0 incidents and a score of 0 will correspond to 1 or more incidents occurring for every 1000 people.

$$H_I = (1 - w) \times 100$$

Where: w = number of reported waterborne disease and illness cases/1000 people.
If w = 0, then H_I = 100
If w >= 1, then H_I = 0

Capacity

This component will measure the capacity of the community to manage their water resources safely and effectively by looking at financial capacity (SURPLUS), education (EDUCATION), and the number of trained operators working in water and wastewater treatment plants (TRAINING). This component is important because it outlines the socioeconomic resources available in the community to manage their freshwater resources on a daily basis, respond to issues that arise, implement policies and programs, and recognize potential or existing problems.

Indicator 13 - Surplus

To examine the financial capacity of a community, the local government's per capita surplus (excess of revenues over expenditures) will be assessed relative to the minimum and maximum levels across the country. Statistics Canada provides data on local government finance that is compiled at the provincial/territorial level. In 2002, local governments in Saskatchewan averaged the highest per capita surplus of $863 per person (+863). Conversely, local governments in Quebec averaged the greatest debt of $2177 per person (-2177). These maximum and minimum values will be used as benchmarks to calculate a score for the community's surplus indicator (C_S) where a value greater or equal to +863 will have a score of 100 and a value of less than or equal to –2177 will be have a score of 0. For values that fall between the benchmarks the following equation can be used:

$$C_S = 100 - \left(\frac{\max - s}{\max - \min} \times 100 \right)$$

Where: max = maximum provincial average for local government per capita surplus (+863)
min = minimum provincial average for local government per capita surplus (-2177)
s = Community's per capita surplus

Indicator 14 - Education

This indicator will look at the level of education within the community. Education can provide individuals with practical and analytical skills that, when applied locally, can positively serve the community in a variety of functions. Education can also serve as a proxy for awareness of health and environmental issues. Education will be an important consideration for the CWSI as it will provide an indication of the human capacity that is available to manage the water resource independently and sustainably.

The education indicator (C_E) will be evaluated using the percentage of the population aged 25 to 64 with a high school education or higher[46]. In 2001, 65.9 % of Canadians aged 20 to 64 had attained at least a high school certificate[47]. The highest provincial/territorial value was recorded in Yukon where 83.5 % of people aged 20 to 64 had attained a high school certificate or higher. The lowest value was recorded in Nunavut where only 59 % of people had a high school certificate or higher for the same age group[48]. These maximum and minimum values will be used as benchmarks for C_E scores where a value greater or equal to 83.5 % will have a score of 100 and a value less than or equal to 59 % will have a score of 0. For those values in between, the C_E score can be calculated using the following equation:

$$C_E = 100 - \left(\frac{\max - e}{\max - \min} \times 100 \right)$$

Where: max = maximum provincial/territorial % of pop aged 20-64 with a high school education or higher (83.5%)
min = minimum provincial/territorial % of pop aged 20-64 with a high school education or higher (59%)
e = community's % of pop aged 20-64 with a high school education or higher

If e >= 83.5%, then C_E = 100
If e <= 59%, then C_E = o
If 83.5% > CE > 59%, then calculate C_E using the above equation

Indicator 15 - Training

This indicator will specifically address the community's capacity with respect to the operation of water and wastewater treatment plants by looking at the level of training that water and wastewater plant operators have received. Adequately trained operators are needed to ensure the reliability and effectiveness of the water and wastewater infrastructure and are necessary to ensure the safety of the community members and the environment. To evaluate capacity in this regard, the percentage of operators with the forms of training listed below will be recorded for each plant. The percentage of operators in each training category will be multiplied by the corresponding factors listed below.

Industry certified	1
Other training	0.5
No training	0

Thus for each plant, the following calculation is required to determine an operator training value:

$$OTV = (1c + 0.5t) \times 100$$

Where: c = % of operators per plant that are industry certified
t = % of operators per plant that have some other form of training

To calculate a final score for the community, the results from the various water and wastewater treatment plants will be integrated using the following equation.

$$C_O = \frac{\sum_{i=1}^{N} w_i OTV_i}{\sum_{i=1}^{N} w_i}$$

Where: OTV_i refers to the operator training value for water or wastewater plant i

w_i is the weight applied to each plant which is based on the percentage of the population that the plant serves.

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[43] Gov. of Alberta web site.

[44] http://www.ccme.ca/ourwork/water.html?category_id=102

[45] According to NRTEE, poorly maintained piping systems and sewers lose up to 25 % of the water they carry.

[46] Includes high school, trade certificate or diploma, college and university (Source: 2001 Census of Population – Statistics Canada)

[47] Excludes census data for one or more incompletely enumerated Indian reserves or Indian settlements (Source: 2001 Census of Population – Statistics Canada)

[48] Ibid