Uneven and Unmonitored: an Overview of Municipal Residential Water Conservation in BC

by

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EXECUTIVE SUMMARY

British Columbia has set a goal of meeting half of new municipal water needs through conservation by 2020, and residential water consumption represents over half of municipal water demand. This report discusses the state of residential water conservation in BC Municipalities, and presents recommendations to improve conservation across the province.

A critical finding is the dearth of publicly available, standardized data surrounding water use and conservation in British Columbia. This report calls for the BC Government, Environment Canada, Local Governments and Researchers to address this gap by:

- Adopting common standards for reporting local government water use
- Collecting better data on water use, distribution and conservation through regular surveys
- Developing a process for integrating randomized control trials in program effectiveness, and incorporating knowledge transfer in the program review process
- Building and coordinating a database to share conservation program reviews, successes and failures

This report also analyzes results from the BC Municipal Water Survey 2016 to shed light on how water conservation varies across the municipal community in British Columbia. Findings include:

- There exists is a wide variety in average residential water consumption across municipalities, from 200 to 1400 liters per capita per day.
- Almost all municipalities have a conservation plan, but there is a large variation in their comprehensiveness.
- Having more conservation strategies is associated with lower residential water use.
- Larger population size is not associated with lower water use.
- Municipalities that are part of a greater water system appear to have lower water use.
- Some proven conservation measures, such as norms-based messaging in billing through comparisons with neighbours, can be readily implemented with little extra investment.

Limitations of this report include the cross-sectional nature of data, a limited sample size of municipalities, and a lack of randomized control trials in existing evidence. Together, these limitations draw attention to the fundamental challenge for British Columbia with regards to conservation planning: improving the quality, quantity and access to BC-specific data.

LIST OF ACRONYMS

BC — British Columbia

BCMWS — British Columbia Municipal Water Survey 2016

BCWWA — British Columbia Water and Wastewater Association

MWWS — Municipal Water and Wastewater Survey

WSA — Water Sustainability Act

ICI — Institutional, Commercial, Industrial

LPCD — Liters per Capita per Day

SF — Single-Family

MF — Multifamily

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INTRODUCTION

British Columbia may be rich in freshwater, but the supply and demand for freshwater resources are not always matched, neither geographically nor seasonally. For instance, we water gardens when it is driest (summer). Similarly, with 86% of British Columbia's population being urban (Statistics Canada, 2011), the demand for water is concentrated in metropolitan areas that do not necessarily coincide with freshwater reservoirs. These mismatches in demand and supply have been largely addressed by building hard infrastructure to store and channel freshwater from greater distances to meet current and future water demands. More recently, governments and water distributors have also recognized the importance of reducing the demand itself through water conservation.

More than half of local government demand for water is for the residential sector (Honey-Rosés et al 2016). It therefore represents the largest sector with potential demand reductions. While senior levels of government—the province in particular—have played a role in encouraging water conservation, through the generation of data, the mandating of conservation plans, and the setting of reduction goals, the issue of water conservation has been overwhelmingly a local issue, to be managed by water suppliers and municipalities.

While almost all municipalities are pursuing some form of water conservation for the residential sector, there have been no attempts to 1) capture what conservation strategies are being used, 2) evaluate which ones are effective, and 3) coordinate between municipalities across the province to share best practices. One previous survey (Ministry of Environment, 1998) did achieve the first goal, but with the aim of cataloguing existing practices rather than to identify successful ones. While this project cannot address all three goals, it does capture the conservation strategies currently implemented by municipalities, and suggests steps to start evaluating their effectiveness. By identifying current conservation strategies, seeing which ones are correlated with lower water use, and highlighting the current paucity of consolidated water data in the province, this project should serve planners, decision-makers, conservation officers, researchers, and interested members of the public in understanding the current situation of residential water conservation in British Columbia.

Ultimately, it is my goal that this project serve as a stepping stone toward the third goal: to help municipalities coordinate

with one another, other governments, and researchers, to share best practices in the pursuit of wiser use of our most precious resource.

While there is an important role for non-profit organizations and industry, recommendations in this report are directed to four specific actors: local governments, provincial government, Environment Canada, and researchers. These are the primary actors in improving conservation across local governments in British Columbia.
The recommendations are presented throughout the report in their corresponding sections, but are also compiled at the end under a separate section.

A note on terminology:
"Water conservation" is the primary term used in this report to refer to the pursuit of a reduction in water use, rather than the terms "water use efficiency" and "water demand management." In most cases these three terms may be used interchangeably. However, I believe "water conservation" contains an ethical component as to why water is being reduced, which I argue speaks better to the recognition of societal values inherent to any planning practice. This is in contrast the more utilitarian terms "water efficiency" and "demand management," used more often in engineering and economics literature.

PROBLEM STATEMENT

The primary goal of this report is to shed light on how water is being conserved in the residential sector in British Columbia municipalities. As part of this goal, there are a few guiding questions I aim to answer.

- **What conservation strategies are being pursued by BC Municipalities to reduce residential water consumption?**
  What are the most common residential conservation strategies in British Columbia? What are the least common? Is there a minimum set of conservation measures that all municipalities have implemented?

- **What conservation strategies are associated with the lowest rates of urban water consumption?**
  Is there any relationship between certain conservation strategies and water use? Are these relationships statistically significant? And do they suggest future directions for other municipalities?

- **Do larger municipalities use less water than smaller municipalities?**
  If more populous municipalities have larger water systems, are there organizational economies of scale that allow for a wider range of conservation policies to be adopted?

BACKGROUND AND PROJECT DESCRIPTION

RECOGNITION OF INDIGENOUS APPROACHES

It is incumbent upon all planners in British Columbia to recognize that many of present-day British Columbia municipalities are on ancestral, unceded territories of indigenous nations. Although the urban scope of my project does not explicitly address water use by First Nations or Métis, I do want to briefly recognize that water was used, managed, shared, and conserved for millennia before the formation of British Columbia or Confederation. With regards to water conservation in particular, place-based stories, which were passed down through generations by elders, played a role in instilling an ethic of water conservation. Consider the following Musqueam story of həm'ləsəm', as told by elder Larry Grant:

> X, who was our transformer, who was here after everything was here to make sure things were correct for people, came across a young person playing with water, where people were able to get fresh water. He was playing with the water, throwing it away and then fooling around, washing his hair, and didn't allow other people to have access to the water. So X came upon him one day and then asked him "why are you not sharing the water?" "Well this is my site, this is my place, this is my water. I can do what I want with it. I can play with it, I can throw it away, I can bathe as many times as I want." So X watched him, and as he was playing with the water, X transformed him into a rock, a rock about that size, and X said "now that you won't share the water, I transformed you into a rock for the whole world to see as they go by". (via. University of British Columbia, 2014)

Although this is the only section in which I touch on indigenous knowledge and and approaches to water management, this story should serve as a reminder to the reader of more traditional ways of pursuing water conservation. Such approaches are not captured in Province-led conservation data collection, nor by extension in this report, which seeks to establish continuity with existing data. This is a weakness and gap in my research, which I hope future researchers will correct.

LEGISLATIVE CONTEXT AND DISCUSSION

FEDERAL

The Constitution Act assigns almost all responsibilities regarding water to the provinces, not the Federal Government. The Federal Government has, however, played a role in collecting water-related data, notably through Environment Canada. It has also played a role in setting health standards (Health Canada), researching climate change (Natural Resources Canada), and managing water on indigenous reserves (Aboriginal Affairs and Northern Development Canada) (Fraser Basin Council, 2011). Of particular importance to the topic of water conservation, Environment Canada's Municipal Water and Wastewater Survey (2011) has shed light on how much water is being used, and metered, by municipality. Another major federal role has been in the provision of grants for water infrastructure (BCWWA 2014). For water conservation in particular, however, the Federal Government has neither been active either in legislation nor in setting specific goals.

PROVINCIAL

From 1909 until the adoption of the Water Sustainability Act in 2016, the British Columbia Water Act served as the primary set of laws governing the management and use of provincial water. However, as the Water Act was adopted in an era of low urbanization, low total water use, and to facilitate economic development, it was not crafted with conservation goals in mind (Brandes & Curran, 2008). Several important limitations to pursuing conservation in the Water Act, highlighted by the Ministry of Environment (1993), include:

- When making allocation decisions, there is no requirement to consider in-stream uses, or to consider levels required
- The system of water planning is based on reacting to license applications rather than conservation planning
- Conservation is limited to conserving fish and wildlife, not to ecological systems as a whole
- Water act does not require existing licensees to meet new standards, and does not allow for adaptive management

In 1998, the Provincial government addressed some of these gaps, with convening of a Water Conservation Working Group to adopt a provincial strategy for water conservation (British Columbia, 1998). Specifically, the Water Conservation Strategy for British Columbia highlighted principles of water conservation, as well as general strategic directions to guide legislation and regulation. Within these strategic directions, however, it is clear that the provincial role is in facilitating local water suppliers and local governments in adopting conservation measures. For instance: "…many strategic actions are more appropriately directed at the local level, to enhance benefits gained from initiatives already taken." (Water Conservation Strategy, 1998, p. 28). Rather than mandate reductions in water use or specific conservation measures, the Provincial strategy encouraged water conservation. Its actions include broad language such as "review water supply plans, official community plans, by-laws, standards, policies and procedures as applicable to ensure efficient delivery, use, and pricing of water," (p. 29). It also included specific actions that identified the responsible actor and specific pieces of legislation, such as "review section 22(l) of the Environmental Assessment Act to enable the executive director to require the inclusion of water use efficiency and water conservation measures in project reports (lead: Ministry of Environment, Lands and Parks)" (ibid). While there were some specific conservation strategies that emerged from the strategy—including most notably the mandate for making changes to the Building and Plumbing Code (strategic direction 2)—the strategy had been overall more *laissez-faire* than dirigisme. This is especially true for the planning-specific strategic directions, which, although mentioned, are much less demanding than they are voluntary. While "Plan, Manage and Evaluate" was identified as an umbrella strategy that included strategic directions "Comprehensive Water Supply Planning" and "Industrial Standards and Management Support," no significant changes are adopted. Rather than require by law that comprehensive plans be drafted by local governments, the strategy reads: "Local governments, utilities, and other large-scale water licensees are encouraged to seriously consider the following advantages in conducting a comprehensive water supply and management plan," (p.32) followed by three bullet points of advantages. Under "actions," the strategy clearly places responsibility on local and regional governments: "Give

full consideration to water use efficiency measures in local and regional water supply planning processes." (ibid.)
It also identifies pricing and finance as strategic directions, calling for a review of pricing structures, as well as encouragements to adopt universal metering and conservation-oriented pricing.

One component of the official Water Conservation Strategy was the catalogue of existing conservation measures in use by different governments and water providers across the province, which is particularly important to this project. This Water Use Efficiency Catalogue (Ministry of Environment, 1998) obtained responses from 94 municipalities (see Figure 1, next page). The conservation measures were grouped by "hard" and "soft" conservation measures. Hard conservation including legal tools, economic and financial tools, and operations and management tools, while soft measures included planning tools, education, school programs, lead-by-example, and partnership/cooperation (see Figure. 1). The Water Use Efficiency Catalogue also reports on the municipal rationale for conservation, and found that capacity constraints (65%) and the need to reduce costs (62%) were the most common reasons, with environmental stewardship (33%) and potential droughts (23%) being less common. Interestingly, this catalogue was also administered to Regional Districts, the province and the federal government. Of the two senior levels of government, it found the federal government to be least involved in water conservation (by number of conservation measures), identifying only 11 of 77 tools as part of its efforts, while the province was active in 20.
I include the Water Use Efficiency Catalogue in this discussion as it provides the only cross-sectional snapshot of what conservation initiatives were being pursued by municipalities, and has not been updated since 1999. The only other similar attempt is the BC Municipal Water Survey 2016, which captures measures active in 2013.
This in itself is an important finding: there is no up-to-date database on what conservation measures are being pursued in the province. By extension, we cannot know which ones are effective at achieving their stated goals.

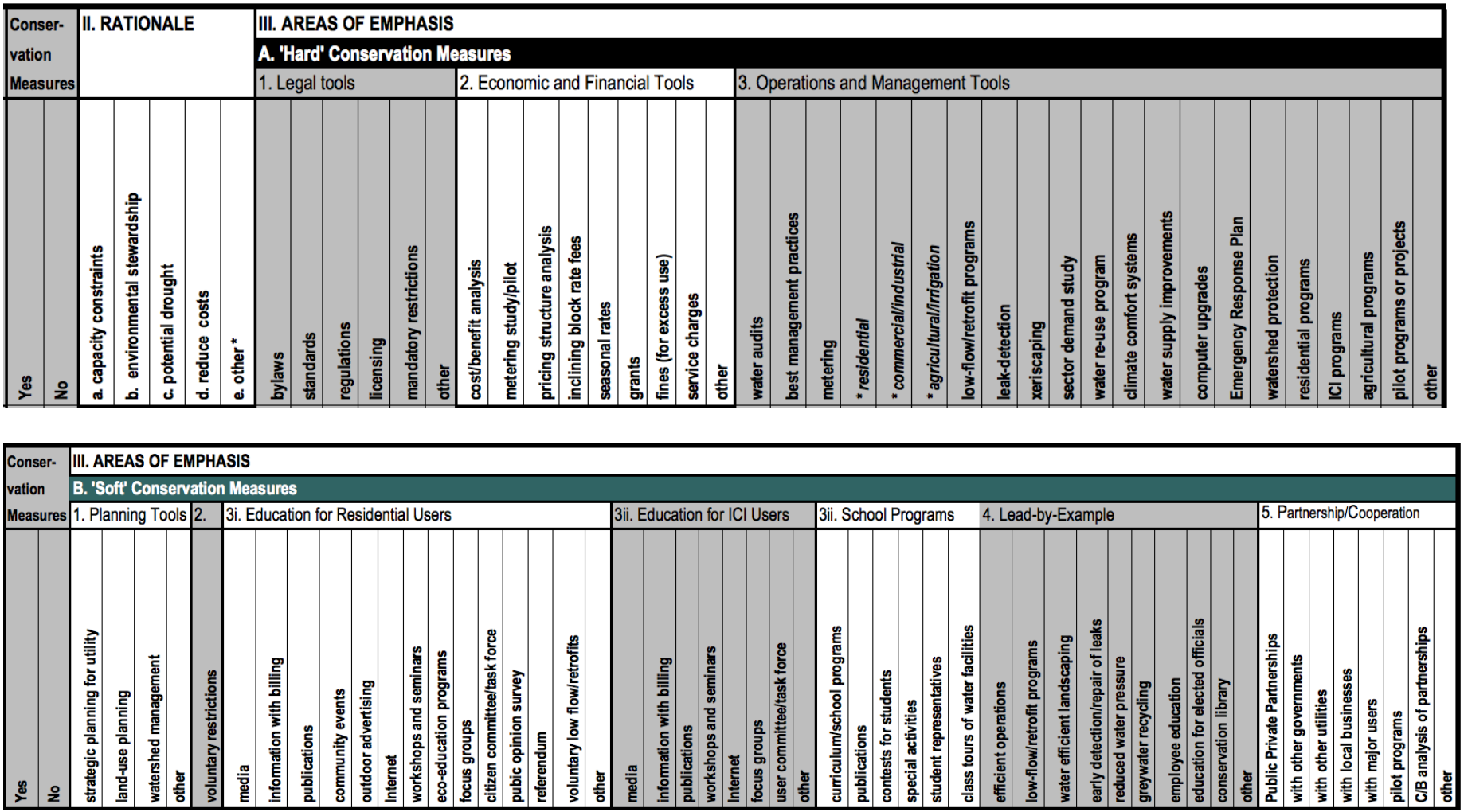

Figure 1 Conservation Measures catalogued in the Water Use Efficiency Catalogue, Ministry of Environment (1998)

There have since been provincially-led educational campaigns and water conservation-related goals, most notably the 2008 Living Water Smart policy. Living Water Smart goals include reducing overall water use by 33% by 2020, and meeting 50% of new municipal water needs through conservation (see summary of goals by Wong et al, 2009).

One particularly important change brought about by the Living Water Smart Policy, which solidifies the role of local providers as the primary actors in conservation, is the provincial requirement that local governments must have a water conservation plan in order to qualify for provincial capital grants for drinking water and wastewater infrastructure (Fraser Basin Council, 2011). To this end, the POLIS Project for Ecological Governance, with support from the Ministry of Community and Rural Development, developed the Water Conservation Planning Guide 1.0 (Wong et al, 2009). The stated purpose of the guide is to "help communities develop and implement comprehensive integrated water conservation plans." (Wong et al, 2009, p.1). This guide, focused on planning process, is an excellent resource that provides a step-by-step approach for small and medium governments to compile their water system profile, forecast demand, set targets, review conservation tools, identify the most appropriate ones, and implement them. However, it is lacking two critical elements that would help the province and municipalities achieve their water reduction goals in a coordinated fashion.

First, it does not provide a solid evidence base of which conservation measures have been effective in other, comparable BC communities. While it provides a small selection of case studies, it places the onus on the "Action team, local governments, municipal engineers, industry representatives, senior government" to identify and compile the list of tools and measures (Wong et al, 2009, p.50). It does refer to one existing evidence base, compiled by Brandes et al (2006)—but this guide too had to resort primarily to case studies and evidence from outside the province. Despite good planning support for municipal conservation following the 2008 Living Water Smart policy, the lack of a BC-specific evidence base is impeding evidence-based conservation planning (more on this under limitations).

Second, the guide's suggested planning process does not address this absence of an evidence base. It ends with a call for monitoring and program review, but leaves out a process for

how to share program effectiveness. By opening up reviews to other local governments, municipalities would facilitate planning knowledge transfer, and ultimately allow for the building of a BC-specific evidence base.

Recommendations

Province:

- Develop and manage a database of municipal water conservation strategies, which include costs of implementation and results.
- Commission a second version of the Water Conservation Planning Guide, which includes the process to share data with other local governments.

Local Governments

- Incorporate knowledge transfer into program review and monitoring, to ensure municipalities learn from one another in a systematic way

Researchers:

- Partner with governments to integrate program evaluation in water conservation, interpret results, and share findings

NEW CONSERVATION PLANNING OPPORTUNITIES

Together with Living Water Smart, the 1998 Water Conservation Strategy and catalogue of water use efficiency form the current conservaton-specific official strategy.
The new Water Sustainability Act (WSA, adopted in 2016) could present opportunities for more province-required conservation-oriented policy. Specifically, the introduction of "water sustainability plans," which allow specific regional issues to be addressed through both co-governance and multi-stakeholder planning in an enforceable manner, has been identified by the POLIS Project on Ecological Governance as a core regulation area in the WSA (Brandes et al, 2015). Despite incorporating significant changes that could make take WSA in a different direction from the 1909 Water Act (which did not feature conservation at all), it also suggests a continuation of having local and regional actors play the lead role in water conservation, rather than in mandating from the provincial level. Furthermore, the POLIS project is clear in its assessment

of the WSA: while it does have the potential to honour its ambitious goals of sustainability, its success will be largely determined by subsequent regulation, which still remains to be legislated.

Given this uncertainty the opportunities afforded by the WSA's water sustainability plans have yet to be realized. These plans are therefore not a focus of this project, which instead looks at how municipalities have pursued water conservation in the lead-up to the WSA's adoption. By illustrating how municipal governments are currently approaching water conservation in their community, it is my hope that this report can assist future planners and decision-makers with relevant information in the formulation of innovative water sustainability plans.

MUNICIPAL WATER SYSTEMS—FINANCE VS CONSERVATION?

Given that local governments in British Columbia are responsible for designing and implementing conservation measures, it is important to understand a general context of municipal water systems in British Columbia.

First, they are often underfunded. In the C.D. Howe Institute's "Wave of the Future: The Case for Smarter Water Policy," Steven Renzetti (2009) begins with a grim picture of Canadian Municipal water systems:

> On average, they lose or cannot account for 20 percent of the water leaving their treatment plants. They face a significant backlog of infrastructure repairs, and replacement costs have been estimated to be billions of dollars. They do not know how much water is consumed by the one-quarter of their residential customers whose water use is unmetered. And, in 2007, the revenues they earned represented only 70 percent of their recorded expenditures – which by most accounts understates the costs of their operations.

The more recent Canadian Infrastructure Report Card (CIFR, 2016) echoes this position, finding that only 71% of potable water systems in Canada are in "good" or "very good" condition. It identifies a need for long-term planning in infrastructure, and notes that smaller municipalities are in particular need: **"All communities, particularly smaller municipalities, would benefit from increased asset management capacity.**" (2016, emphasis not added, p.6).

Furthermore, the CIFR points out that only 14% of Canadian Municipalities' water systems have adaptation strategies that factor in climate change, which may be responsible for more severe droughts in British Columbia. Again, small municipalities are particularly at risk in this respect (only 10%).

British Columbia municipalities do not escape this nationwide trend. In its report "Are our Water Systems at Risk?" (2015) the British Columbia Water and Wastewater Association (BCWWA) sums up the current financial state of water and stormwater systems: "…the majority of of BC Municipalities do not generate sufficient revenues from fees to pay for the full cost of providing services. In order to reach full cost pricing in the worst cases, rates would need to nearly double to reach financial sustainability." (p. 22) In particular, they draw attention to small municipalities having greater financial gaps due to the lack of economies of scale. When discussing what needs to change, the BCWWA highlights the need for full-cost accounting, and more specifically the need to adjust water rates to cover the full cost of service. They point out how such full cost pricing, which may take the form of volumetric and increasing block rates, can "support sustainable systems and drive water conservation" (p.22). Given the clear connection between water rates and conservation, the difficult financial situation of municipal water systems, and the ability for conservation to reduce water supply costs, do we se a provincial shift toward volumetric pricing, higher rates, and greater water conservation?

The BCWWA report suggests that we do not. They argue that a historical dependence on senior levels of government has been hard to move away from. Referring to a 2014 Canadian Water and Wastewater Association survey of utilities, which found that the majority of respondents in BC identified the unpredictability of federal/provincial grant programs as a threat to infrastructure, the report is unequivocal: water systems are in precarious financial situations that undermines their resilience, and municipalities should avoid the risk by adjusting their pricing practices.

This finding that there has not been a province-wide shift to volumetric pricing is supported by recent findings from the BC Municipal Water Survey 2016, which found that, of 44 respondents, 29 are still charging only flat rates for single-family dwellings (32 for multifamily dwellings) (Honey-Rosés

et al, 2016.) Only 5 are charging increasing block rates for single-family residences. And only 2, or less than 5% of respondents, charge increasing block rates for multi-family.

The Canadian Municipal Water Priorities Report (Canadian Municipal Water Consortium, 2015) suggests another obstacle to full-cost recovery is "Declines in fee-based revenues from decreasing water consumption due to successful conservation efforts" (p. 16). This poses an interesting challenge for understanding the context of residential water conservation in British Columbia—an apparent trade-off between financial and social-ecological goals. While successful water conservation can reduce the demand for supply-side expansion, and therefore costs, if revenues are tied to the amount being consumed, then successful conservation can also decrease revenues. Is there therefore an incentive to not conserve water? One potential solution put forward by the Canadian Municipal Water Priorities is to combine fixed fees (to ensure full cost accounting) with volumetric pricing. This is indeed happening in British Columbia: the BCMWS found that 13 of the 44 responding municipalities (30%) have a combination of a volumetric charge and a base charge for single-family homes (10 for multi-family).

Recommendations

Researchers:

- Study pricing options and implications to assist local governments in improving system resilience

WHY RESIDENTIAL WATER USE?

There are three reasons why this project focuses on the residential sector, rather than other sectors. First, the residential sector represents the largest demand for potable water in local governments, more than all others combined (BCMWS, 2016). The other sectors, which are industrial, commercial, institutional (often combined as ICI), and agricultural, represent only 44% of total urban water demand (ibid.). Second, the economic make-up of local municipalities varies much more across the province than does the residential sector. The demand for water that service-based businesses of downtown Victoria are different from resource extraction support services or industrial activity surrounding Prince Rupert's port.

Lastly, it depended on what data was available. ICI-specific conservation measures are more targeted due to the differences within the sector. The BCMWS only asked about two ICI-specific conservation measures, and a more thorough survey would be required to properly catalogue and assess conservation policy in the ICI sector.

METHODS

The context section set the legislative context and general background for this project. It revealed how, with few exceptions, conservation efforts belong mainly in the municipal domain. It also uncovered a long-term and ongoing BC-specific data gap on what municipalities are conserving water. In order to address this lack of existing data, the primary method chosen to conduct this professional project was a survey of municipalities.

A survey of BC municipalities allows for municipal water practitioners, those most familiar with local water systems, to answer questions of how water is being conserved. Much like the 1998 Water Use Efficiency Catalogue (Ministry of Environment), it allows a cataloguing of conservation strategies.

THE BC MUNICIPAL WATER SURVEY 2016[1]

As a Research Assistant in the Water Planning Lab, under the guidance of Principal Investigator Jordi Honey-Rosés, I aided in the design and administration of the BC Municipal Water Survey 2016. In light of the lack of up-to-date data regarding how water is distributed, metered, priced among BC Municipalities, the survey was developed to fill this gap in a way that provides continuity with the Environment Canada Municipal Water and Wastewater Survey (MWWS, last administered in 2009). This provided an opportunity to also include questions about conservation efforts, not captured the MWWS, to allow for this report's investigation.

We administered the survey with the municipal water community between June and December 2015. Municipal governments were contacted by telephone and followed up by email, with approval from the Behavioural Research Ethic Board of the University of British Columbia. In our initial contact with municipal staff, we aimed to identify the person who was able to answer our questions about municipal water use. Once we had identified the correct individual, we sent him or her a document with the critical information we sought to

[1] Parts of this 'BC Municipal Water Survey 2016' methodology section are from the BC Municipal Water Survey 2016, which I co-wrote with Jordi Honey-Rosés and Claudio Pareja. For more thorough overview of methodology, please refer to the BCMWS 2016.

collect, so they could prepare in advance if necessary. We asked all respondents to provide data from 2013, although we accepted data from other years. We also allowed respondents to complete the survey on their own time and submit their response electronically if they preferred. Municipalities with a population under 10,000, and those who were not reachable by phone, were emailed the survey.

Several questions were included that addressed conservation. The most important involved a list of water conservation measures, which respondents checked if they were active. This question read: "Which of the following water conservation strategies does your municipality offer? *We are interested in programs that are currently active, not past programs or activities. Mark all that apply,"* and was followed by a list of seventeen conservation measures. Respondents could also include conservation measures that were not in the list.

The conservation measures were:

1. Low flow toilet rebate
2. Low flow showerhead and/or faucet rebate
3. Other low flow appliance rebate (for residents)
4. Educational watersaving campaigns (including tips, fact sheets, school outreach, etc…)
5. Rainwater harvesting or rain barrel program
6. Residential water reuse programs: includes grey water system program/rebate/education
7. Xeriscaping: any municipal effort to adopt or educate the public about low-water
8. Seasonal water pricing
9. Fines for excess use
10. Residential water audits
11. Industrial, Commercial, or Institutional water audits
12. ICI water reuse programs: including municipal or commercial reclaimed water cooling systems
13. Active leak detection program
14. Mandatory restrictions
15. Municipal Retrofit program
16. Provide residents with household water consumption data/trends in billing
17. Provide residents with water use consumption levels relative to other users

These questions were chosen to provide continuity, in certain cases, with the Water Use Efficiency Catalogue published by the Ministry of Environment (1998). However, due to conservation being only one topic covered by the BCMWS,

and a desire to maximize response rate by keeping the survey manageable, the same level of detail could not gathered. Instead, the 77 variables in the Water Use Efficiency Catalogue are grouped, where appropriate, into more general categories. For example, the Water Efficiency Catalogue asks about 28 measures regarding school programs, education for residential users, and education for ICI users. The BCMWS instead asks municipalities whether they are engaged in any "Educational Watersaving campaigns (including tips, fact sheets, school outreach, etc…)".

The BCMWS also allowed us to ask about conservation measures not covered by the Ministry of Environment catalogue. Specifically, conservation measures 16 and 17, regarding the provision to residents of specific information regarding their household consumption data, or their consumption levels relative to other users, were not asked in the catalogue[2].

Perhaps more importantly, the other sections of the BCWMWS, covering water consumption, pricing, and metering practices, allows us to answer the guiding questions set forth at the beginning of this report.

The survey methodology changed with the water pricing section of the BCMWS. Rather than asking respondents for the data directly (it was quickly revealed that they did not have pricing information at their fingertips), gathered by asking respondents for the bylaw that sets water rates. The bylaw was then analyzed and categorized based on whether single-family and multi-family fees were flat, volumetric (constant, increasing, or decreasing), or both. If available, pricing information was gathered for 2013, to represent the date of the other data. In many instances, however, the data is from 2014 or 2015.

[2] The Water Use Efficiency catalogue did, however, ask about the measure "information with water billing," under both the residential and ICI Education categories. As these can include tips and fact sheets, this is not strictly comparable to questions 16 and 17 of the BCMWS, which are more specific.

STATISTICAL ANALYSIS

In addition to describing the general findings of the dataset, I examined correlations between the number and types of water conservation strategies adopted by municipal governments and residential water consumption per capita. This meant selecting municipalities that had responded with information on 1) total water consumption, 2) the share of which went to the residential sector 3) share of the municipality's population served, and 4) conservation measures adopted.
This resulted in a sample size of 29 municipalities, ranging in population from 647 (New Hazelton) to 640,469 (Vancouver).

Of the 17 specific conservation measures that respondents were asked for in the BCMWS, 15 are related, either directly or indirectly, to residential water use. Two others (Industrial, Commercial, or Institutional water audits and ICI water reuse programs), having to do specifically with ICI sector, are excluded from the analysis.

In addition to these 15 conservation strategies, I have added Increasing Block Pricing for Single-family, and for Multi-family, as additional strategies.
In order to see whether the resulting 17 strategies are associated with lower residential water use, I conducted an analysis of variation (ANOVA) on each of them. I conducted an ANOVA to compare the effect of each conservation measure (IV) on the residential residential liters per day per capita (DV, also from the BCMWS[3]). This allows us to see if there is a statistically significant difference in means, assuming a normal distribution.
In addition, I conducted two ANOVA to compare the effect of 1) being part of a larger water provider and 2) population size on the residential per capita consumption. This is a way of seeing if the claim put forward by Renzetti (2009), that larger water systems have greater economies of scale and more resources, may also apply to the conservation: might multi-jurisdictional water systems have more pooled resources to put

[3] in light of updated information, I revised one data point from the original dataset,. Vernon's population, according to the Greater Vernon Water annual report (2014), is 53,000, thereby reducing the residential per capita consumption to 209 lpcd.

toward water conservation? Are large cities more efficient in their residential water consumption?

LIMITATIONS

CAUSALITY

One important limitation of having a cross-sectional survey is that it is not possible to establish causality, for several reasons. First, we do not know when a given measure was adopted by a municipality. Second, we do not know water use before and after the strategy was put into place. Third, we cannot account for all external factors, or confounds. For example, climate, the adoption of multiple conservation measures at once, and changing societal norms could all contribute to a reduction in residential water use over a given time period for a single municipality. For these reasons, and because of the low sample size, I stress that the results in this report be considered cautiously.

Other limitations stem from the fact that we ask only about active conservation programs. This means that past conservation programs that were discontinued, which may have had a lasting impact on water use, are not captured in this analysis. Also, some respondents may have answered with 2015 in mind, rather than 2013, given that we ask about "currently active" programs. For more methodological limitations, please consult the appendices of the BCMWS.

LACK OF EXPERIMENTAL RESEARCH

Unlike in the field of energy conservation, water conservation programs are rarely evaluated using randomized control trials (Ferraro and Price, 2013). An experimental research design allows researchers and municipalities to assess not only whether a particular conservation strategy is associated with a decrease in water use, but also whether it is because of that specific intervention that water use dropped. Having a control group, which can account for the multiple other forces that influence water use (see causality section), together with a sufficient sample size, are critical prerequisites to proper evaluation of conservation program effectiveness. Regrettably, although some experimental designs for water conservation have been conducted and published (see Ferraro and Price, 2013; Goldstein et al., 2008), none of these are specific to British Columbia. While some of the lessons from these experiments may be generalizable, it remains that there is

no BC-specific effort to generate thorough evaluations of conservation program effectiveness. If such studies are being conducted, then they are taking place within local governments, or potentially in multi-jurisdictional collaborations (e.g. Okanagan Basin Water Board). There is, however, no common forum for the systematic exchange of program effectiveness.

Recommendations

Province: Take the lead on

1) Developing planning resources for randomized experimental design in local governments
2) Coordinating the transfer of program effectiveness results between municipalities
3) Condition capital funding on municipalities demonstrating evidence that their proposed conservation efforts are effective.

Municipalities: where possible, implement or pilot water conservation strategies with randomized control trials to allow for program effectiveness

Researchers: partner with governments (local and senior), BCWWA, and coordinating agencies to integrate randomization in water conservation, interpret results, and share findings.

AVAILABILITY OF DATA

The most important limitation in this study is the lack of available data. The 1998 Water Use Efficiency Catalogue and the 2016 BCMWS (Honey-Rosés et al, 2016) are the only efforts at collecting conservation information in the province. However, even these efforts have collected only basic conservation measure information. Information surrounding date of implementation (to assess impact), implementation intensity (to assess differences of similar measures between governments), benefits and costs of conservation measures (to evaluate benefits), and program effectiveness are still not being collected in a systematic manner.

Furthermore, even basic data on water use and distribution are not being collected provincially or federally in manner that can be compared. For example, the BCMWS sheds light on how much water is used by the residential sectors of responding

municipalities, but these represent only 32% of local governments and 66% of the population (Honey-Rosés et al, 2016). Even the Environment Canada Municipal Water and Wastewater Survey (MWWS) reached only half of local governments, and 63% of the population (Environment Canada, 2011). Most importantly, the MWWS was discontinued after its 2011 report on 2009 data. The basic water use data collected by both the BCMWS and MWWS is the foundation upon which any evaluation of water conservation can be undertaken, and needs to be continued.

Furthermore, appendix 3 of the BCMWS reveals the number of methodological inconsistencies between local governments' collecting and reporting of standards (Honey-Rosés et al, 2016). There are currently different standards for the collecting of data surrounding water use, distribution, metering, pricing, and conservation. For example, water volume units range from cubic meters, imperial gallons, to hundreds of cubic feet. Whereas these can be converted in a manner that allows for inter-municipal comparisons, other data points are incomparable. For instance, municipalities have different definitions of multi-family housing, which can include some commercial uses and semi-detached homes (Appendix 3, Honey-Rosés et al, 2016). The lack of common standards prevents transfer of knowledge between municipalities regarding what programs are most effective.

Recommendations

Province:

- In coordination within Environment Canada and BCWWA, adopt common standards for data collection on water use, distribution, metering and conservation.
- Ensure continuity of BCMWS, to track progress of water conservation efforts within municipalities.

Local Governments:

- Pursue universal metering to improve water system quality.

Environment Canada:

- Reinstate the Municipal Water and Wastewater Survey

FINDINGS

THERE IS A WIDE VARIETY IN CONSERVATION UPTAKE ACROSS MUNICIPALITIES

In terms of how many conservation measures were adopted by municipality, the numbers ranged from no conservation measures (Armstrong[4]), to thirteen separate conservation measures for Mission and Abbotsford alike (who share a water system and set of measures), to everything in between (Figure 2). The BC Government, since the 2008 Living Water Smart policy, requires that municipalities have a conservation plan in place if they want to qualify for capital grants related to water systems. One might expect that this would result in two groups of municipalities: those who have adopted conservation plans and therefore have a number of adopted measures, and those that did not adopt such plans, who have very few measures. The BCMWS indicates that this is not the case. Instead, there is a fairly even distribution, with most municipalities having between four and eight (Honey-Rosés et al, 2016). 90% of municipalities have eight or fewer measures, leaving only Vancouver (10), Richmond (11), Abbotsford and Mission (13) with more than eight.

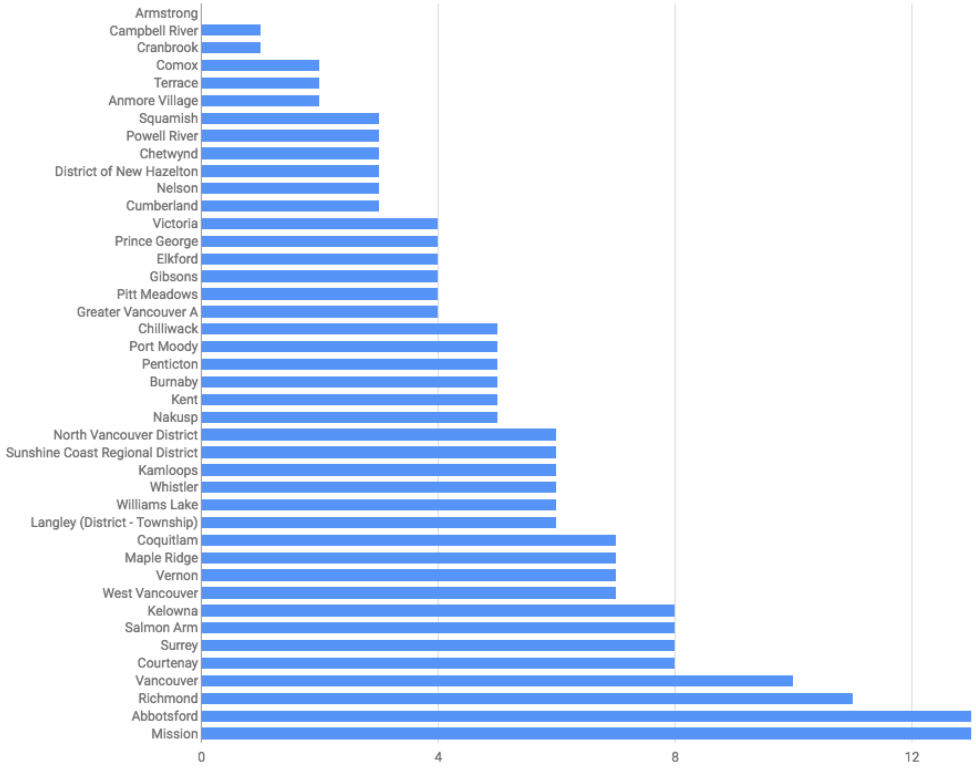

Figure 2: Number of Conservation Measures per Municipality

[4] Armstrong did indicate, however, that the Okanagan Basin Water Board does run conservation-oriented advertising in the City of Armstrong.

SEVENFOLD DIFFERENCE EXISTS IN AVERAGE RESIDENTIAL WATER USE BETWEEN MOST AND LEAST CONSUMING MUNICIPALITIES

Average residential water consumption also exhibits a wide range, from Abbotsford at 197 lpcd to Elkford at 1400 lpcd: a seven-fold difference between the highest and lowest average residential water use per capita. However, unlike the number of adopted measures, water use per capita is not as evenly distributed, with the majority (62%) of municipalities using between 200 and 400 liters per capita per day (Figure 3). Elkford's position as outlier, at 1400 lpcd, can be explained in part by its use of bleed lines within homes and the system (Colombia Basin, 2016). Bleed lines are open water lines that ensure continued flow throughout the winter to prevent freezing of pipes. Abbotsford, on the other end of the spectrum with the lowest residential water consumption, has had a long history of water conservation. Factors that may be contributing to Abbotsford's low water consumption include having the greatest number of conservation measures adopted universal smart metering as of 2011, and a comprehensive educational campaign through Abbotsford Mission Water & Sewer Services (Honey-Rosés et al, 2016).

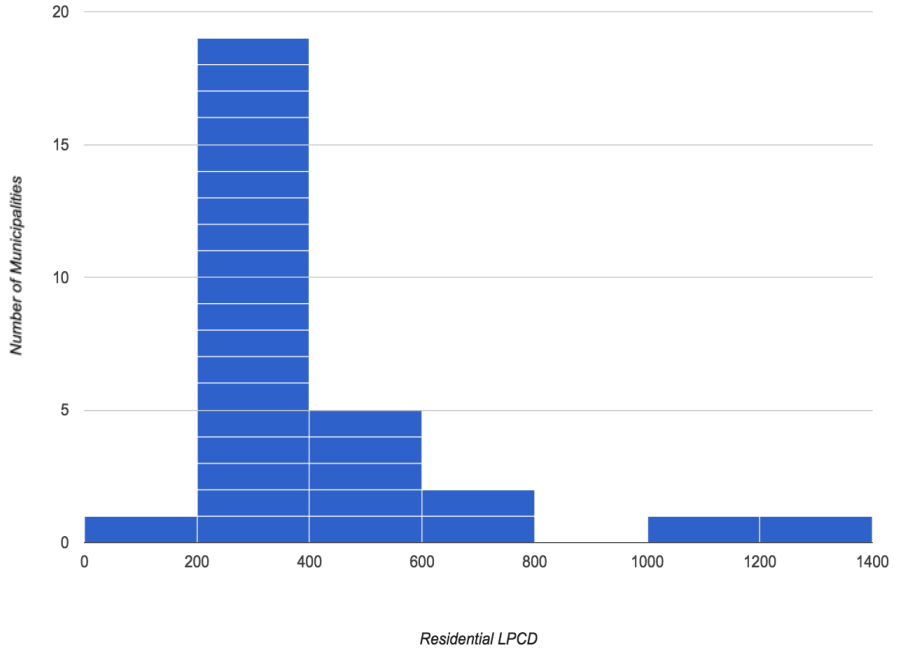

Figure 4: Histogram of Residential Consumption per Capita

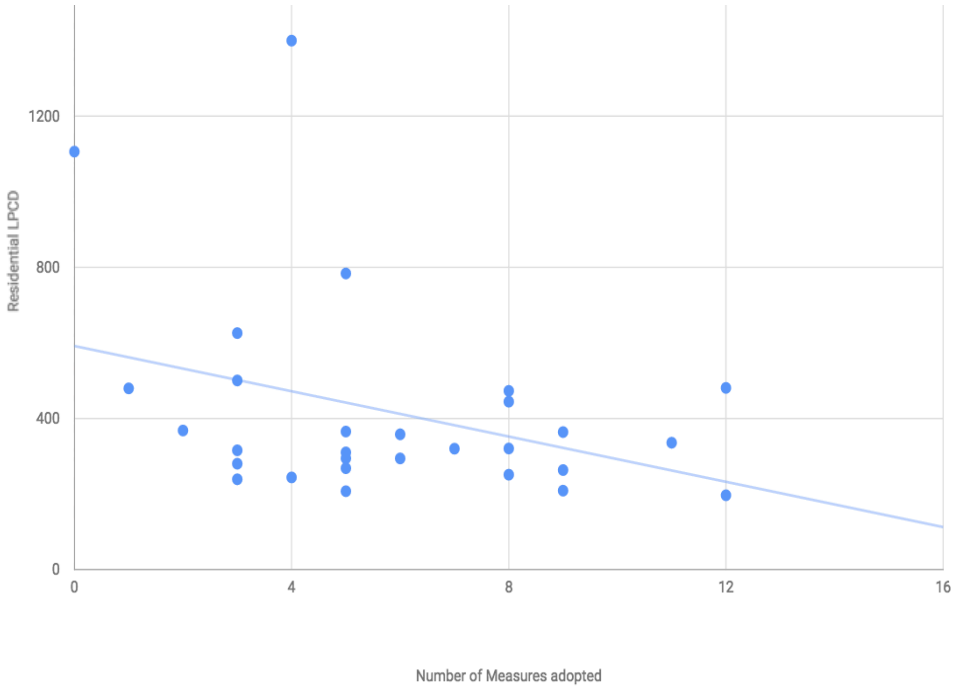

Figure 3: Residential Water Consumption by Number of Conservation Measures

MOST POPULAR MEASURES REMAIN THE SAME

"Education", "Mandatory restrictions", and "Active leak detection" are the three most common conservation measures among responding municipalities. 80% of municipalities have some form of educational campaign to encourage water conservation, 73% have mandatory restrictions in place for certain users and situations, and 60% have active leak detection.

A comparison with the 1998 Catalogue of Water Efficiency (BC Government) must be interpreted cautiously, due to different samples and breakdown of questions (most notably the under-sampling of small municipalities in the BCMWS). That said, a few comparisons are warranted. First, Education and Mandatory restrictions were the most common conservation measures in 1998, with leak detection not far behind—this suggests that relative popularity of the top measures has not changed much. Second, more municipalities are pursuing water conservation practices. Despite being the most popular measure, Education was a measure of only 50% of responding municipalities in 1998, compared to 80% in 2013.

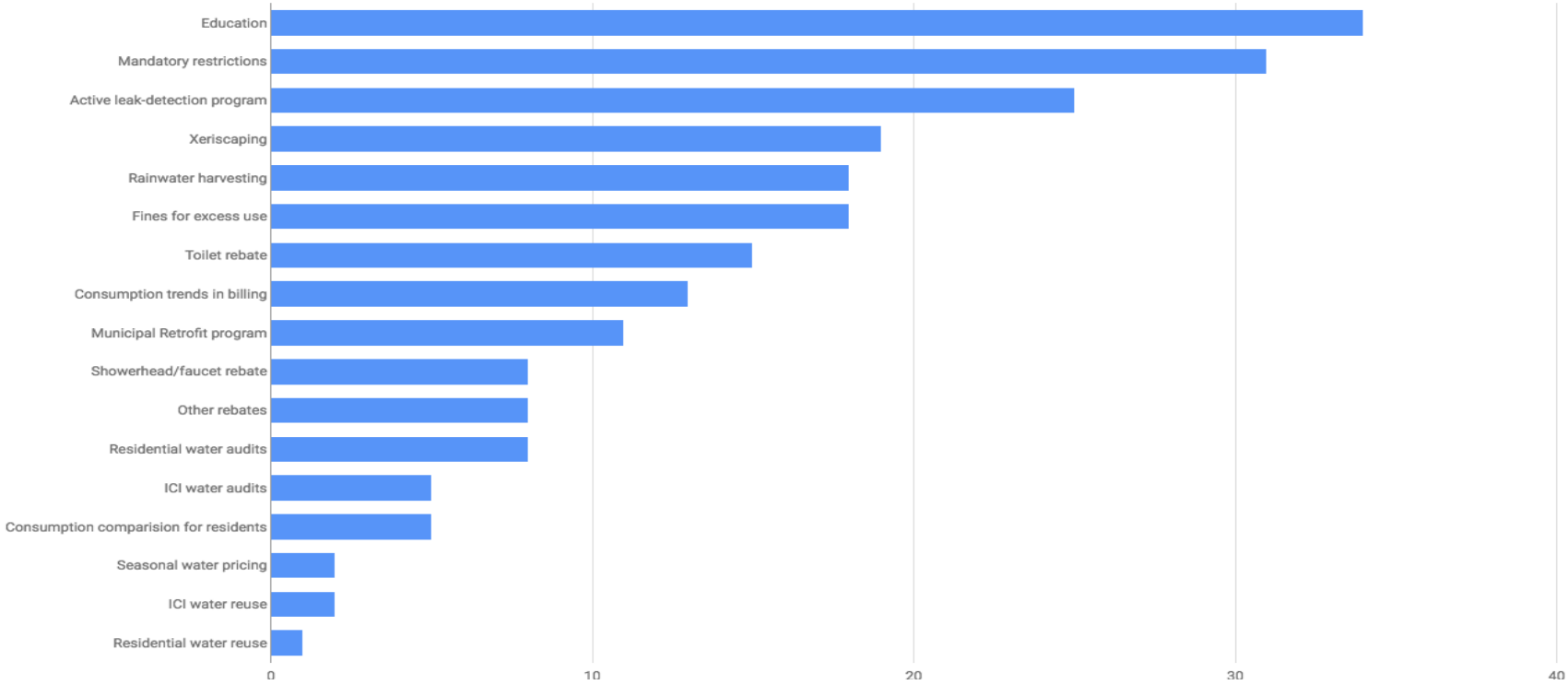

Figure 5 — Most Common Conservation Measures in BC Municipalities

LESS POPULAR CONSERVATION MEASURES DESERVE A CLOSER LOOK

The five least popular measures among the 42 responding municipalities are: residential water reuse programs, or grey water systems (1); ICI water reuse (2); Seasonal Water pricing, where residents pay more in the summer when supplies are more limited and demand is higher (3); consumption comparison for residents, which involves having information about water use relative to other users in billing information (4); and ICI water audits, a service to help businesses assess their water use (5).

The lack of uptake of these measures cannot be explained by a lack of effectiveness. The least popular measure, grey water system, was piloted in the City of Guelph for use in toilets. Their final report shows savings of 22.6 liters per capita per day (City of Guelph, 2012). The major reasons for lack of uptake have been regulatory: until recently, health provisions barred the adoption of any grey water reuse system (ibid.) The Drinking Water Protection Act prohibits requires that potable water be used for all domestic purposes, which includes sanitation (toilets and urinals) (Abbotsford/Mission Water and Sewer Services, 2012). In British Columbia, local health districts needed to approve proposed grey-water systems on a case-by-case basis until 2012 (ibid.). More recently, however, the Plumbing Code was revised to start introducing regulation surrounding both grey water and rainwater harvesting. An Abbotsford/Mission Water and Sewer Services (2012) report stated: "Many initial regulatory changes are expected in BC over the next several years; however, it may be many more years before all the necessary regulatory changes are adopted." (p. 7).

These recent regulatory shifts that allow for grey-water water systems must also then be regulated at the municipal level. The lack of re-use systems observed in this sample, then, can likely be explained by the implementation lag that follows such cascading regulatory changes: changes were made starting in 2012, and the BCMWS data in this report is from 2013.

Seasonal water pricing, consumption comparison information for residents, and ICI water audits, however, do not require changes to existing regulation. Indeed, they are all in place to some degree or other. The correlation between increased water price and water conservation has been established (Renzetti,

2009), suggesting that seasonal water pricing would be effective. In fact, it is already happening at larger scales: Metro Vancouver charges its municipalities for bulk water on a seasonal basis, charging more for water during the summer (Metro Vancouver, 2014). The fact that most Metro Vancouver municipalities do not pass those seasonal costs on to residents suggests that the reason is likely political. Metro Vancouver's board members are not directly elected to that position, unlike municipalities' councils. A second reason that could account for seasonal pricing not being passed on, that most municipalities do not have the metering infrastructure in place to charge volumetrically. That said, it would still be possible for unmetered municipalities to charge a higher seasonal flat charge for water, to both better reflect its true costs (systems being built for summer demand) and to achieve water conservation.

Comparative water use information for residents may be a "low-hanging fruit" for water conservation initiatives, given that the required process is already in place for many metered municipalities. This conservation measure entails sending residents information of their water use with additional information as to how it compares to others' use. An experimental study in Cobb County, Atlanta, Georgia had the local utility send targeted, mail-based educational letters to its water users to test the effectiveness of this measure (Ferraro and Price, 2013). The design, rooted in social psychology, found that social comparisons can indeed lead to conservation, by suggesting (it is argued) that high users are in violation of social norms. Those targeted with this 'strong social norm' treatment found a decline of 12%, relative to the control group's decline of 8% in water use, and to other treatment groups. The results are statistically significant at the $p<.05$ level.

A conservation of 4% may not sound like a lot, but the ease with which a conservation program can be implemented is critical in assessing its implementable. In this case, it means that over one third of municipalities sampled in the BCMWS (Honey Rosés et al., 2016) that meter and bill single-family residents in a volumetric fashion have all the information they need, as well as the billing system in place, to begin such a program.

The fact that only five of those sixteen municipalities have a similar program in place, despite strong evidence of its

effectiveness, further indicates that there is little transmission of program effectiveness between municipalities in British Columbia.

Recommendations

Province:

- Continue introducing regulation to facilitate the adoption of grey-water and rainwater harvesting systems.
- Assist local governments in transferring lessons (successes and failures) in conservation to others.

Local Governments:

- Where possible, include norm-based comparisons with neighbours on bills for residents.
- As greywater and rainwater regulation is adopted at the local level, collect and report information regarding costs and water use reductions to enable program evaluation.

Researchers:

- Partner with local governments to identify implementable conservation strategies,

RAINWATER HARVESTING PROGRAMS ARE ASSOCIATED WITH LOW WATER USE

Only one of the seventeen water conservation measures asked about in the BCMWS is associated with lower per capita residential consumption in a statistically significant manner: rainwater harvesting (including rain barrel program).
This does not, however, mean that implementing a rainwater harvesting program will necessarily lead to a decrease in residential water consumption (see limitations section). Although this is a possibility, it is also possible that rainwater harvesting is an 'extra' conservation measure pursued by local governments that have more comprehensive water conservation strategies. This is borne out by an ANOVA test, which shows that the mean number of conservation measures adopted between municipalities that have rainwater harvesting, and those that do not, cannot be explained by chance ($p<.05$). That is to say, having rainwater harvesting as a conservation measure is associated with a greater number of conservation measures.

Furthermore, a regression analysis reveals that a greater number of conservation measures is also associated with lower water use ($p<.10$). This suggests that multi-pronged conservation strategies may be effective in reducing overall residential water consumption.

Recommendations

Researchers:

- Investigate how diversity of conservation measures within a local government impacts water demand.

BIGGER POPULATION SIZE IS NOT ASSOCIATED WITH LOWER RESIDENTIAL WATER USE. BEING PART OF A GREATER SYSTEM SUPPLIER IS.

Renzetti makes the case that larger water systems have greater economies of scale, and that smaller water systems in Canada should be consolidated for more efficient water use (2009). I tested a parallel argument: that bigger and consolidated water systems, having more resources at their disposal from economies of scale, have more to devote to conservation.

First, a regression analysis testing the effect of population size on residential water consumption does not yield a statistically significant association. This means we cannot reject the null hypothesis that population size has no effect on average residential water consumption.

Interestingly, however, an ANOVA test reveals that consolidated water systems—municipalities that responded getting water from another provider—are associated with lower water use ($p<.05$).

Taken together, theses tests suggest that the presence of a multi-jurisdictional water provider may have more influence on residential water consumption than population size alone. This raises important questions from a planning perspective. First, is regional conservation planning more effective than local conservational planning? If that is the case, what are the characteristics of regional water suppliers that may account for the difference? Also, how do the interactions between multi-jurisdictional and the municipalities they serve impact water conservation strategies?

Although answering these questions are beyond the analytical scope of this analysis (requiring follow-up case studies on multi-jurisdictional water suppliers), I highlight them here as an important direction for future research.

Recommendations

Researchers:

- Investigate the difference between regional and municipal scales of conservation. Are regional water providers better equipped, or in a better position, to adopt water conservation measures?

Province:

- Identify opportunities for consolidation of local water systems.

CONCLUSION AND RECOMMENDATIONS

Nearly all BC municipalities surveyed in the BCMWS have a conservation plan, due in part to provincial requirements and water efficiency goals (Fraser Basin Council, 2011). However, conservation efforts are largely uncoordinated, undertaken within individual municipalities and their multi-jurisdictional water suppliers. The result is a conservation disparity across the province, with little evidence of municipal program effectiveness being compiled and transferred.

The primary findings and recommendations of this report address the existing knowledge gap. Federally, Environment Canada should reinstate its Municipal Water and Wastewater Survey. Provincially, the government should pursue its ambitious goals by facilitating the exchange of lessons between municipalities: mandating common standards and reporting, building a conservation effectiveness database, and coordinating its continual update. Importantly, the province should partner with researchers to develop a sequel to its Water Conservation Planning Guide to enable the building of this evidence base.

Local governments should aim to measure the impact of their water conservation programs, possibly through experimental designs such as randomized control trials. By learning from their own programs they may also transfer knowledge to other local governments. Those who have universal metering should adopt norm-based comparisons with neighbours in residential billing.

Researchers also have an important role to play in partnering with levels of government to enable more effective program evaluation, research design, and knowledge transfer across governments. By working together, researchers and government officials can contribute to making BC a world leader in water conservation research and implementation.

Specific recommendations include:

Province

- Adopt common standards for data collection on water use, distribution, metering and conservation in coordination within Environment Canada and BCWWA.

- Ensure continuity of BCMWS, to track progress of water conservation efforts within municipalities.
- Develop and manage a database of municipal water conservation strategies, which include costs of implementation and results.
- Commission a second version of the Water Conservation Planning Guide, which includes the process to share data with other local governments.
- Take the lead on
    - Developing planning resources for randomized experimental design in local governments
    - Coordinating the transfer of program effectiveness results between municipalities through water conservation database
    - Condition capital funding on municipalities demonstrating evidence that their proposed conservation efforts are effective.
- Continue introducing regulation to facilitate the adoption of grey-water and rainwater harvesting systems.
- Assist local governments in transferring lessons (successes and failures) in conservation to others.
- Identify opportunities for consolidation of local water systems.

Local Governments

- Where possible, implement or pilot water conservation strategies with randomized control trials to measure program impact
- Where possible, include norm-based comparisons with neighbours on bills for residents.
- As greywater and rainwater regulation is adopted at the local level, collect and report information regarding costs and water use reductions to enable program evaluation.
- Incorporate knowledge transfer into program review and monitoring, to ensure municipalities learn from one another in a systematic way.

Environment Canada

- Reinstate the Municipal Water and Wastewater Survey.

Researchers

- Partner with governments (local, regional, provincial and federal), BCWWA, and coordinating agencies (e.g.

OBWB) to integrate randomization in water conservation, interpret results, and share findings.

- Study pricing options and implications to assist local governments in improving system resilience.
- Investigate how diversity of conservation measures within a local government impacts water demand.
- Investigate the difference between regional and municipal scales of conservation. Are regional water providers better equipped, or in a better position, to adopt water conservation measures?

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