EVALUATION OF COMMUNITY WATER CONSERVATION EFFORTS IN THE COLUMBIA BASIN 2009 to 2015

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Dated July 14, 2016.
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EXECUTIVE SUMMARY

In 2009, Columbia Basin Trust initiated the Columbia Basin Water Smart Initiative (Water Smart\(^1\)) to provide financial and technical support to participating communities to support achievement of a targeted Basin-wide 20% reduction in average community water demand\(^2\) over a seven-year period from 2009 to 2015. The following report is an evaluation of Water Smart, which is ending formally in late 2016. The assessment focused on the efforts of 14 of 26 participating communities that have acquired sufficiently comparable water data over the 7-year period from 2009-2015.

The purpose of this report is to:

- evaluate what was actually achieved as a result of community action relative to annual weather variability from 2009-2015;
- to assess lessons learned; and
- to make recommendations regarding future actions that might be most fruitfully pursued given the findings of this evaluation.

There are many factors that influence water use, and so it was understood from the outset that the targets may not be achievable for all communities over a short period of time, due to the complex interaction of infrastructure issues, climatic variability, changes in land use activities, and human behaviour.

Water Smart is a unique water conservation program because for the first time the 14 participating communities were able to develop a consistent and comparable water accounting program that allowed them to accurately identify and address their priority water demand management issues. Specifically, the two greatest challenges facing all communities in the Columbia Basin are a) water loss in the distribution system due to aging infrastructure that is prone to leakage, and b) peak summer water demand, typically driven by residential irrigation.

The water loss management program that was developed through Water Smart was successful, and not only helped to build in-house capacity for water loss management, but stimulated collaboration between water utility operators throughout the region. This has lead to significant improvement in the use of night flow measurement to assess water loss, and has resulted in widespread repairs of leaks. Ten of 14 communities achieved reductions in winter water demand ranging from 2 to 53%, largely attributable to water loss management. However, while large savings were made by repairing leaks, this problem will continue to be of concern until the long-neglected infrastructure funding gap is addressed.

A number of communities worked to address local summer peak water use through implementation of a face-to-face public outreach program called Water Smart Ambassadors. Reducing summer demand has proven to be challenging, with 6 of 10 communities achieving July and August peak demand reductions. It is noted that 2015 was a record-hot year, and implementation of the Water Smart Ambassadors program, coupled with watering restrictions,

\(^1\) ourtrust.org/watersmart
\(^2\) For the purposes of Water Smart, community water demand includes commercial, municipal, and residential demand, and excludes (where possible) agricultural and industrial demand.
allowed these 6 communities to achieve demand reductions despite strong historical correlations between peak water use and sustained high temperatures.

By 2015, 12 out of 14 communities had achieved total demand reductions ranging from 2 to 39% of annual demand. From 2009 to 2015, on average the 14 communities reduced total water demand by 11%.

During the Water Smart Initiative, two of the 14 communities examined in this study implemented universal water metering programs. Others are considering this option but are hoping to learn from the experience gained by the two metered communities. In the meantime, they are addressing more urgent issues associated with system leakage. Only a few communities achieved the 20% reduction target over 7 years, but all made major progress to reduce their water footprint. The greatest improvements were achieved in overall capacity building and in substantial improvements in water data collection accounting. Communities were partially successful in reducing winter water use and the summer peak, but these issues will require ongoing attention by all of the communities.

It is shown that increased climatic variability is a major issue for future water use in the Basin. It is recommended that Basin communities continue to maintain aggressive ground and surface water conservation programs in the future.

Particular focus should be given to supply and demand issues under a climate change scenario for both surface and groundwater sources. This is of particular importance because the summer of 2015 was the hottest in many communities since records began, and 2012 was the wettest. The implications of climate change for water management in the East and West Kootenays are explored briefly.

Lessons learned from Water Smart are summarized, and are thought to be transferrable to other communities in other regions, regardless of community size. The primary lessons learned focus on:

- Comprehensive and accurate water accounting, including, in some cases, universal metering;
- Water Loss Management and asset management planning;
- Establishment of efficient and equitable water pricing;
- Peak (outdoor) demand management;
- Source water inventory and planning and
- Ongoing collaboration and communication.

The participating Water Smart communities should be commended for helping to initiate and participating in this successful water conservation program. It is one of the most unique, innovative and timely water conservation programs that should be featured as one of the best examples of how a collaborative community engagement can lead to successful improvement of water resources management.
1. INTRODUCTION

Canadians are among the largest domestic water users in the world, but most of the available data is from cities where water is metered and where the difference between residential, commercial, and industrial uses can easily be measured. Little data is available for small Canadian communities, where water is often not metered, where support for infrastructure repair and replacement may be lacking, and where customer-scale water accounting is infrequent.

Given the evidence of increasing climatic variability and the basic concern to provide sufficient water to all residents in the future, Columbia Basin Trust (The Trust)\(^3\) initiated an exploratory analysis of municipal water use in Basin communities in 2005 (Ronalds, 2005). The data collected at that time suggested that Basin communities were using excessive amounts of domestic water, but the reliability of this data was questionable because few communities had a consistent water accounting system. Concerns were expressed that increased climatic variability might lead to supply constraints in years with low rainfall coupled with high temperatures. One of the most cost effective adaptation strategies to address climatic variability and improve local climate resilience is to focus first on water conservation.

1.1. Columbia Basin Water Smart

In 2009, the Trust initiated the Columbia Basin Water Smart Initiative (Water Smart\(^4\)) to provide financial and technical support to participating communities to support achievement of a targeted Basin-wide 20% reduction in average community water demand\(^5\) over a six-year period from 2009 to 2015. Data issues do not allow for aggregate data analysis for all 26 communities (see Section 1.2 for details of data issues) and 14 communities have been included in this evaluation study.

Since 2009, Water Smart has worked with 26 local governments, including two regional districts, 23 municipalities, and one First Nation band\(^6\). Each community set their own local demand reduction targets ranging from 5 to 50% reduction in community water demand by 2015 from the 2009 baseline year.

The average demand reduction for the 14 communities included in this study from 2009 to 2015 was 11%, with the range being from +11% to -39%. The 2009 to 2015 results are discussed in detail in Section 5.0.

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\(^3\) www.ourtrust.org

\(^4\) www.ourtrust.org/watersmart

\(^5\) For the purposes of Water Smart, community water demand includes commercial, municipal, and residential demand, and excludes (where possible) agricultural and industrial demand.

\(^6\) See Appendix 2 for a listing of all participating Water Smart communities as well as communities that have been included in this program evaluation study.
In order to facilitate the achievement of both community specific and Basin-wide targets, since 2009 Water Smart has provided participating communities with a wide range of technical, educational, and financial resources intended to support development of lasting in-house capacity for effective water demand management. Some of these include:

- **Water Smart Match Funding** of up to $10,000 per community per year to implement actions identified in each community’s Water Smart Action Plan. Since 2009, some communities have accessed over $50,000 in match funding to support local demand reduction planning, analysis and action.

- **Water Smart Team** helped communities assess their water conservation priorities, and develop and implement their Water Smart Action Plans to achieve their water conservation targets. Support has included:
  
  - technical guidance,
  - assistance in developing requests for proposals
  - proposal submission review and comment
  - evaluation of draft consultant reports
  - development of technical resources
  - ongoing data collection and analysis support for gross, monthly and leakage analysis data and
  - communications and outreach support.

- **Water Smart Ambassador Program**: 13 Water Smart communities have participated in a Water Smart developed, community delivered face-to-face public outreach and education program that primarily targets residential and park irrigation demand reduction. Water Smart Ambassadors support residents with free lawn and garden soil and irrigation assessments; support to properly program automated irrigation systems; free hose timers for manual irrigators; and in some cases provide free rain sensors for automated irrigations systems, to be installed at the property owners’ expense. The Ambassadors also assist public parks staff with irrigation system audits for parks and sports fields. In some cases, they have assisted communities to map properties that use winter bleed lines, and in others have conducted indoor fixture audits for commercial accommodations. In all cases, the purpose of the program is to support communities to achieve reductions in peak water demand.

- **Water Smart Learning Opportunities**: These have included extensive training in water loss management, irrigation best practices training for parks staff, water utility rate setting education, data collection and analysis training, and more.

- The **Water Smart Website** was developed as a central access point for information and technical tools developed through the learning opportunities. It is also a basic entry for each community’s public communications on water conservation and a place to share news and information with staff and elected officials in Water Smart communities.

- **Water Smart Collaboration Network**: This was an informal network that has arose from a growing desire from staff in Water Smart communities to connect with and learn from colleagues in other Basin communities. The Water Smart Team connects individuals with knowledge and learning needs in order to develop regional capacity for water demand management. While this is an intangible “resource”, it has proven to be one of the most
important factors in Water Smart’s success, by allowing communities to collaborate effectively with and learn from each other and from leading water conservation experts.

1.2. Evaluating Water Smart

The following report is an evaluation of the learning from and outcomes of Water Smart at the end of 2015. The purposes of this evaluation are to:

- evaluate what was actually achieved as a result of community action as opposed to annual weather variability;
- to summarize lessons learned; and
- given the findings of this evaluation, to make macro-level recommendations regarding the most effective and cost effective water conservation actions that can be taken by communities in future to reduce total and peak water demand. Community-specific recommendations for action are not included in this evaluation.

Detailed analyses of changes in monthly and annual water consumption, the relationship between water demand and climate, and the relationship between water utility rates and demand are presented in subsequent sections of this report.

Changes in data reliability and availability since 2009

In 2009, just one of the 26 participating Water Smart communities was universally metered and just one had a complete commercial/institutional metering program. Since then, four additional communities have implemented universal metering programs, and one more has completed a commercial/institutional metering program. In addition, over half the communities have made substantial improvements to data collection infrastructure (e.g., source meter calibration or replacement; implementation of data logging capacity; improvements to SCADA systems; etc.) and data analysis capacity (e.g., operator training; software enhancements). These water accounting improvements ensure that the data presented in this study can be relied upon as comparable across the participating communities.

Twelve of the 26 participating Water Smart communities have been excluded from this program evaluation due to one of the following conditions:

- changes in data accuracy, including source-meter replacement, that make it impossible to compare data from the 2009 baseline through the project to the 2015 study year (a positive improvement for these communities);
- in two cases, annual and gross monthly data sets were not available for analysis; or
- late entry into Water Smart that prevents data analysis back to 2009.

All but one of the 12 communities that are excluded from this study now have reliable gross water supply data, and a new baseline-year of 2011 or later will allow for accurate long term water demand data and trend analysis from that point forward. This is a significant qualitative improvement resulting from participation in Water Smart.

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7 See Appendix 2 for a list of the 26 communities in Water Smart, and the 14 communities included in this evaluation.
1.3 Drivers for Water Conservation in the Basin

It is essential to understand that the ecosystem water supply scenario in the Basin at this time is one of abundance as the normal state. Only two of the participating communities were facing imminent ecosystem supply constraint in 2009, and in both cases, these particular constraints have been or will soon be resolved by measuring, locating, and reducing leakage in the municipal water distribution system. Up to the end of 2014, ecosystem supply limitation was not generally perceived by local governments to be a strong driver for pursuing water conservation in the Columbia Basin region.

Through the 2009 to 2015 period of Water Smart, the most imminently perceived drivers for water demand management have been infrastructure resilience and sustainability – peak water demand and leakage are driving costly infrastructure expansion and/or replacement, exacerbating the local and regional water utility infrastructure funding gap.

Like the rest of BC, however, the summer of 2015 was unusually hot and dry, returning ecosystem supply protection to the forefront of perceived drivers for long-term water conservation action by local governments. In the foreseeable future, climate change is projected to result in reduced community water availability and higher water demand across the Basin.\(^8\) Given this approaching scenario, it can reasonably be assumed that ecosystem water availability will, in future, be more in keeping with the summer 2015 experience, and will thus also be an increasingly prominent driver for water demand management in the region.

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2. KEY FACTORS THAT INFLUENCE COMMUNITY WATER DEMAND

There are many factors that influence water demand. Typically, community water demand exhibits large seasonal variability, with relatively lower demand and smaller variation during the winter months, and rapid increases in demand during dry, hot summers (see Figure 2.1.1, below).

Climatic conditions have a major influence on how much water is used by a variety of actors.

Land use and development patterns can influence water demand.

A wide range of technological and infrastructure factors directly influence gross water demand. Smaller communities often struggle to find the financial resources to build and maintain the water infrastructure that is required to deliver water to consumers. Proper water accounting is often limited. Attracting and maintaining the requisite skilled workforce is a persistent challenge. And typically there are limited resources for public education programs about water and its use, conservation, and the infrastructure that delivers it from source to tap.

The local source of water, local storage capacity, community culture, prevailing climatic conditions, and even drought-related media from distant locales, also play a key role in shaping public perception about how much water is actually consumed and the level of awareness about local drivers for water conservation.

2.1. The Climate Factor

Temperatures play a primary role in water demand. Water consumption changes significantly between winter and summer because comparatively little water is used outdoor during the period from November to March.

Summer Demand

During spring and summer, water consumption increases with temperature and is usually the highest in July or August, when the maximum annual air temperatures are reached (see Section 2.1 for detailed discussion of climate and demand in the study communities). Water consumption increases even more when, in addition to higher temperatures, precipitation in the summer is low. An example of the impact of air temperature on water use throughout the annual cycle is provided in Figure 2.1.2. It shows the relationship between monthly total water use and the mean monthly maximum temperature in 2015 in Nelson, Nakusp, and Trail.
Figure 2.1.1 Typical annual water demand curve

Figure 0.2 Relationship between temperature and water use during winter and summer in three communities in the Columbia Basin in 2015.

Winter Demand

Winter water demand is typically unaffected by temperature and is fairly constant throughout the winter season. Consumption during winter is therefore normally used as a baseline for understanding domestic indoor water demand. Exceptions to this are cases in some mountain communities where winter water bleeding\(^9\) is required in cold periods to prevent freezing of water in pipes. Another issue is in communities that cater to winter tourism – if universal metering is not in place and tourism data is unreliable (as is the case in the communities

\(^9\) Winter bleeding is the practice of maintaining a small, constant flow of water to prevent the service pipe to a property from freeze, and is necessary in some parts of the Basin due to soil type or infrastructure installation specifications that are susceptible to freezing. A guideline is 250 ml of water per hour. In some cases, residential bleed lines will run a full ¾" hose open all winter long, far in excess of the requirement to prevent freezing.
included in this evaluation), expressing community water demand in liters/person/day (L/P/D) based on resident population is not entirely accurate. There are at least five Basin communities subject to significant variability in winter tourism occupancy, and there is one community with atypically high volumes of residential and municipal winter bleeding.

In contrast, summer water demand generally reflects the difference between indoor and outdoor water use, with the caveat that that indoor use also increases somewhat during the summer. Also, some communities have population growth due to summer tourism that cannot easily be accounted for. Nevertheless, the rate of change in summer water use is usually highly sensitive to temperature, as will be shown in the evaluation in Section 4. Temperature alone, however, is only a partial factor in how much water is used. Precipitation also plays a role in water use, particularly for outdoor purposes. Water consumption increases more significantly during hot and dry summers than during hot and wet summers. As shown in Figure 2.1.2 above, there are large differences between communities in summer water consumption. These are largely a function of local conditions in temperature, outdoor water use behaviours and culture, and local implementation (or lack thereof) of water conservation measures.

2.2. Land Use Factors

Land use development patterns, activities, and environmental settings also play a role in water use. Summer consumption is greatly influenced by the amount of gardening and watering of lawns that occurs. For example, Maurer (2009) showed that up to 45% of all domestic water is used for lawn watering in four communities in the Okanagan. Adding 30 cm of topsoil before planting turf can save up to 30% of the irrigation requirement for lawns. Domestic vegetable production also impacts water use. Swimming pools can, in some cases, also be a significant factor, depending on prevalence.

Urban density and lot size also have an influence on water use. Large average parcel size means people may use more water for outdoor purposes in the summer, while with smaller size lots, irrigable area is smaller and water demand may also be less. There are significant differences in average parcel sizes among Basin communities, and this appears to be a factor in average per capita demand, though no data analysis of this hypothesis has been undertaken specifically for this report.

Parcel size has a related implication for water demand management – dense urban centers also have more impervious surface, which results in less opportunity for water to infiltrate into soils, which further reduces opportunity for green water management (the amount of rainfall that is stored in the soil and used for biomass production). Thus, the relationship between land use patterns, water demand, and storm water management is complex and must be considered at the local scale, taking climatic conditions (present and future) into consideration (Marsalek and Schreier, 2013).

2.3. Technology, Infrastructure, and Management Factors

Local infrastructure and the management practices of the water utility also have an impact on water demand.

2.3.1. Water Loss

Many communities (both in the Basin and across the developed world) have water distribution systems that include significant sections of old and deteriorating infrastructure. As a result,
distribution system leakage can add up to significant annual water demand in the form of leakage or “water loss”. If not properly addressed, these losses occur throughout the entire year. In the Basin (as is common across North America), water loss averages about 40% of annual water demand, with some communities experiencing losses over 70% of annual demand. Using standard industry terminology, the ratio of unavoidable to real annual losses is called the Infrastructure Leakage Index (ILI)). Basin local governments are generally experiencing ILIs in the range of 4 to 28 with anything over 8 being considered severe. Typically, an ILI of 3-5 is an achievable local target for Basin local governments. It is clear that water loss presents a high priority opportunity to sustainably reduce total water demand while also improving the overall condition, resilience, and sustainability of local water utility infrastructure. This learning at the Basin scale is highly transferrable to other regions and jurisdictions.

2.3.2. Peak Demand (Irrigation Behaviour)
Irrigation, whether manual or automated, is the primary driver of significant peaks in summer water demand in the Basin. Outdoor water use can be significantly influenced by the type of irrigation system that is used for lawns. It is commonly but erroneously believed that automatic, in-ground irrigation systems are water savers, but they may actually use up to 30% more water than surface irrigation due to failure to properly set and adjust timers seasonally, a typical lack of rain sensors, and failure to maintain the physical system on an annual basis, resulting in unseen leakage, similar to conditions experienced in ageing municipal water distribution infrastructure.

2.3.3. Water Metering
Probably the most important management factor in water conservation is the ability to accurately understand how much water is being used, when, where, and by whom, for what purposes. Collection of this data requires implementation of locally appropriate metering programs, including, at minimum, accurate metering at the water system source, as well as distribution system metering, Industrial/Institutional/Commercial (ICI) metering, residential metering, and/or universal metering (including both flat and volumetric billing models).

Unless water utilities properly account for the water they collect from the ecosystem, pump, store, treat, and finally distribute, it is difficult to properly manage the resource and the infrastructure required to deliver it from source to tap. In the absence of accurate metering, at minimum, and sufficiently refined customer level metering, including ICI or universal metering, it can be nearly impossible to determine the differences between residential, commercial and industrial use, or between indoor and outdoor demand. Without appropriate metering, prioritizing, developing, implementing, and accounting for the effectiveness of water conservation actions can be very challenging, and it is also nearly impossible to equitably assess and allocate full-costs between user groups.

There is accumulated evidence to show that once universal water metering is in place with an appropriate volumetric rate structure, residential consumption usually drops by between 25 and 30%. It is also clear through the Water Smart program that accurate accounting of gross supply

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10 In plain English, all water systems leak, but not all leakage can or even needs to be addressed. Every water system has a certain amount of unavoidable leakage that can be estimated using international standard calculations. If the unavoidable leakage is equal to measured total leakage, then the ILI ratio is expressed as a value of 1. This is virtually unattainable – thus, the ILI ratio expresses in simple and almost universally comparable terms the condition of the infrastructure relative to the best case scenario, and as compared to other water utilities across the “developed” world. Anything over an ILI of 8 is considered severe water loss that must be addressed as an immediate priority for the water utility.
and night flow in the distribution system through proper distribution system metering can significantly enhance water loss management efforts, which are currently the number-one opportunity for cost effective demand reduction in most communities, within the Basin and elsewhere.

2.3.4. Indoor Fixtures
Indoor water demand is directly influenced by indoor fixture type. For example, widespread installation of low-flush toilets can save relatively large amounts of water (and wastewater). A conventional single flush toilet uses 13L/flush, which can amount to use of 75-100 L/P/D. Conversely, a 3 litre + 6 litre duel flush system uses 21 L/P/D which results in a savings of up 50-75 L/P/D. Other water saving devices equally influence water demand. It is important to note that only one of the 26 Water Smart communities has pursued indoor demand reduction actions because, for nearly every community in this region, the most effective and cost effective opportunities for water demand reduction at this time are water loss management and peak demand reduction. Indoor demand management will become increasingly cost effective with improvements to water accounting infrastructure and practices and sustained reduction in distribution system water loss. There is also an important, but often neglected relationship between indoor fixtures and wastewater treatment requirements that should factor into a utility’s decisions regarding indoor water demand management activities.

2.3.5. Water demand policies and bylaws
Local governments exercise significant influence over water demand through adoption, implementation, and enforcement (or lack thereof) of water-related policies and bylaws. In addition to the influence of water rates on water consumption behaviour, the existence or absence of watering restrictions bylaws and/or policies, and the associated education and enforcement practices can profoundly influence daily, monthly, and annual water demand. Similarly, the existence or lack of policies and/or bylaws regulating requirements for property owners to repair leakage in service lines to private properties can influence year-round water loss and hence total demand. It is important that water utilities policy makers adopt regulations that are targeted to address their local infrastructure realities and to achieve specific local water conservation objectives.

2.4. Human Factors
Human behaviour and perception is another factor that influences water consumption. Anecdotally, many people in the Columbia Basin take water for granted and think that water is abundant and we do not need to worry about ecosystem supply. In the Columbia Basin, there is a fairly realistic perception that water is normally plentiful, but this is misunderstood to mean also that water conservation need not be a priority.

With increasing climatic variability, increasing costs to treat water, and the need to maintain sufficient in-stream and ground water flows for essential environmental services, it is critical that we know how much water is available in the ecosystem before we allocate it for human use. Improved public awareness about the need to account for water availability, human water demand, and for water conservation is becoming increasingly important. Canadians are among the largest water users in the world, and significant reductions in use can be achieved by conservation methods at very low cost and no hardship to any individual – water demand management can be a no-regrets strategy for climate resilience, provided that a local demand reduction program is supported by accurate data. Achievement of real behaviour change in water use requires an effective public education program driven by accurate data to ensure that
people are aware of local supply and infrastructure constraints, demands, and costs. It is very costly to build and maintain infrastructure to store and deliver water to all households at all times, and the costs of treating water are increasing rapidly. It must be understood that human behaviour can be slow to change, and requires persistence and consistency of outreach and education in order achieve sustained results.
3. MUNICIPAL WATER USE IN THE BASIN

3.1. Water Use Estimates vs. Proper Water Accounting

Accurate and proper water accounting has not been a common practice in many communities in BC, including within the Basin. Without proper metering within the water supply and distribution system, elected decision makers and utility managers have an inadequate basis upon which to decide how to allocate limited financial resources for water supply and conservation. In 2005, Ronalds conducted an exploratory evaluation of how much water was used in Basin communities in 2005 by talking to water utility management personnel. Because little water use was metered at that time, some of the figures provided were approximations or best guesses. The results indicated that most communities were using excessive amounts of domestic water. It was based, in part, on this exploratory information that the Trust decided to introduce and support the Water Smart Initiative in 2009.

Utilities need to ensure that, at minimum, accurate water accounting takes place at the supply source and within the distribution system. Until recently this has not been the case in the Basin, nor is it typical across BC and even Canada. One water researcher has characterized the state of water data collection in Canada as “minimalist” (Bakker and Cook, 2011, 279). Demonstrating the importance of proper water accounting, a comparison is made in Figure 3.1 between the 2005 exploratory survey data and the total average water consumption measured by individual communities over 4 years (2011 to 2014) through Water Smart. In 2005, the estimates were based on either the local utility operator’s estimates or partial measures of water distribution from the source depending on the availability of metered data at the time.

As shown in Figure 3.1, below, the 2005 water use estimates of only three communities showed a good comparison, while water use in the others was either under- or over-estimated. This demonstrates that accurate water accounting is critical to support sustainable water supply and demand management.
3.2. Average Per Capita Water Demand Between Communities

Average daily total consumption in Basin communities is very high in comparison to other communities and jurisdictions. Figure 3.2 shows total average daily water use in L/P/D\textsuperscript{11} for the period from 2009 to 2015. The values range between 570-1786 L/P/D\textsuperscript{12} including all municipal water uses, leakage, and commercial, recreation, and domestic use (where possible agricultural and large industrial uses have been excluded for the Water Smart data sets). Only in two communities in this study was it possible to accurately separate the residential use from commercial/industrial use as a result of universal meter data.

\textsuperscript{11} Litres per capita per day

\textsuperscript{12} At the upper end of this range, communities are experiencing severe water loss in the distribution system.
Figure 3.2 Differences in average total daily water consumption in 13 Columbia Basin communities from 2009 to 2015, in L/P/D (including institutional, industrial, and commercial use and leakage).

In large cities like Vancouver, about 35% of city water is used for commercial, industrial and institutional proposes, while the same type of use is typically much lower (less than 20%) in small communities with few commercial and industrial users. For comparative purposes, in Vancouver, total per capita consumption (including Commercial and Industrial) is about 580 L/P/D. This suggests that only two communities in the Basin have similar levels of water consumption\(^{14}\) (see also Section 5 for further discussion of residential and total water demand in the Basin as compared to other provinces, states, and international cities).

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\(^{13}\) RDCK-Erickson has been excluded from this chart due to disproportionately higher per capita demand driven by agricultural water use, which would skew the data from the other communities

\(^{14}\) Note that Vancouver residents are comparatively high water users internationally, and only commercial and industrial users are metered.
As summarized in Section 2, prevailing climatic conditions play a key role in water consumption. Temperature is the main driver in the summer period, while in winter, temperatures have little influence on water use (except in those communities that practice winter water bleeding). Analysis of climate factors in the Basin from 2009 to 2015 indicates that there are 3 logical climate sub-regions that allow for similar comparison of climate influence on water demand.

Figure 4.1 shows how the Water Smart communities included in this study have been grouped together throughout the report based on similar climatic regimes during the study period.

- The **North** climate sub-region includes Golden, Revelstoke, and Nakusp (for these communities 2009 was the hottest year in the study period).
- The **South-East** climate sub-region includes Fernie, Sparwood, and Elkford (for Fernie 2014 was the hottest; 2015 was hottest for Sparwood and Elkford).
- The **South-West** climate sub-region includes Cranbrook, Creston, Fruitvale\(^{15}\), Kaslo, Nelson, RDCK-Erickson, Rossland, and Trail (for these communities 2015 was the hottest year).

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\(^{15}\) For ease of nomenclature, throughout this report the shared Beaver Valley / Fruitvale communities and water system are referred to simply as Fruitvale. The Beaver Valley Water Service of the Regional District of Kootenay Boundary owns the water distribution system. The Village of Fruitvale operates the water system.
4.1. Temperature and Precipitation Differences, 2009 to 2015

The Columbia Basin experienced a wide range of climatic conditions over the seven-year period of the study. Eleven climate stations were used for our analysis. Over the seven-year period from 2009 to 2015, the coldest summer occurred in 2010 at most stations, and 2015 was the hottest in eight stations. In contrast, the three northern stations (Nakusp, Revelstoke, Golden) had the hottest summer in 2009, which had a positive influence on their demand reduction outcomes from 2009 (Figure 4.2).

A comparison of precipitation and temperature from 2009 to 2015 is provided in Table 4.1 and the year-by-year results for each community are summarized in Figure 4.3.

As shown previously (see Figure 2.1.1), winter water consumption changes relatively little in response to temperature, but once summer temperatures reach approximately 14°C, water consumption increases linearly in relation to temperature, principally as a result of outdoor water use for single-family irrigation. Because 2015 was an unusually hot and dry year in most places in the Basin, a comparison is made in Section 4.2 between water consumption and summer air temperatures for 2009-14 and 2015.

Figure 4.2 Differences in mean maximum summer temperatures (May-September) between 2009 and 2015 in 11 different climate stations in the Columbia Basin (note: Warfield is the weather station for both Rossland and Trail).

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16 See Appendix 1 for a list of climate stations used in this evaluation.
17 The early and significant demand reductions achieved by many Water Smart communities in 2010 and 2011 were, therefore, attributable in large part to colder, wetter weather, rather than to efficiency action. Conversely, the demand reductions achieved from 2012 to 2015 can be better attributed to community water efficiency action that overcame the hotter, drier weather.
Table 4.1 Summary of temperature and precipitation comparisons between climate stations

<table>
<thead>
<tr>
<th>Stations</th>
<th>Highest Mean Maximum Summer Temperature (May-September)</th>
<th>Lowest Summer Precipitation (May-September)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castlegar</td>
<td>2015</td>
<td>2015</td>
</tr>
<tr>
<td>Nelson</td>
<td>2015</td>
<td>2015 (second lowest)</td>
</tr>
<tr>
<td>Kaslo</td>
<td>2015</td>
<td>2015</td>
</tr>
<tr>
<td>Creston</td>
<td>2015</td>
<td>2015</td>
</tr>
<tr>
<td>Warfield</td>
<td>2015</td>
<td>2015</td>
</tr>
<tr>
<td>Cranbrook</td>
<td>2015</td>
<td>2015</td>
</tr>
<tr>
<td>Nakusp</td>
<td>2009 (second lowest)</td>
<td>2009 (second lowest)</td>
</tr>
<tr>
<td>Revelstoke</td>
<td>2009</td>
<td>2009</td>
</tr>
<tr>
<td>Golden</td>
<td>2009</td>
<td>2009</td>
</tr>
<tr>
<td>Sparwood</td>
<td>2015</td>
<td>2009</td>
</tr>
<tr>
<td>Fernie</td>
<td>2014</td>
<td>2015</td>
</tr>
</tbody>
</table>
Figure 4.3 Differences in summer climatic conditions (mean maximum temperature and total summer precipitation) at 7 basin weather stations over the seven-year study period from 2009 to 2015.
4.2. Monthly Air Temperature and Water Consumption

The total monthly water use was compared with mean monthly maximum air temperature for all 14 communities. Over the seven-year period, some communities experienced the warmest and driest, as well as the wettest months since historic records started. Figures 4.4 to 4.17 show the relationship between mean monthly maximum air temperature and total monthly water use since 2009. Because 2015 had an unusually warm and dry spring and summer, the 2015 data is highlighted in red, while the data for all other years is provided in blue.

During the winter period, the water use pattern is fairly constant, but at about 14°C water consumption increases, but at different rates in different communities. The increased demand is primarily attributed to outdoor water use, although other factors, as presented in Section 2, also influence the local rate of increase.

Figure 4.4 Differences in total monthly water use and mean maximum monthly air temperature in Golden BC (2009 to 2014 data is in blue and the 2015 data is in red).

The warmest and driest summer in Golden occurred in 2009. The 2015 total water consumption was not significantly different from the previous years, although the winter consumption was at a lower level, suggesting some improvement in winter consumption through water loss management.
Figure 4.5 Differences in total monthly water use and mean maximum monthly air temperatures in Revelstoke BC 2009 to 2014 and 2015.

Revelstoke had the warmest and driest summer in 2009. 2015 was the second warmest summer, but had more precipitation. Reliable attribution of the cause of total and monthly demand reduction from 2009 to 2015 is not possible given uncertainty in Revelstoke’s available data prior to 2014.

Figure 4.6 Differences in total monthly water use and mean maximum monthly air temperatures in Nakusp BC 2009 to 2014 and 2015.

Nakusp experienced the warmest summer in 2009, while 2015 was the second warmest, but had more precipitation. No significant water conservation was achieved in 2015.
Figure 4.7 Differences in total monthly water use and mean maximum monthly air temperatures in Fernie BC 2009 to 2014 and 2015.

Fernie experienced the driest but not the hottest summer in 2015. Water consumption from September to December 2015 was lower than in the previous years, which is likely due to repair of distribution system leaks. Significant leakage in Fernie may obscure the relationship between temperature and water demand.

Figure 4.8 Differences in total monthly water use and mean maximum monthly air temperatures in Elkford BC 2009 to 2014 and 2015.

Based on data from the Sparwood weather station, Elkford experienced the warmest summer in 2015. Water consumption in 2015 remained relatively high during the January-March period, likely as a result of the regular practice of bleeding pipes to prevent freezing. Some significant conservation was achieved during the summer due to conservation outreach and bylaw education. However, significant leakage and above-normal operating pressures in Elkford’s distribution system may obscure the full relationship between temperature and water demand.
2015 was the warmest but not the driest summer in Sparwood. Their conservation outcomes as of 2015 are impressive and can be attributed to the installation of universal metering and improved water loss management practices. Despite these efforts, Sparwood is still experiencing significant leakage and high summer demand.

Cranbrook experienced the hottest and driest summer in 2015. The unusually warm and dry spring of 2015 resulted in very high water use in May (as was experienced across much of the region), prior to implementation of water restrictions. Restrictions in June to August resulted in normal water consumption in spite of the hot and dry summer.
Figure 4.11 Differences in total monthly water use and mean maximum monthly air temperatures in Creston BC 2009 to 2014 and 2015.

Creston experienced the hottest and driest summer in 2015 over the study period. As a result, 2015 water consumption was very high during the April-May period before water restrictions were put into effect. Outdoor water restrictions implemented in June 2015 proved to be effective in reducing water use from June to September. Demand spiked in October after restrictions were lifted.

Figure 4.12 Differences in total monthly water use and mean maximum monthly air temperatures in RDCK-Erickson BC 2011 to 2014 and 2015.

Like Creston, Erickson experienced the hottest and driest summer in 2015. As a result, the 2015 water consumption was very high during the April-May period before water restrictions were put into effect. Cherry harvesting also occurred one month earlier than is typical, which affected 2015 demand timing. Outdoor water restrictions implemented in June 2015 proved to be effective in reducing water use in from June-September. Demand spiked in October after restrictions were lifted.
Figure 4.13 Differences in total monthly water use and mean maximum monthly air temperatures in Fruitvale BC 2009 to 2014 and 2015.

Fruitvale experienced the hottest and driest summer in 2015 over the study period. Conservation measures coupled with water loss management were effective in lowering both winter and summer consumption.

Figure 4.14 Differences in total monthly water use and mean maximum monthly air temperatures in Trail BC 2009 to 2014 and 2015.

Trail experienced the hottest and driest summer in 2015 and only moderate conservation was achieved in the June- August period. It appears that Trail’s summer demand remains high regardless of temperature, year over year.
Rossland had the hottest and driest summer in 2015 over the study period, but achieved significant water conservation success primarily due to universal metering. Water restrictions in summer 2015 may have played a significant part in lowering consumption in June to September.

Nelson experienced the hottest and driest summer in 2015. The total and monthly demand reductions in Nelson are most likely attributable to pipe repair and replacement.
Kaslo experienced the hottest and driest summer in 2015. The significant difference between 2009 to 2013 and 2014 and 2015 is attributable to location and repair of major leakage in the distribution system in early 2014, which resulted in a total annual demand reduction of 39% from 2009 to 2015. The moderate water restriction efforts in June in 2015 also supported significant water savings in summer 2015. Prior to 2014, the leakage in Kaslo’s distribution system was masking the full relationship between temperature and water demand.

4.3. Summer Temperature as the Major Driver of Water Consumption

As noted elsewhere in this report, water consumption during the winter is relatively constant except in communities that practice pipe bleeding to prevent freezing. However, summer water consumption is highly temperature-influenced in those communities that use domestic water for outdoor garden use.

To show how sensitive water consumption is to temperature, a linear correlation and regression analysis was performed between mean maximum monthly air temperatures and total water use for all communities. The data in Figures 4.18 to 4.19 show that good linear relationships were found when summer temperatures rise above 14°C. All correlations/regressions were significant (R2 >0.50) except for Elkford and Fernie, because both communities have above average leakage, and Elkford also bleeds water to prevent pipe-freeze in the winter; these factors mask a strong relationship between summer temperature and water demand in both communities.

In Figure 4.18, an illustrative comparison is made of the differences in total summer water use between two communities using the 2009 to 2015 data. Details for regressions for the north and south-east communities are shown in Figure 4.19 and for the south-west communities in Figure 4.20.
Figure 4.18 Differences in the relationship between mean maximum summer air temperatures and total summer water consumption using the 2009 to 2015 data for two communities.

Figure 4.19 Quantitative relationships between total monthly water consumption and mean maximum monthly air temperatures in the north and south-east portion of the Columbia Basin.
Figure 4.20 Quantitative relationships between total monthly water consumption and mean maximum monthly air temperatures in different communities in the south-west Basin.

This data analysis allows us to compare differences in water consumption in L/P/D in the summer (May-September) between communities for every 1°C temperature increase above 14°C. Based on Figure 4.21, Trail, Nakusp, and Kaslo have the highest increases in summer water use, and these communities should focus primarily on summer outdoor water use conservation. In contrast, Nelson, Rossland, Revelstoke, Fernie, and Golden have the least sensitive water consumption in relation to increasing summer temperatures.

It is noted that Erickson’s regression value indicates a significant relationship between water demand and temperature. It is tempting to discount this relationship due significant commercial agricultural water demand. However, water use restrictions in Erickson do not apply to commercial agriculture, but were nevertheless very effective in reducing peak demand. This suggests that, despite high agricultural water use, there is a significant relationship between temperature, total water demand, and other discretionary water uses such as residential and non-commercial (hobby) agriculture.
Figure 4.21 Total summer water consumption (May-September) in L/P/D for every one-degree mean maximum temperature increase above 14°C in the different communities between 2009 and 2015.

RDCK-Erickson was not included in Figure 4.21 because the monthly average demand, used for both domestic and agricultural purposes, shows a rate of 436 L/P/D for every one-degree increase in summer temperature above 14°C, disproportionate to all other communities in the Basin.
4.4. Differences in Summer and Winter Water Consumption

As shown in Figure 4.22, November and February were the two months with the lowest water consumption, while July and August were the months with the highest water consumption.

![Figure 4.22 Frequency of lowest water consumption months in the winter and the highest summer water consumption months using the 2009 to 2015 data set.](image)

The differences in the lowest winter water consumption, the highest summer water consumption, and the annual mean are shown in Figure 4.23. Nelson, Rossland and Revelstoke have the smallest differences between summer and winter water use, while Trail, Kaslo, and Elkford have the highest difference.

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18 Elkford and RDCK-Erickson were excluded from these charts because their unique context and data sets would skew the results for all other communities – Elkford due to winter bleeding; RDCK-Erickson due to agricultural demand.
Figure 4.23 Differences between the winter month with the lowest consumption and the summer months with the highest consumption.
5. ANALYSIS OF TOTAL AND MONTHLY WATER DEMAND

5.1. Comparison of Total Monthly Water Consumption 2011 to 2015

The data collected over the seven-year project was analysed in the following way: 2009 was considered the baseline year to which all other years where compared. Due to the year-long process of preparing the original Water Smart Action Plans, all communities were delayed in commencing active water conservation activity until 2010 or 2011. Given this delay in causality for change in water demand, each community’s progress in water consumption was examined on a month-by-month basis from 2011 to 2015.

The percent reduction in monthly water consumption compared to the 2009 baseline was determined for each year.

Because summer 2009 was the warmest in the northern communities of Golden, Revelstoke, and Nakusp, their 2015 results benefitted from the fact that the 2009 baseline year was the hottest and driest, resulting in higher 2009 summer water use, as shown in Figure 5.1. For Golden and Revelstoke, measurable reductions were achieved in all months in each of the 5 years between 2011 to 2015.

For all other communities, 2015 was the warmest, and in most cases the driest, which made water savings more challenging, and makes it clear that these outcomes are attributable to action, and not principally to climatic variability. Their results are provided in Figures 5.2 to 5.5.

In almost all cases, the largest total percent decrease from 2009 occurred in June. However, June demand reductions are not necessarily attributable to actions implemented by Water Smart communities. Instead, they include an unusually dry, hot June in the 2009 baseline year, leading to exaggerated appearance of savings in subsequent years to 2015.

Because the early spring in 2015 was exceptionally dry and warm across the entire region, water consumption (red line) increased until June but then declined, likely as a result of summer water restrictions that were put in place in most communities in June/July. This is most evident in Revelstoke and Nakusp, where spring water conservation was small but improved rapidly as summer progressed. Golden had a more delayed and moderate success in water conservation (Figure 5.1).

The communities of Fernie, Sparwood, and Elkford in the southeast Basin still have not achieved lower water consumption in July (Figure 5.2), but were successful in reducing winter consumption through implementation of water loss management best practices.

Figure 5.3 shows that Kaslo and Rossland have achieved impressive consumption reductions during the winter, but for very different reasons. Kaslo successfully resolved a major water loss issue. During the 2009 to 2015 period, Rossland completed their universal metering program and implemented critical pipe replacement. Nelson was also successful in reducing winter consumption through water main and service connection replacement, but, like Kaslo, continues to have a summer water conservation opportunity.

Trail, Fruitvale, and Cranbrook (Figure 5.4) reduced their winter consumption. They still have some issues with high water consumption in early July, but were successful in reducing consumption in late summer (Figure 5.4).
Creston and Erickson (Figure 5.5) rely on the same water supply system but have different challenges because a large portion of water use in Erickson is for agriculture. Both have been successful in reducing late summer water use through implementation of effective water loss management and public education initiatives.

Figure 5.1 Changes in 2011 to 2015 water consumption in Golden, Revelstoke, and Nakusp compared to 2009.
Figure 5.2 Changes in 2011 to 2015 water consumption in Fernie, Sparwood, and Elkford compared to 2009.
Figure 5.3 Changes in 2011 to 2015 water consumption in Kaslo, Rossland, and Nelson compared to 2009.
Figure 5.4 Changes in 2011 to 2015 water consumption in Trail, Fruitvale, and Cranbrook compared to 2009.
5.2. Comparison of Change in Total Annual Water Consumption, 2011 to 2015

Each community's 2011 to 2015 change in total water demand has been tabulated. See Figure 5.6 for the north and southeast communities in the Columbia Basin, and Figure 5.7 for the southwest communities.

The results show that Kaslo had the greatest overall success in reducing total annual water consumption in 2014 and 2015 by 36 to 39%. This was accomplished by capping a major leak that resulted in reducing water loss levels that had been very high.
Revelstoke and Golden also accomplished substantial water consumption reductions ranging from 10 to 20% in 2014 and 2015, but had the advantage of having a locally hot climate with associated high water consumption baseline in 2009, which was not the case for the other communities.

Sparwood and Rossland, the two communities that opted for universal metering, showed the most consistent year by year reduction in total water consumption, reaching 12 to 23% reductions in 2014 to 2015.
Nakusp, Trail, and RDCK-Erickson had initial savings of 10 to 20% in 2011 to 2013, but showed little progress in 2014 to 2015.

Creston, Fruitvale, and Cranbrook made good progress until 2014, ranging from a 13 to 20% reduction in 2014, but had moderate success when dealing with the hot summer in 2015.

5.3. Comparison of Monthly and Total Water Conservation Outcomes, 2009 to 2015

To evaluate each community’s water conservation outcomes, 2009 consumption was used as a baseline and the percent change in total and monthly demand were tabulated.

5.3.1. 2009 to 2015 Total Reduction

Table 5.0 Total and average demand reduction 2009 to 2015

<table>
<thead>
<tr>
<th>Community</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaslo</td>
<td>-39%</td>
</tr>
<tr>
<td>Rossland</td>
<td>-23%</td>
</tr>
<tr>
<td>Golden</td>
<td>-16%</td>
</tr>
<tr>
<td>Fernie</td>
<td>-15%</td>
</tr>
<tr>
<td>Creston</td>
<td>-15%</td>
</tr>
<tr>
<td>Fruitvale/Beaver Valley Water Service</td>
<td>-14%</td>
</tr>
<tr>
<td>Sparwood</td>
<td>-12%</td>
</tr>
<tr>
<td>Revelstoke</td>
<td>-10%</td>
</tr>
<tr>
<td>Elkford</td>
<td>-7%</td>
</tr>
<tr>
<td>Cranbrook</td>
<td>-5%</td>
</tr>
<tr>
<td>Nelson</td>
<td>-5%</td>
</tr>
<tr>
<td>Trail</td>
<td>-2%</td>
</tr>
<tr>
<td>Nakusp</td>
<td>+1%</td>
</tr>
<tr>
<td>RDCK Erickson</td>
<td>+11%</td>
</tr>
<tr>
<td>Average Demand Reduction, 2011 to 2015</td>
<td>-11%</td>
</tr>
</tbody>
</table>
5.3.2. 2009 to 2015 Monthly Reduction
The percent change in monthly consumption from the 2009 baseline year was calculated for 2014 and 2015 (Tables 5.1 and 5.2). Numbers in yellow reflect increases and numbers in blue reflect successful reductions in water consumption.

Table 5.1 The percent reduction achieved in total water consumption in 2014 and 2015 as compared to the 2009 baseline year for the northern and southeastern communities in the Basin19.

Table 5.2 The percent reduction achieved in total water consumption in 2014 and 2015 as compared to the 2009 baseline year for the southern and southeastern communities in the Basin20.

19 Baseline year for Fernie in this monthly analysis was 2011, as there was no monthly data available for 2009.
20 Ibid..
Trends in summer, winter, and mean total annual water consumption for the 2009 to 2015 period are charted in Figure 4.23. In this case the April-September period was considered “summer” while October–March was considered “winter”.

Figure 5.8 Trend in summer, winter, and annual average total water consumption between 2009 to 2015.
5.4. Summary of Water Smart Achievements, 2009 to 2015

5.4.1. Analysis of Seasonal Results, 2009 to 2015

Winter: The results in Tables 5.1 and 5.2 show that 10 of 14 communities achieved significant water use reductions of 2 to 53% during the January-March winter period in 2014 and 2015. Winter demand reductions attributable to water loss management may be reflected throughout the year, including through the summer months.

June: 10 of 14 communities experienced reductions in June consumption from -5% to 20% by 2015. The appearance of significant savings in June is, however, exaggerated by the hot, dry June in the 2009 baseline year. A portion of these savings can, however, be attributed leak reduction.

July/August: Reducing summer peak consumption was more challenging. As of 2015, 6 of 14 communities were consistently able to reduce the July and August peaks by 9 to 51%. Kaslo’s extreme reduction (51%) is solely attributable to leakage reduction. For the other communities, reductions are attributable to a mix of water loss management, effective water conservation outreach, and/or implementation of watering restrictions.

September: Due in many cases to implementation of drought-level watering restrictions that were sustained into September 2015, all 14 communities achieved water reductions of 6 to 46% in September 2015. Kaslo’s September savings reached 55%, but are due to water loss management as opposed to peak demand management efforts.

December: December consumption showed similar results to the January-March reduction efforts.

Annual: By 2015, only two communities showed increases in water demand, while all others achieved savings ranging from 2 to 39% annually from the 2009 baseline.

5.4.2. Summary of Overall Water Smart Outcomes, 2009 to 2015

Our data analysis suggests the following overall outcomes:

- From 2009 to 2015, conservation efforts were successful in most communities.
  - Considering the complexity of all the factors that can influence water use on an annual basis, these results are quite encouraging with respect to the efficacy of each community’s demand management efforts from 2009 to 2015 and the support provided to communities via the Trust’s Columbia Basin Water Smart Initiative.

- It will be difficult to sustain consistent reductions due to two primary factors:
  - Even significant success in reducing leakage in the distribution system through application of water loss management best practices can be rapidly undermined due to pressure transience and the dynamic nature of water infrastructure. Without consistent analysis of night flow data, coupled with a consistent and properly funded infrastructure repair and replacement program, total water demand will rise, most rapidly in communities with areas of variable or high water pressure.
During the 2009 to 2015 study period, average summer temperatures generally increased, in keeping with climate science projections for the region. Increasing climatic variability and extremes play a key role in water demand and conservation. Unless effective water restrictions and public outreach programs are implemented in a timely manner during hot and dry spring and summer months (April and May), water conservation successes earned to date through peak demand management will be very challenging to sustain.

5.4.3. Summary of Water Conservation Challenges to be Addressed in Future
The most critical water conservation challenges that all communities continue to face are:

- Improving water accounting (metering);
- Fixing leaking infrastructure (Water Loss Management);
- Reducing peak demand;
- Improving limited knowledge about the relationship between projected future ecosystem supplies, human demand, and storage requirements; and
- Asset Management and Revenue Sufficiency.

Each of these is addressed below.

5.4.3.1. Improving Water Accounting
Most communities in this evaluation have a challenge in quantifying how much water is used by different user sectors (residential, ICI, leaks, etc.). Only two have implemented universal metering, though several others are considering it. The main reasons for reluctance to move towards universal metering tend to be potential resident concerns and implementation costs. In the Basin, for some communities, cost/benefit analyses have determined that universal metering is not currently the most effective or cost effective tool for reducing total or peak demand. For example, in the Beaver Valley Water Service/Fruitvale, it has been determined that pressure management (reduction) in the distribution system is the more effective and cost effective demand reduction opportunity in the near term.

It is noted that universal metering is neither a necessary condition in the short term, nor a sufficient condition in the long term for water conservation success. However, the two communities in this study that have transitioned to universal metering (Rossland and Sparwood) have achieved the most consistent, though not the largest, water demand reductions.

In order to better account for leaks and water consumption, significant improvements are being made in most of the communities in this study through installation of new metering within the distribution systems to measure consumption and leakage within distinct zones (District Metered Areas). For the first time, all participating communities are now focused on improving their water accounting systems. This is a major achievement for Water Smart.

Also of significance is the finding that very few, if any, of the communities in the study conduct regular water meter calibration of their source and distribution system meters, which can result in steady and significant “meter down-drift” and false appearance of water savings over extended periods of time. Calibration of large distribution systems meters on a minimum five-year cycle and assessment for replacement is essential to long-term water conservation success.
5.4.3.2. Water Loss Management
Almost all communities started comprehensive water loss management programs after 2009. Prior to 2009, in most communities “water loss management” consisted of periodic acoustic leak sweeps in the absence of night flow data collection or zone meter analysis. Training of staff and sharing expertise between communities has clearly been a success. It should be remembered that this is a long-term problem with all infrastructure, but particularly in communities with infrastructure nearing the end of its lifespan. Fixing one leak will not necessarily reduce water use if another leak occurs elsewhere in due course. The infrastructure deficit is clearly apparent in many Basin communities and needs to be addressed locally through improved best practices, and provincially and federally through improved funding mechanisms tied to infrastructure resilience. What is impressive is the almost unanimous move towards water loss management best practices among participating communities. As noted above, water savings gained through water loss management will not be sustained in the absence of applied asset management as an operational norm.

5.4.3.3. Reducing Peak Demand
This is the most challenging part of any water conservation program, including Water Smart, because it depends on many factors including temperature, precipitation, type of outdoor and indoor water use, and commercial, institutional, and agricultural practices, among others. Also, individual behaviours, perceptions, and biases can be very difficult to influence. All Water Smart communities are struggling with how to communicate water conservation in a manner that results in measurable demand reduction. The Water Smart Ambassador Program has been instrumental in promoting effective water conserving irrigation practices within the participating local governments and among residents. And while changing human behaviour in the short run is difficult, sustaining those changes, once achieved, is even more challenging and requires a long term vision and plan to manage. A mix of education, technological interventions (e.g., hose timers, rain sensors), financial incentives, and bylaws should be considered to address this issue, especially in those communities where the relationship between temperature and demand shows strong correlation (see Section 4.3 for details for all communities). As climate variability and extremes increase, there will be more pressure to effectively manage peak demand, and a combination of “carrots and sticks” will be required. It is also important that communities begin to collect and analyse daily and hourly water demand data to determine the importance of and opportunity for peak hour and peak day water demand management.

5.4.3.4. Improving limited knowledge about the relationship between projected future ecosystem supplies, human demand, and storage requirements
This topic was not addressed through Water Smart, but is essential to be addressed if communities are to achieve water resilience in a changing climate. With increasing climatic variability, increasing costs to treat water, and the need to maintain sufficient in-stream and ground water flows for essential environmental services, it is critical that we know how much water is available in the ecosystem before we allocate it for human use. Few Basin communities have adequate ground water mapping and/or stream flow monitoring data to support long-term water planning. While Water Smart communities have built a robust water demand data set, it is not easily paired with ecosystem supply data, nor have communities typically assessed the relationship between cost and benefits of water conservation (demand side management) versus development of new water supplies and/or expanded storage (supply side management). Building reliable, continuous ecosystem supply data for ground and surface sources is an essential next step for achieving water resilience in a changing Basin climate.
5.4.3.5. Asset Management and Revenue Sufficiency
A second essential topic that has not been addressed by communities through Water Smart is aging infrastructure leading to widespread leakage that occurs on a persistent basis – this is the infrastructure deficit, or, more precisely, the infrastructure funding gap. Unless communities have an accurate inventory of their infrastructure assets and a plan for repair and replacement, it is challenging to achieve consistent water demand reductions. A GIS-based inventory and asset management plan is an important, but often lacking first step. The main challenge to implementing an effective asset management plan is to ensure sufficient funding, which in the short run is a significant challenge for many communities. Shifting to rate structures based on accurate revenue requirement analyses and water use data is critical to the achievement of infrastructure sustainability (see Section 8 on water pricing) and revenue sufficiency and stability21.

6. UNDERSTANDING RESIDENTIAL WATER USE AND WATER RATES IN THE BASIN

6.1. Estimating Residential Water Demand in the Basin

Only two of the 14 Basin communities in this evaluation have initiated universal metering and, given that the others are not metered, it is therefore not possible to accurately quantify how much water should be allocated for residential use, and for uses other than residential. Leakage, and industrial, commercial, and institutional (ICI) water use varies significantly between communities, as do water uses for firefighting, flushing, and municipal irrigation, among other variables.

The challenge of discerning residential demands from total demands illustrates clearly the need for enhanced water demand data collection to properly inform long-range community planning, water and sewer utility rate setting, and asset management planning.

For Rossland and Sparwood, per capita volumes for commercial, residential, and institutional use, and leakage were accurately quantified from universal meter data. For all other communities the non-residential use had to be estimated from partial data. Based on water balances developed by the Columbia Basin Water Smart Team for each of the individual communities, an estimated percentage of total demand was chosen to be approximately representative of residential use rates in each community. For example: for Elkford, it was estimated that the residential use was somewhere between 40 to 50% of the total water consumption (see yellow highlights in Table 6.1). For all communities that had a range of estimated percentage of residential water use, the mid-point was used to provide the comparative graph between total water used and residential water use (Figure 6.1).
Table 6.1 Percent Estimated residential water use in L/P/D for 2014 and 2015. The 100% data is total water use in L/P/D. Data highlighted in yellow represents the range of the best-estimated percentage of total demand attributable to residential uses22.

<table>
<thead>
<tr>
<th>Community</th>
<th>2014 100%</th>
<th>2015 100%</th>
<th>2014 70%</th>
<th>2015 70%</th>
<th>2014 60%</th>
<th>2015 60%</th>
<th>2014 50%</th>
<th>2015 50%</th>
<th>2014 40%</th>
<th>2015 40%</th>
<th>2014 30%</th>
<th>2015 30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>*RDCK (Erickson)</td>
<td>1907</td>
<td>2356</td>
<td>1335</td>
<td>1649</td>
<td>1144</td>
<td>1414</td>
<td>954</td>
<td>1178</td>
<td>763</td>
<td>942</td>
<td>572</td>
<td>707</td>
</tr>
<tr>
<td>Fernie</td>
<td>1819</td>
<td>1690</td>
<td>1274</td>
<td>1183</td>
<td>1092</td>
<td>1014</td>
<td>910</td>
<td>845</td>
<td>728</td>
<td>676</td>
<td>546</td>
<td>507</td>
</tr>
<tr>
<td>Elkford</td>
<td>1606</td>
<td>1356</td>
<td>1124</td>
<td>949</td>
<td>964</td>
<td>814</td>
<td>803</td>
<td>678</td>
<td>643</td>
<td>542</td>
<td>482</td>
<td>407</td>
</tr>
<tr>
<td>Trail</td>
<td>1109</td>
<td>1144</td>
<td>776</td>
<td>801</td>
<td>665</td>
<td>686</td>
<td>554</td>
<td>572</td>
<td>444</td>
<td>458</td>
<td>333</td>
<td>343</td>
</tr>
<tr>
<td>Nakusp</td>
<td>844</td>
<td>897</td>
<td>591</td>
<td>628</td>
<td>506</td>
<td>538</td>
<td>422</td>
<td>449</td>
<td>337</td>
<td>359</td>
<td>253</td>
<td>269</td>
</tr>
<tr>
<td>Kaslo</td>
<td>807</td>
<td>778</td>
<td>565</td>
<td>545</td>
<td>484</td>
<td>467</td>
<td>403</td>
<td>389</td>
<td>323</td>
<td>311</td>
<td>242</td>
<td>233</td>
</tr>
<tr>
<td>Golden</td>
<td>769</td>
<td>751</td>
<td>538</td>
<td>526</td>
<td>461</td>
<td>451</td>
<td>384</td>
<td>376</td>
<td>307</td>
<td>300</td>
<td>231</td>
<td>225</td>
</tr>
<tr>
<td>*Creston</td>
<td>843</td>
<td>848</td>
<td>590</td>
<td>594</td>
<td>506</td>
<td>509</td>
<td>422</td>
<td>424</td>
<td>337</td>
<td>339</td>
<td>253</td>
<td>254</td>
</tr>
<tr>
<td>Revelstoke</td>
<td>629</td>
<td>706</td>
<td>440</td>
<td>494</td>
<td>377</td>
<td>424</td>
<td>314</td>
<td>353</td>
<td>252</td>
<td>282</td>
<td>189</td>
<td>212</td>
</tr>
<tr>
<td>Cranbrook</td>
<td>618</td>
<td>669</td>
<td>433</td>
<td>468</td>
<td>371</td>
<td>401</td>
<td>309</td>
<td>335</td>
<td>247</td>
<td>268</td>
<td>166</td>
<td>201</td>
</tr>
<tr>
<td>Fruitvale</td>
<td>561</td>
<td>595</td>
<td>393</td>
<td>417</td>
<td>337</td>
<td>357</td>
<td>280</td>
<td>298</td>
<td>224</td>
<td>238</td>
<td>168</td>
<td>179</td>
</tr>
<tr>
<td>Nelson</td>
<td>549</td>
<td>519</td>
<td>384</td>
<td>363</td>
<td>330</td>
<td>311</td>
<td>275</td>
<td>259</td>
<td>220</td>
<td>207</td>
<td>165</td>
<td>156</td>
</tr>
<tr>
<td>Rossland24</td>
<td>552</td>
<td>541</td>
<td>386</td>
<td>379</td>
<td>331</td>
<td>325</td>
<td>276</td>
<td>271</td>
<td>221</td>
<td>216</td>
<td>166</td>
<td>162</td>
</tr>
<tr>
<td>Sparwood</td>
<td>938</td>
<td>933</td>
<td>657</td>
<td>653</td>
<td>563</td>
<td>560</td>
<td>469</td>
<td>467</td>
<td>375</td>
<td>373</td>
<td>281</td>
<td>280</td>
</tr>
</tbody>
</table>

23 Creston’s and Erickson’s total (100 percent) demand figures include each community’s proportional allocation of leakage in the arrow creek main line; Creston’s total demand also includes commercial brewery demand.
24 Rossland and Sparwood have universal meter data and thus these figures are accurate, and not estimated as they are for all other communities in Table 6.1.
The Water Smart Team made a major contribution in helping communities to quantify leakage losses, and in many cases found that water loss was very high, sometimes exceeding 50% of total demand. Further, in the absence of customer scale meter data, the commercial, industrial and institutional values could only be estimated.

The results show that the estimated residential water demand for Creston, Revelstoke, Sparwood, Nelson, Rossland, and Kaslo were in the 233-280 L/P/D range. Golden, Cranbrook, and Fruitvale ranges between 335-387 L/P/D while Fernie, Elkford, Trail, and Nakusp were in the 404-610 L/P/D range. RDCK-Erickson’s very high per capita demand includes substantial distribution system leakage in the Arrow Creek mainline (shared with Creston) as well as spring and summer commercial agricultural water use.

Despite uncertainty in the residential demand estimates, it remains evident that there are significant differences between total water consumption and residential water use.

### 6.2. Comparing Basin Total and Residential Demand with Canadian and International Demand

To put the 2015 water consumption in the communities in the Columbia Basin into a national and international perspective, a comparison was made between daily per capita water demand in Basin communities with the average demand in some Canadian Provinces and in select states and other jurisdictions using both total water use in L/P/D, and residential water use in L/P/D. The total water use includes residential, commercial, industrial, and institutional water use.
use and other non-revenue water, such as leakage, in each community. Residential use is determined either through universal metered data, or by applying an industry standard estimate of residential indoor demand ranging from 200-230 L/P/D. The methodology applied to each community is informed by the quantity and quality of available water demand data.

**Canadian Residential Water Demand Comparison**

Environment Canada (2011a) did a national survey in 2009 to determine water uses in all municipalities in Canada. This included proportional water use for different municipal activities and different sizes of communities. Table 6.2 shows the percentage of different water uses for Canada and for communities the size of those in the Columbia Basin.

Based on the Canadian survey, about 2/3 of the total water use was consumed for residential purposes. However, this seems to be very different from the conditions in the Columbia Basin, where residential uses were estimated to be between somewhere between 30 to 50% of total consumption.

**Table 6.2 percentage of municipal water use for different purposes and different sizes of communities based on Environment Canada 2009 national survey.**

<table>
<thead>
<tr>
<th>Size of Municipality</th>
<th>Residential Water Use</th>
<th>Commercial/ Institutional Water Use</th>
<th>Industrial/ Agricultural Water Use</th>
<th>Leakages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada Average</td>
<td>57.4 %</td>
<td>18.7 %</td>
<td>10.6 %</td>
<td>13.3 %</td>
</tr>
<tr>
<td>1000-2000 People</td>
<td>71 %</td>
<td>12 %</td>
<td>8 %</td>
<td>9 %</td>
</tr>
<tr>
<td>2000-5000 People</td>
<td>65 %</td>
<td>15 %</td>
<td>12 %</td>
<td>8 %</td>
</tr>
<tr>
<td>5000-50000 People</td>
<td>58 %</td>
<td>19 %</td>
<td>11 %</td>
<td>12%</td>
</tr>
</tbody>
</table>

The 2009 Environment Canada (2011a) data was summarized in Figure 5.9, and the results show that British Columbia has the 4th highest average total and residential water use per person in Canada. The Canadian average was 510 L/P/D for total water use and 274 L/P/D for residential water use.
Figure 6.2 Average total and residential water use in Canada and the different provinces in L/P/D (Source: Environment Canada 2011a).

As presented at Table 6.1 and Figure 6.1, the 2015 data from the 14 communities in this study show a residential use estimate of between 233-629 L/P/D (excluding RDCK-Erickson).

Only 4 communities exceed the average per capita demand of Canadian provinces (ranging from 189-395 L/P/D) as published by Environment Canada (2014).

The average Canadian water demand values were 510 L/P/D for total per capita demand, and 274 L/P/D for residential demand, while the Basin communities average 865 L/P/D for total use and 354 L/P/D residential use. This suggests that Basin residential use is very similar to BC and Canadian averages, but that total water use is significantly higher in most Basin communities, reflecting a combination of leakage and poor collection of and refinement in water demand data at the local scale.

International Residential Water Demand Comparison

A selection of average total and residential water use rates for US states, European countries, and other international cities is provided in Table 6.3. Similar to the Basin comparison to Canadian and BC data, the international results show that just three of the Water Smart communities exceeded the maximum range for residential per capita use presented in Table 6.3, while 10 of the 14 communities exceeded the maximum for total per capita water use (see Figure 6.1 above).

Total water consumption is much higher in the Basin than in most international cities (almost double those published for European cities), while residential water demand is estimated to be within the normal range of cities in North America.
Table 6.3 Select water demand data for cities, states and countries in L/P/D

<table>
<thead>
<tr>
<th>Cities, Country or States</th>
<th>Total Water Use Average L/P/D</th>
<th>Residential Water Use Average L/P/D</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancouver</td>
<td>477</td>
<td>353</td>
<td>Metro Vancouver 2014</td>
</tr>
<tr>
<td>Surrey</td>
<td>367</td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>West Vancouver</td>
<td>250</td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>Tuscon (AZ)</td>
<td>558</td>
<td>376</td>
<td>Gleick 2008 (OECD Data)</td>
</tr>
<tr>
<td>Denver (CO)</td>
<td>620</td>
<td>403</td>
<td>&quot;</td>
</tr>
<tr>
<td>Portland (OR)</td>
<td>450</td>
<td>233</td>
<td>&quot;</td>
</tr>
<tr>
<td>Sidney (Australia)</td>
<td>349</td>
<td>178</td>
<td>&quot;</td>
</tr>
<tr>
<td>Melbourne (Australia)</td>
<td>337</td>
<td>205</td>
<td>&quot;</td>
</tr>
<tr>
<td>UK (Average)</td>
<td></td>
<td>150</td>
<td>&quot;</td>
</tr>
<tr>
<td>France (Average)</td>
<td></td>
<td>164</td>
<td>Nauges 2010</td>
</tr>
<tr>
<td>Germany (Average)</td>
<td></td>
<td>122</td>
<td>Gleick 2008 (OECD Data)</td>
</tr>
<tr>
<td>BC (Average)</td>
<td>494</td>
<td>312</td>
<td>Honey-Roses et al. 2016</td>
</tr>
<tr>
<td>Idaho/Utah (average)</td>
<td></td>
<td></td>
<td>USGS 2014 Maupin 2014</td>
</tr>
<tr>
<td>Wisconsin (average)</td>
<td></td>
<td></td>
<td>&quot;</td>
</tr>
<tr>
<td>USA Average</td>
<td>371</td>
<td>250</td>
<td>&quot;</td>
</tr>
<tr>
<td>Basin Average</td>
<td>985</td>
<td>395</td>
<td>2015 Water Smart data</td>
</tr>
<tr>
<td>Basin Max</td>
<td>1690 LPD (Excluding RDCK)</td>
<td>629 LPD (Excluding RDCK)</td>
<td>See Figure 6.1.</td>
</tr>
</tbody>
</table>
7. WATER LOSS MANAGEMENT (LEAKAGE CONTROL)

7.1. Issues

Mitigating water loss is clearly the most critical water demand problem and conservation opportunity facing all communities – the participating Water Smart communities have made tremendous progress towards the identification and repair of leakage. The monitoring of night flow demand at source meters on a semi-annual basis has allowed communities to compare baseline flow and better quantify system leakage. In some communities, the installation of zone meters within the distribution system to test for leakage during low-flow months has been a major achievement. Many of these efforts were successful because in-house capacity improvements were supported through a variety of accredited and peer-to-peer technical training programs. The frustrating problem is that leaks will occur on a continuous basis as systems age. Until utilities successfully replace all parts of the supply system that are old and at high risk of breakage, this problem will not likely reduce in priority. The next section provides a crude estimate of leakage occurring in Basin communities.

7.2. Estimating Water Loss

It is generally estimated that annual water loss ranges between 30 and 70% in most Basin communities. This rate of water loss is typical across water systems in developed nations and is not unique to the Basin. Expressed using standard industry terminology, the ratio of unavoidable to real annual losses is called the Infrastructure Leakage Index (ILI). Basin local governments are generally experiencing ILIs in the range of 4 to 28 with anything over 8 being considered severe. Typically, an ILI of 3-5 is an achievable local target for Basin local governments.

Water Smart has been very successful in building in-house capacity to address this problem. For the first time, the majority of the communities in this study have improved their data acquisition and analysis capacity (SCADA), and many have improved the state of distribution system metering. These enhancements have supported improved leak detection and provide a rational basis for planning and implementing pipe repair and replacement programs. This should be considered a major success and has led to considerable water savings. For example, Figure 5.7 shows that Kaslo repaired a major leak in 2013, which resulted in an annual reduction in water use of 46% in 2014; this was accomplished cost effectively and without additional water conservation and education programs.

It should be recognized that water use conservation realized through water loss management will not be sustainable until communities have a reliable inventory of the age and condition of the water infrastructure that supplies water to utility customers. Once that is in place, a staged repair and replacement plan can be put in place to assure that future losses due to leakage can be mitigated. Those communities that have old and very lengthy mainline supply piping systems with larger numbers of connections are of course at greater risk than those with smaller systems, as shown in Figure 7.2.

At the time of this report, very few Basin communities have comprehensive asset management programs. This is one area where additional focus and attention would be of significant benefit for most communities.
Figure 7.1 Reduction in water consumption in Kaslo after repair of major leak in 2013.

Figure 7.2 Differences in number of connections and length of main water lines for a selection of Basin communities. Those in red have a more challenging task than those in blue.
8. UNDERSTANDING WATER UTILITY RATES (CHARGES) IN THE BASIN

Each of the 14 communities provided their water utility rates for 2015, and the rates differed widely between communities. A comparison was made between the amount of water used annually and the rates charged. The two communities that have initiated water metering are moving from flat annual rates into volumetric based water rates. All of the unmetered communities charge a flat annual water rate that varies between residential water use and different commercial water uses. Some water use regulations are very simple, while others are more complex.

It is not typically appropriate to compare rates between jurisdictions because the right rate must be developed, taking the uniquely local infrastructure and finance conditions of the water utility into consideration. Often, during a rate setting process, policy makers will request comparisons of their utility rates with those of nearby communities. This practice is counterproductive and may be harmful to the financial viability of the water utility, because there is no relationship between the financial break-even point of one utility relative to another. The analysis in this section of Basin water utility rates as compared to other jurisdictions is intended to illustrate the relationship between low rates and high demand, as has been demonstrated in water literature generally.

8.1. Water Utility Rates in Basin Communities

The differences in Basin annual flat rates are provided in Table 8.1 for single-family homes in unmetered communities, and in the two communities that are in transition to metered cost accounting.

Water rates for commercial activities are also highly variable and are shown in Table 8.2. The highest variabilities in different commercial rates were for car wash, garage water use, swimming pools and church water use rates.

Table 8.1 Comparison of Annual Water Rates for single residences

<table>
<thead>
<tr>
<th>Communities</th>
<th>Type of Rates</th>
<th>Residential Rates Unmetered</th>
<th>Residential Rates Metered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranbrook</td>
<td>Flat Annual</td>
<td>$240.- /Year</td>
<td></td>
</tr>
<tr>
<td>Creston</td>
<td>Flat Annual</td>
<td>$301.- /Year</td>
<td></td>
</tr>
<tr>
<td>Fernie</td>
<td>Flat Annual</td>
<td>$298.- /Year</td>
<td></td>
</tr>
<tr>
<td>Communities</td>
<td>Type of Rates</td>
<td>Residential Rates Unmetered</td>
<td>Residential Rates Metered</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Sparwood</td>
<td>Metered</td>
<td>$6424.08/Year</td>
<td>$210.24 Base + ($ /m3 to be determined)</td>
</tr>
<tr>
<td>Elkford</td>
<td>Flat Annual</td>
<td>$217.-/Year</td>
<td></td>
</tr>
<tr>
<td>Fruitvale</td>
<td>Flat Annual</td>
<td>$276.-/Year</td>
<td></td>
</tr>
<tr>
<td>Trail</td>
<td>Flat Annual</td>
<td>$321.50.-/Year</td>
<td></td>
</tr>
<tr>
<td>Rossland</td>
<td>Metered</td>
<td>$387.-/Year</td>
<td>$201.- Base rate + $0.25/m3 (up to 30m3), 40.40/m3 (up to 100m3), $0.60/m3 (&gt;100m3) May increase in 2016</td>
</tr>
<tr>
<td>Nelson</td>
<td>Flat Annual</td>
<td>$569.-/Year</td>
<td></td>
</tr>
<tr>
<td>Kaslo</td>
<td>Flat Annual</td>
<td>$306.45/Year</td>
<td></td>
</tr>
<tr>
<td>Nakusp</td>
<td>Flat Annual</td>
<td>$352.-/Year</td>
<td></td>
</tr>
<tr>
<td>Revelstoke</td>
<td>Metered</td>
<td>$369.-/Year</td>
<td>$1.92/m3 for first 45m3  + $2.274/m3 (for each m3 over 45m3)</td>
</tr>
<tr>
<td>Golden</td>
<td>Metered</td>
<td>$240.60/Year</td>
<td>$284.76 Base + $2.36/m3 (up to 1100m3) $2.76/m3 (up to 4399m3) $3.08/m3 (&gt; 4399 m3)</td>
</tr>
<tr>
<td>RDCK (Erickson)</td>
<td>Flat rate</td>
<td>$180-420.-/Year</td>
<td></td>
</tr>
</tbody>
</table>
Table 8.2 A comparison of the range of water rates for different commercial activities between the 14 communities based on 2015 rates.

<table>
<thead>
<tr>
<th>Type of Use</th>
<th>Communities</th>
<th>Water Rates in $ / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Numbers</td>
<td>Mean</td>
</tr>
<tr>
<td>Residential (single)</td>
<td>14</td>
<td>$298</td>
</tr>
<tr>
<td>Hotels/Motels /Unit</td>
<td>12</td>
<td>$131</td>
</tr>
<tr>
<td>Car Wash /Bay</td>
<td>8</td>
<td>$534</td>
</tr>
<tr>
<td>Laundromat/Unit</td>
<td>6</td>
<td>$158</td>
</tr>
<tr>
<td>Garage</td>
<td>10</td>
<td>$377</td>
</tr>
<tr>
<td>School / Room</td>
<td>9</td>
<td>$205</td>
</tr>
<tr>
<td>Church</td>
<td>5</td>
<td>$346</td>
</tr>
<tr>
<td>Swimming Pool</td>
<td>8</td>
<td>$181</td>
</tr>
<tr>
<td>Light Commercial</td>
<td>10</td>
<td>$261</td>
</tr>
</tbody>
</table>

8.2. Complexity of Setting Appropriate Rates and Ways to Address the Issues

The data provided by the communities for this study did not provide a reliable breakdown of commercial vs. residential water use\(^\text{25}\). The leakage portion is generally estimated to be high, and only a few communities use water for agricultural purposes. As a result, we used the residential water demand determined in chapter 5.0 for the 2015 data and the 2015 water rate information provided by the communities. As shown in Figure 8.1, 6 of 14 communities have water rates of less than $1 per m\(^3\) while the rest ranged from $1.11-$2.74.

Environment Canada published water pricing rates that combine residential and sewer rates – because none of the Basin sewer rates were available, a direct comparison with other Canadian communities was not possible. Residential water use rates in other places and countries published by Gleick (2009) were used to compare to Basin results (Figure 8.2). The data shows that with the exception of Nelson, Basin water use rates are well within the Canadian ranges, but relatively low in comparison with rates in major cities in Europe.

The two communities in this study that have introduced universal metering since 2009 are moving toward revised rates and rate structures, and they have options to move away from 100% flat rates into increasing block rates. This will be a more equitable way to assign costs to water users, since it is based on volumetric consumption. This is also partially done in some unmetered communities that set water rates based on the size of pipe. It is suggested that

\(^{25}\) Sparwood and Rossland have universal meter data, but it was not available for analysis in this study.
increasing water utility rates should be a priority in order to generate sufficient revenues to achieve full cost recovery for the water utilities and to partially cover the cost of replacing old and deteriorating infrastructure.

**Figure 8.1 Estimated Residential water rates in $/m^3 based on flat annual rates and L/P/D rates previously provided in Table 6.1.**

**Figure 8.2 Water rates in $/m^3 per person for residential water users in other countries.**

It is common for Basin water utility rates to cover the cost of service and delivery of water to households, but not to cover infrastructure repair and replacement costs (full cost accounting). Higher rates should be charged in order to cover repair and replacement costs. This may require staged rate smoothing over an extended period of time in order to avoid “sticker shock” for water utility customers. Revenue requirement, cost of services, and rates studies are likely
required in most communities in order to determine unique and sustainable per cubic meter or flat rate charges for the water utility.

Different types of rate structures that are practiced around the world are provided in Table 8.3. The most equitable way of generating revenues is using fixed monthly base rate plus an inclining block rate based on volumetric use. This of course requires that the municipalities have universal metering in place.

Table 8.3 Different rate structures for water use around the world.

<table>
<thead>
<tr>
<th>Rate Structure Details</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unmetered</td>
<td></td>
</tr>
<tr>
<td>Flat Rate</td>
<td>Unlimited water use</td>
</tr>
<tr>
<td>Metered</td>
<td></td>
</tr>
<tr>
<td>Constant Unit Charge (Volumetric)</td>
<td>All users pay the same rate $/m³</td>
</tr>
<tr>
<td>CUC</td>
<td>Users pay a fixed monthly charge plus water</td>
</tr>
<tr>
<td>CUC with Base Monthly Charge</td>
<td>used at a fixed rate in $/m³</td>
</tr>
<tr>
<td>Metered</td>
<td></td>
</tr>
<tr>
<td>Block Rates - Increasing Block Rates (IBR)</td>
<td>Step rate changes for increased volume</td>
</tr>
<tr>
<td></td>
<td>of water used (e.g. higher rates by</td>
</tr>
<tr>
<td></td>
<td>threshold 50, 100 m³)</td>
</tr>
<tr>
<td>Block Rates – Decreasing Block Rates (DBR)</td>
<td>Same as above but high water users</td>
</tr>
<tr>
<td></td>
<td>get lower rates. Incentive to attract</td>
</tr>
<tr>
<td></td>
<td>industrial/business users</td>
</tr>
<tr>
<td>Combine Increasing Block rate and Fixed Base Rate</td>
<td>Fixed monthly base and increased rates</td>
</tr>
<tr>
<td></td>
<td>in steps of amount of water use categories</td>
</tr>
</tbody>
</table>
9. INCREASED CLIMATIC VARIABILITY

All climate models suggest that climatic variability is increasing globally and locally, and that we can expect more extreme events in terms of droughts, floods, and fire. The past few years in the Basin have exhibited these climate trends, with significant flooding, drought, and wildfire events around the region. The overall trends that are relevant for the Columbia Basin are summarized in Figure 7.1. The implications are that surface water resources will become more vulnerable, and more reliance will be placed on groundwater resources during emergency conditions. This means that communities will need to pay much more attention to both types of water resources, beginning with accurate water accounting from source (supply) to tap (demand).

![Main Climate Change Processes in the Columbia Basin](image)

Figure 9.1 Overall climatic trends based on climate model data.

9.1. Observed Climatic Variability in the Columbia Basin

There is general agreement that temperatures have been increasing over historic times in the Basin, and this is best expressed by comparing the changes in extreme maximum and minimum temperatures for most climate stations. Appendix 1 shows the historic changes in temperature for select climate stations in the East Kootenay and West Kootenay between 1960 and 2015.

Since temperatures and precipitation have an important influence on water consumption, it is important to examine climatic events during the seven years of the Water Smart Program and to determine if there is any evidence that the climatic variability is increasing in relation to the historic record. The length of the available historic record for all climate stations differs from station to station, which obviously influences the results, but several stations have records that go back 100 years, and these are the most important ones to consider.

First, the mean maximum summer temperatures were plotted against summer precipitation for the May to September period. As shown in Figure 9.2, 2015 was the wettest summer in five communities (Creston, Cranbrook, Sparwood, Golden, and Kaslo). The summer of 2012 was the wettest in Castlegar, and 2013 was the second wettest in Creston and fourth wettest in
Kaslo over the past 100 years. The summer of 2015 was the hottest at the Warfield station (Trail, Rossland, and Fruitvale), and the second hottest in Revelstoke, Kaslo, and Nelson, while 2009 was the hottest in Revelstoke and the second hottest in Nakusp. What these results show is that during the seven years of the study period, the region experienced some of the most extreme conditions in temperature and precipitation since historic records were taken over 100 years. This means that communities need to become aware of these new norms and develop conservation strategies to cope with these new conditions.

Figure 9.2 Overall long-term summer climatic trends in precipitation and mean maximum summer air temperatures over historic records.

To show this in greater detail, the conditions during the month of June were examined because some of the most unusual events occurred during this time of the year in the Columbia Basin.
Figure 9.3 shows the mean maximum air temperature and the precipitation for June over the historic record.

Figure 9.3 Long-term June climatic trends in precipitation and mean maximum summer air temperatures over historic records.
The results show that some of the most historically extreme precipitation and temperature events occurred during June over the seven years of the Water Smart Program. Castlegar, Creston, Kaslo, Warfield, Nakusp, and Sparwood experienced the hottest June since historic records began, while Nelson and Revelstoke had the second hottest June. At the same time, 2013 was the wettest June in Castlegar, Nelson, Kaslo, and Revelstoke over the past 100 years. In addition, the June rainfall was the highest in 2005 in Cranbrook, Creston, Nakusp, Sparwood, and Golden during the time when the first preliminary survey on water conservation was initiated by the Trust.

These results have major implications for the water managers in the Columbia Basin. An example of the effect of extreme events is provided in Figure 9.4, which shows the rainfall record for June in Kaslo. Historically, the highest June rainfall occurred in 1963 with 120 mm, but in 2005, 2012, and 2013, the June rainfalls were 30 to 70% higher than any time over the previous 100-year record. The two storms in 2012 and 2013 resulted in major flooding in both Kaslo and Nelson, and seriously damaged the drinking water intake in Kaslo. In contrast, the record hot 2015 spring and summer created concerns about potential water shortages in many communities.

Figure 9.4 June precipitation in Kaslo between 1901 and 2014, showing that rainfall events in 2005, 2012, and 2013 were substantially higher than any other events over the 114 years historic time period.

Some of the temperature trends in the Basin are provided in Appendix 1, showing that there is clear evidence that the mean temperature has increased in a statistically significant way over the past 50-100 years. What is of even more importance is that the extreme minimum temperatures are increasing more rapidly than the mean and maximum temperatures. This is particularly evident during the winter months, and suggests that in the future we will likely experience less snow and earlier snow melt in the spring, which should be of concern for water managers.
9.2. Implications for Water Management – East and West Kootenay

The observed climate data clearly shows that the measured information matched the climate model projections, and communities need to be aware of these trends in their water conservation efforts. The main implication for water managers is the shift from snow to rain and the increase in temperatures.

Earlier snow melt means that the peak streamflow period will occur earlier in the spring and this will result in longer dry summer periods.

**East Kootenay:** This is more pronounced in the East Kootenay, and those communities that rely on streams for their water supplies will need to either consider more water supply storage capacity or reduce their summer water consumption to avoid shortages in late summer. This is even more pertinent because summer temperatures in the south of the East Kootenay continue to increase.

**West Kootenay:** In contrast, the West Kootenay is experiencing more late winter/early spring rainfall events, driving earlier freshets, coupled with change in annual average snow pack. Those relying on streamflow as their only or primary water source will likely experience more floods and problems associated with sediment transport, which has an effect on water treatment options. The flooding issues are of significant concern because they can be very destructive to infrastructure. At the same time water is removed very rapidly during storm events and unless there is sufficient storage capacity, that water resource will not be available once peak demand occurs in the summer.

Warmer winters may benefit communities that are bleeding water in pipes to prevent freezing, but in general summer water use will likely be of greatest concern because of:

- a) less snow, more rain in the early part of the year; and
- b) extended and longer summer dry periods.

![Image](image.png)

**Figure 0.1 Graphic depiction of implications of projected increases in mean temperature and variance (extremes) (Mel Reasoner, 2016).**
All of this suggests that water supply questions need to be re-examined in order to determine what the best adaptation strategy should be at the local scale. The key question to be discussed locally and regionally is, how well can human water demand be matched to projected ecosystem supply, and what the best long-term options are between expanding supplies and reducing demands under the climate change and population growth scenarios.

The 2015 hot summer is a wake-up call, because many communities initiated summer water restrictions to reduce the demand, but the decision about when to implement the different stages of restriction is a major challenge. Since April and May were some of the driest on record, few restrictions were put in place in early spring. This resulted in increasing water use from May to June, and only once restrictions were in place did the consumption decline. A good example of this is the 2015 consumption record in Creston, shown in Figure 4.9.
10. LESSONS LEARNED

Given increased climatic variability and the many other factors that influence water use, it is suggested that Basin communities should continue to implement water conservation efforts as part of regular operations and long term planning and management of their water distribution systems.

10.1. Comprehensive and Accurate Water Accounting

The first significant success of community water conservation efforts through Water Smart was the establishment of a comprehensive framework to account for gross water demand in a systematic and standardized manner. This has allowed accurate quantitative comparison of water management challenges within and between communities in the region. For most communities this is the first time they have established accurate month-by-month accounting of how much water is distributed and for which uses. As noted elsewhere in this paper, this scenario is not abnormal in Canada, and development of robust water demand and water loss data is an essential first step in achieving water conservation and resilience outcomes. Just as critically, the requirement for periodic calibration of large gross supply water meters has been made clear – regular scheduling (at approximately five-year intervals) of meter calibration is essential to ensure that water data remains accurate and does not slowly drift artificially downward over time.

It is clear that the methodical approach to data collection and analysis that has been established by most Water Smart communities should continue permanently at the local scale. Further, regional collection, aggregation, and analysis of water demand data, in conjunction with climate data and stream and ground water data, should be implemented as a long-term initiative to support water resilience locally, and across the Basin as a whole.

10.1.1. Universal Metering

Gross water demand data, collected at point of treatment and distribution and throughout the distribution system, is an essential minimum requirement for responsible management of water resources and infrastructure. Many communities are reluctant to proceed beyond this stage of metering to initiate universal water metering because the initial cost of installing meters is high, and public support may be low. As long as there are no concerns about ecosystem supply, population growth continues to be very slow, and minimal changes in climate are experienced, this may be justified. However, climatic condition projections are being realized, human behaviours are difficult to change without incentives and regulations, and infrastructure deterioration continues in all communities.

Without proper water accounting, it will be difficult to prioritize how financial resources for water supply and distribution. Communities should periodically evaluate the costs and benefits of universal metering in the context of their unique utility assets and challenges, to determine at which point the benefits outweigh the costs, both operationally and financially. Many communities would benefit from a phased approach, transitioning from accurate source metering to distribution system metering, through to some combination of ICI and Universal metering.
It is important to remember that universal metering is neither a necessary condition for effective water conservation in the short term, nor a sufficient condition in the long term. To be effective as a water conservation tool, universal metering must be implemented in conjunction, at minimum, with a fully costed asset management plan; a careful assessment of revenue requirements that includes capital replacement; an outreach program to support peak demand management; and a practical and effective water restrictions bylaw, among other key water policies.

There have been impressive technological advances with the introduction of smart water meters that can be read remotely on a daily or monthly basis. Introducing these new systems is currently still expensive, but prices are dropping as these technologies become mainstream. Introducing this type of remotely-sensed meter system will allow communities to skip an entire generation of technologies and move them directly into the digital age of water monitoring and accounting. In a national survey of all communities in Canada by Environment Canada (2011a), average residential water use has declined between 18 and 52% as a result of metering (see Table 10.1 below). In addition, metering will allow for better determination of leakage and will allow communities to implement volumetric pricing.

Water Smart has provided extensive technical guidance on implementation of effective water metering programs ranging from source meters, distribution system meters, ICI metering, and universal metering. Water Smart has also supported cost of services, revenue requirements, and rate-setting studies. These studies are imperative to achievement of local revenue sufficiency and stability for Basin water utilities.

Sparwood and Rossland are two Basin communities that initiated universal metering, and the results show that they have steadily reduced water consumption. They were successful in their metering implementation programs, and present an example to other Basin communities for “how-to” for universal metering. The experience gained by these two communities should be examined by other Basin communities contemplating universal metering.

The Basin communities that have transitioned to universal metering are now in a much better position to account for water, decide on priorities, and recover sufficient revenues to pay for upkeep of the system and save water in the long run. This is one of the key adaptive strategies to cope with increased climatic variability and expected increases in seasonal tourism in many mountain communities.

Table 10.1 Differences between metered and unmetered water use based on Environment Canada (2014) data (Source: Environment Canada 2011a and b).

<table>
<thead>
<tr>
<th>Size of Municipality</th>
<th>Total Residential Water Use L/C/D</th>
<th>Metered Residential Water Use L/C/D</th>
<th>Unmetered Residential Water Use L/C/D</th>
<th>% Difference between Metered and unmetered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000-2000 People</td>
<td>371</td>
<td>275</td>
<td>440</td>
<td>37 %</td>
</tr>
<tr>
<td>2000-5000 People</td>
<td>385</td>
<td>245</td>
<td>510</td>
<td>52 %</td>
</tr>
<tr>
<td>5000-50000 People</td>
<td>313</td>
<td>255</td>
<td>400</td>
<td>36 %</td>
</tr>
<tr>
<td>Size of Municipality</td>
<td>Total Residential Water Use L/C/D</td>
<td>Metered Residential Water Use L/C/D</td>
<td>Unmetered Residential Water Use L/C/D</td>
<td>% Difference between Metered and unmetered</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------</td>
<td>------------------------------------</td>
<td>--------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Average BC</td>
<td>353</td>
<td>325</td>
<td>395</td>
<td>18 %</td>
</tr>
<tr>
<td>Average Canadian</td>
<td>274</td>
<td>229</td>
<td>376</td>
<td>39%</td>
</tr>
</tbody>
</table>

10.2. Water Loss Management

Impressive gains were made in assessing, locating, and repairing distribution system water loss in almost all of the Basin Water Smart communities.

Integration of data from newly-calibrated or replaced source meters, as well as enhanced SCADA capacity in many communities has provided the foundation for success in leakage reduction. Certified, technical water loss management training and sharing of in-house knowledge on how to detect and repair leaks has been a resounding success, building sustainable in-house capacity for water loss management excellence.

Despite successes to date, water loss management training should continue to be a training priority for Water Smart communities for the following reasons:

- a) there is a large staff-turn over and new staff need to be trained;
- b) leakage will continue to be a major water conservation challenge for the foreseeable future because of continuously aging infrastructure and pressure transience; and
- c) new technologies are emerging that improve detection efficiency and pipe repair technology.

10.3. Asset Management Planning

Few Basin communities have completed and are implementing comprehensive inventory and asset replacement plans, though many are starting this process. In 2009, Water Smart communities were losing between 30 and 70% of their domestic water to leakage, with ILIs as high as 28. While Water Smart has not provided support in this area, it is evident due to the high levels of distribution system (and private-side) leakage, that the infrastructure funding gap is significant and will require a carefully orchestrated approach to resolve.

While asset management is not traditionally considered a “water conservation activity”, is it as essential as accurate data collection for long-term demand reduction success.
10.4. Efficient and Equitable Water Pricing.

As shown in Section 9, Basin water utility rates are relatively low in the Columbia Basin, which diminishes the perceived and financial value of water, creating a disincentive for water conservation behaviours. Charging flat annual water utility rates creates a further disincentive to conserve water.

Since 2009, five Water Smart communities have been supported to conduct water utility revenue requirement, cost of services, and rate studies with the goal of achieving revenue stability and sufficiency within a 20-year time frame. While these studies can present significant political and financial challenges to local governments, they are an essential first step to build resilient and cost-effective water distribution systems based on full cost accounting for operations, maintenance, and capital repair and replacement.

In a recent national survey, 57% of British Columbians expressed a willingness to pay more tax for upgraded infrastructure to ensure safe drinking water (RBC 2016).

10.5. Peak Demand Management

Through robust data analysis, peak demand was identified as the second-most effective and cost-effective opportunity to reduce water consumption in our region. The Water Smart Ambassador program has been extremely well received in the Basin, and has been demonstrated to deliver climate-beating results for peak demand management. In most Basin communities, the peak demand reduction opportunity lies in residential irrigation demand. While the Ambassador Program is a “behaviour change program”, it does not rely on good will or brochures with persuasive messaging to secure measurable water conservation results. Instead, for no charge, Water Smart Ambassadors provide residents with face-to-face, at-your-home education, as well as the physical tools that residents need to reduce their irrigation demand – providing free hose timers for those who irrigate manually, and support to properly program the automatic timers for those with in-ground irrigation systems, as well as providing rain sensors. By physically changing residential irrigation potential, the Ambassador program has supported communities to achieve peak demand reductions even during times of sustained, above-normal spring and summer temperatures, as experienced in 2015.

It is important to note that not every community’s peak demand is necessarily driven by lawn irrigation, as analysis of water demand data is required to determine the best means of reducing peaks in demand. For example:

- Elkford experiences winter peaks (December to February) due to extensive residential and municipal winter bleeding to prevent line freezing. A clear bylaw is required for winter-bleed shut-off in the spring, coupled with support for bleed-line reduction to the minimum required flow rate to prevent freezing. It is noted, however, that Elkford has also achieved summer demand reduction by implementation of the Ambassador program targeting residential lawn irrigation reduction.

- Valemount experiences two to three 3 peak demand periods in the year, concurrent with tourism spikes that drive up indoor demand in the community’s unusually high proportion of commercial accommodation units. In this case, indoor water use efficiency targeting the commercial accommodation sector may be more effective that targeting outdoor (irrigation) reduction.
Regardless of the cause of peak demand, the strategy must include physical intervention to secure water conservation outcomes – good intentions will not result in water savings.

While in-house community capacity to implement effective peak demand management programs may be limited, it is essential that this issue be included in every community’s strategy for water conservation and resilience. Inter-community collaboration and external support may, however, be required to deliver such programs effectively.

10.6. Source Water Inventory and Planning

Water Smart has successfully focused on demand-side management. However, many communities do not have a good understanding of how much water they have available and what to do in an emergency situation (flood, wildfire, drought), nor what the implications are for their local supplies from increased climate variability and extremes.

Communities that rely on rivers and springs as their water source face a dilemma about how much water to withdraw from the source and how much to leave to maintain environmental services during a drought. Several have limited groundwater sources as an emergency back-up or as primary supply, but few, if any, have a full understanding of the size of the aquifer and the natural recharge rate, nor about the implications of climate change for the future viability of the aquifers as community water supply.

Flood plain and aquifer mapping is limited across Canada and in the Basin. In this region, the problem is exacerbated by limited numbers of stream flow monitoring stations on water sources that are serving community water supplies.

In order to be able to achieve water and climate resilience, it is essential that communities integrate their now-robust water demand data with readily available climate data, sub-regional climate impact projections (e.g., PCIC’s Plan2Adapt website), and with ecosystem supply monitoring data.

10.7. Collaboration and Communication Drive Success

Water Smart’s collaborative approach and support for peer-to-peer engagement was a driving factor in the initiative’s success. Empowering Basin water managers and operators with knowledge, tools, and technical support was an essential investment into local and regional capacity development on water conservation.

An unanticipated Water Smart outcome was how its collaborative, data-sharing approach fuelled learning, capacity development, cooperation, and innovation among and between community water managers and operators, even extending to Water Smart Ambassadors. Prior to Water Smart, interaction between the water managers and operators in neighbouring communities was an exception, not the rule – communities worked in relative isolation from each other. However, Water Smart’s focus on data collection and sharing as the basis for collaboration illuminated common water conservation issues and challenges faced by Basin

26 https://www.pacificclimate.org/analysis-tools/plan2adapt
communities. In many ways, this provided the missing foundation for water personnel to engage in knowledge exchange and collaborative problem solving\textsuperscript{27}.

The gains and progress made through early collaborations and peer-to-peer networking paved the way for Water Smart to pilot an industry-certified peer-to-peer (P2P) approach to operator training. P2P training allows Basin water operators to both deliver and receive training within their communities, in small groups, and using hands-on, practical exercises, as opposed to traditional classroom-based learning, while at the same time meeting continuing education requirements of Provincial certification.

In a similar way, Water Smart Ambassadors in 13 Basin communities were supported to meet weekly by phone during the irrigation season. The conference calls allowed the Ambassadors in each community to share their ideas, and to brainstorm ways to overcome challenges and barriers they were facing in assisting residents to reduce peak demand.

Through sharing data, successes, and failures, and making connections with other communities with similar challenges, Water Smart has fostered a strong professional network invested in best practices around water conservation, confirming the benefits of “deep and persistent collaboration”.

\textbf{10.8. Water Smart – An Innovative, Unique, and Effective Program}

Based on the results of this evaluation, it is clear that the Columbia Basin Water Smart Initiative has supported communities to achieve real and sustainable water conservation outcomes. Water Smart has demonstrated national and provincial leadership in water conservation and the lessons learned are highly transferrable to other jurisdictions, regardless of size or density.

Working at a regional scale in a simultaneous, collaborative water conservation program with 26 communities (14 of which were included in this evaluation) to account for water and initiate a wide range of conservation activities is clearly innovative. There were many mutual benefits for participating communities, and the feedback has been very positive. Often small communities lack access to necessary expertise and finances, and they usually develop their own approach. What works in one community does not necessarily work in another because local conditions and constraints are different. Water Smart identified common issues and clearly demonstrated how each community could better account for water and improve the management of both the resource itself and the local infrastructure that conveys water from source to tap. Given the evidence of increased climatic variability in the Basin, it is critical that communities continue their efforts initiated through Water Smart. Now that the key issues have been identified, consistent progress is well within reach to arrive at resilient water supply and distribution systems that are efficient and sustainable.

\textsuperscript{27} This paragraph was written by Ingrid Liepa, 2016.
ACKNOWLEDGEMENTS

The authors would like to thank Columbia Basin Trust for facilitating this program evaluation. The following water operators, managers and administrators provided key informant interview information about local issues, constraints and future plans: Joe McGowan and Chris Zettel (Cranbrook), Dave Cockwell (Fernie), Colin Farynowski (Creston), Robin Douville (Erickson), Leigh Adamson (Rossland), Lila Cresswell (Fruitvale/BVWS), Neil Smith (Kaslo), Danny Dwyer (Sparwood). Many thanks for taking the time to provide your insights and information.

REFERENCES


APPENDIX 1. CLIMATE STATION DATA USED FOR THE ANALYSIS.

11 climate stations were used to determine the climatic effects on community water use. The monthly extreme maximum temperature, the monthly mean maximum temperature, and the monthly mean temperatures were used for the analysis. The monthly mean maximum temperature proved to be the best statistical choice (Highest R2-Value) for comparing water use with temperatures.

Not all communities had climate station data, so the nearest climate station was used for the comparison between temperature and water use. As shown in Table A1, the climate data from the Warfield station was used for the water use analysis for Trail, Fruitvale, and Rossland; the Sparwood station was used for the Elkford and Sparwood analysis; and the Creston station data was used for the RDCK and Creston data analysis.

Table A1 Climate stations used for the water use analyses.

<table>
<thead>
<tr>
<th>Climate Stations</th>
<th>Elevation (m)</th>
<th>Station #</th>
<th>Data Applied to Community</th>
<th>Length of Record Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castlegar A</td>
<td>495</td>
<td>1141455</td>
<td></td>
<td>1966-2015</td>
</tr>
<tr>
<td>Cranbrook A</td>
<td>927</td>
<td>1152106</td>
<td>Cranbrook</td>
<td>1939-2015</td>
</tr>
<tr>
<td>Creston</td>
<td>610</td>
<td>1142160</td>
<td>Creston &amp; Erickson</td>
<td>1913-2015</td>
</tr>
<tr>
<td>Golden A</td>
<td>785</td>
<td>1173210</td>
<td>Golden</td>
<td>1923-2015</td>
</tr>
<tr>
<td>Fernie</td>
<td>1001</td>
<td>1152850</td>
<td>Fernie</td>
<td>2009-2015</td>
</tr>
<tr>
<td>Kaslo</td>
<td>600</td>
<td>1143900</td>
<td>Kaslo</td>
<td>1913-2015</td>
</tr>
<tr>
<td>Nakusp CS</td>
<td>512</td>
<td>1145297</td>
<td>Nakusp</td>
<td>1966-2015</td>
</tr>
<tr>
<td>Sparwood A</td>
<td>1158</td>
<td>1157635</td>
<td>Sparwood &amp; Elkford</td>
<td>1980-2015</td>
</tr>
<tr>
<td>Warfield RCS</td>
<td>576</td>
<td>1148705</td>
<td>Trail, Fruitvale &amp; Rossland</td>
<td>1929-2015</td>
</tr>
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</table>
The monthly climate data for 2009 to 2014 were compared between those pairs of stations that showed the best temperature relationships. As expected, the southernmost stations Cranbrook/Creston and Castlegar/Warfield generally showed the highest mean maximum temperatures throughout the year, while Nakusp/Revelstoke and Fernie/Sparwood showed consistently lower temperatures.

Changes in temperatures trends for stations the West and East Kootenay are provided in Figure A1.1 Changes in precipitation for the same stations are shown in Figure A1.2.

The trends show increasing winter minimum temperatures and increased precipitation in the spring in the West Kootenay.

There is general agreement that temperatures have been increasing over historic times in the Basin, and this is best expressed by comparing the changes in extreme maximum and minimum temperatures in most climatic stations. Figure A1.2 shows the historic changes in temperature for selective climate stations in the East Kootenay and the West Kootenay between 1960 and 2014.

The results show that the monthly extreme minimum and mean minimum temperatures have increased the most in the wintertime (particularly in January) and the increases were larger in the northern part of the East Kootenay than in the West Kootenay. At the same time, there have been relatively small changes in the maximum temperatures in both the East and West Kootenay. Golden showed the largest changes in minimum temperature, and this will eventually affect the snow accumulation.
Figure A1.1 Average temperature changes in the East and West Kootenay between 1960 and 2014 (red colors are increases, while blue colors are decreases in degree Centigrade).

Precipitation changes are much more complex and the results shown in Figure 8.1 indicate that spring precipitation has increased during the March to June period in the West Kootenay, while precipitation has changed little in the East Kootenay. What is of the greatest concern is the decrease in snow cover in the winter (December-January), which is more pronounced in the East Kootenay.
If these trends persist, then it is expected that snow will melt earlier and this will create longer dry summer periods in the East Kootenay, while the West Kootenay will likely experience more flooding events in the spring, since rainfall events have increased the most during that time period.

This is corroborated by the recent flood events in Castlegar, Nelson, Kaslo, Fairmont, Elkford, and Sparwood. As shown in Figure 8.2, Kaslo has experienced three rainfall events in June that were almost twice as high as the previous 1963 event, which was the highest over a 100-year period.
### APPENDIX 2. LISTING OF PARTICIPATING COMMUNITIES

26 communities participating in the Water Smart Initiative 2009 to 2014

<table>
<thead>
<tr>
<th>Communities indicated with a * entered the initiative after 2012</th>
<th>14 communities included in this evaluation of Water Smart outcomes 2009 to 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castlegar #</td>
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<tr>
<td>Cranbrook</td>
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<tr>
<td>Creston</td>
<td>Creston</td>
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<tr>
<td>Elkford</td>
<td>Elkford</td>
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<tr>
<td>Fernie</td>
<td>Fernie</td>
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<tr>
<td>Fruitvale – Beaver Valley Water Service</td>
<td>Fruitvale – Beaver Valley Water Service</td>
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<tr>
<td>Golden</td>
<td>Golden</td>
</tr>
<tr>
<td>Invermere*</td>
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<tr>
<td>Kaslo</td>
<td>Kaslo</td>
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<td>Kimberley#</td>
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<td>Montrose#</td>
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<tr>
<td>Nelson</td>
<td>Nelson</td>
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<tr>
<td>New Denver*</td>
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<tr>
<td>Radium Hot Springs#</td>
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<td>Revelstoke</td>
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<td>Rossland</td>
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<td>Location</td>
<td>Location</td>
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<td>------------------------</td>
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<td>Silverton*</td>
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<tr>
<td>Slocan</td>
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<td>Sparwood</td>
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</tr>
<tr>
<td>Trail</td>
<td>Trail</td>
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<tr>
<td>Valemount#</td>
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