Greywater Recycling and Reuse in Alberta

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1.0 Executive Summary

As pressures on Alberta's freshwater resources grow, and as new sources of supply become increasingly scarce, efforts are underway to identify new ways of meeting our ever-growing water demands. There has been a significant amount of research undertaken to develop methods to reduce the demand for water by increasing the efficiency of water use, and to expand the usefulness of alternative sources of water that were previously considered unusable. Among these potential new sources of supply is "greywater."

Greywater is defined as wastewater generated from domestic activities such as laundry, washing and bathing. It differs from toilet water, which is designated sewage or "black water" and contains human waste. Greywater composes 50% to 80% of residential wastewater generated from all of a household's sanitation uses (except toilets), and can be of far higher quality than black water due to its lower levels of contaminants.

Greywater reuse offers a variety of opportunities and challenges, and greywater technologies, uses and policies vary widely around the world. Modern and developed jurisdictions in Australia and the United States are at the forefront of implementing these water reuse management practices, and in Canada, British Columbia is leader in developing policy and legislation to safely manage the recovery and reuse of municipal wastewater.

In Alberta, potable water is currently used for all contact and non-contact applications including lawn watering and toilet flushing. Greywater and black water are combined in a single sewage stream, treated, and are returned to the environment. Thus, most greywater ends up as effluent. There is no requirement to use potable water for non-contact applications. However, there is a significant opportunity for greywater to be recycled for these applications. The recovery and reuse of municipal wastewater (reclaimed water) for non-contact commercial and institutional, household and landscape purposes could increase the amount of net water available without effecting current consumption patterns, volumes or life styles.

For example, an estimated 258,000 cubic meters of municipal (residential) greywater is produced every day in Alberta, and an estimated 161,000 cubic meters of municipal (residential) toilet water is flushed each day in Alberta. If greywater was reused strictly for toilet flushing in municipal homes, Alberta would conserve an estimated 59 million cubic metres of water a year, or up to 25 percent of all residential water consumption (source: WaterSMART). Taken a step further, the increased use of all household reclaimed and greywater has the potential to reduce fresh water demand from households by as much as 40 percent. Put another way, an existing water license might be able to serve hundreds or even thousands of additional homes, by more effectively managing a limited resource.

Current Alberta regulations prohibit the full exploitation of these water reuse practices, and these regulations need to be improved to encourage wastewater recovery and reuse. Alberta's building codes and reclaimed water standards need to be updated to reflect the province's current economic and environmental requirements, and to take advantage of the many proven water recycling and reuse technologies and practices commonly in use throughout the world today.

Alberta has joined many other global communities where the demand for water has reached or has exceeded the natural capacity of the watershed. Now that new water licenses are no longer available in southern Alberta, additional demand must be met by looking at new and innovative methods to reduce demand, reuse water, or transfer water license allocations from others.

Alberta must take active steps to better manage and more effectively use the water that is available, examining all feasible alternatives, and developing a structured plan for the implementation of those alternatives. Many municipalities and developers are now reducing water demand through water conservation measures such as water efficient appliances and low flow showerheads. However, other significant and promising opportunities exist to use water in a more efficient and environmental friendly manner. The increased use of reclaimed and greywater, in particular, presents one of the greatest untapped opportunities to better use and manage Alberta's existing water supplies.

2.0 Project Scope

This study is Part 1 of a two part project focusing on: (1) the role of greywater in reducing residential potable water use; and, (2) environmentally friendly water treatment technologies.

The purpose of this study is to:

- Examine the potential of greywater reuse to reduce water demand;
- Provide an analysis of the key challenges that must be addressed for greywater reuse to be accepted and implemented in Alberta; and,
- Assess the market opportunities, technology requirements, and manufacturing options associated with using technologies and solutions to reclaim greywater or harvest rainwater to reduce residential potable water use for non-contact applications.

Part 2 of the project will assess technologies to treat water that result in a smaller environmental impact and/or reduce the use of harmful or synthetic chemicals (chlorine, etc). This work will be released in a separate, companion document.

3.0 Background

3.1 Definition and Overview of Greywater

Greywater is defined differently in various parts of the world. Generally, greywater gets its name from its cloudy appearance and from its classification as being “between” fresh potable water ("white water"), and sewage water that contains contaminating elements such as human waste ("black water"). In a residential household context, greywater is generally the leftover water from baths, showers, hand basins and washing machines. Water from toilets is considered black water. Greywater can be of far higher quality than black water, because of lower levels of contaminants.

Rainwater, which can also be collected for use, is not considered to be greywater, and is often used for simple garden irrigation. Greywater is also distinct from reclaimed water, which is wastewater (including black water) that is treated by a centralized wastewater treatment plant for potable or non-potable reuse.

Wastewater from kitchen sinks and automatic dishwashers tends to have high concentrations of organic matter that encourages the growth of bacteria, and is referred to as “dark greywater.” Many regions in Canada lack clear regulations or standards regarding greywater capture and reuse, but among the regions that do have regulations, many do not allow wastewater from the kitchen to be reused. The Uniform Plumbing Code in the United States and greywater regulations in Queensland, Australia, also do not allow the reuse of kitchen wastewater (Alkhatib et al. 2006, MPMSAA 2008).

Greywater may contain many of the same contaminants as raw sewage, but generally in lower concentrations (see Table 2). For example, greywater can contain fecal coli forms and nutrients including nitrogen and phosphorus (WHO-ROEM 2006, Maimon et al. 2010). Greywater is often, but not always, treated before it is reused, and the degree of treatment can vary. Some greywater may be allowed to seep into the ground to recharge aquifers and reduce the volume of wastewater needing to be treated, but this depends on the level of contaminating elements it contains.

Table 1: Wastewater Definitions

Term	Definition	Also Referred to as
Greywater	Untreated wastewater that has not come in contact with black water	Gray Water, graywater, greywater
Black Water	Wastewater from toilets	Sewage
Dark Greywater	Untreated wastewater that has not come in contact with black water, but is from lower-quality sources such as the kitchen sink or dishwasher	Often considered part of black water

Table 2: Breakdown of Typical Household Greywater in Canada
(source: adapted from waterforever factsheet, 2008; Statistics from Environment Canada)

Stream	Contents / Possible Contaminants	Key Risks	Typical Water Quality Profile and Treatment
Bathroom (bathtub, shower, sink, spa)	Bacteria, hair, organic material and suspended solids (skin particles, lint, food particles), body fats, oil and grease, soap and detergent residue, cleaning products Some fecal contamination, including bacteria and viruses	Fecal contamination, risk to public health Over time, build up of chemicals in soils, potentially impacting soils, vegetation and groundwater	Cleanest wastewater: Low pathogens, low organic content – moderate treatment requirements
Laundry	Suspended solids (dirt and lint), organic material, oil and grease, sodium, nitrates and phosphates (from detergent), increased salinity and pH, bleach, chemicals Some fecal contamination including bacteria and viruses	Fecal contamination, risk to public health Over time, build up of detergents in soils, vegetation and groundwater Bleaches and disinfectants can potentially kill organisms in the soils	Variable levels of pathogens, high organic content – high treatment requirements
Kitchen (sink, dishwasher, garbage disposal)	Heavily polluted with bacteria, organic material and suspended solids (food particles), cooking oils, grease, soaps, detergents, chemicals, cleaning products Potential fecal contamination including bacteria and viruses	Fats which cannot be broken over time will build up in the soil so it repels water Contaminants build up in soils, vegetation and groundwater	High pathogens, high organic content – advanced treatment and disinfection

3.2 Water Use in Alberta and Greywater Use Potential

In Alberta, most homes have one set of pipes that bring drinking water into the residence and another set of pipes that take water away. In this system, all devices that use water and all applications of water end up using a single quality of water, that is, highly treated potable drinking water (see Figure 1).

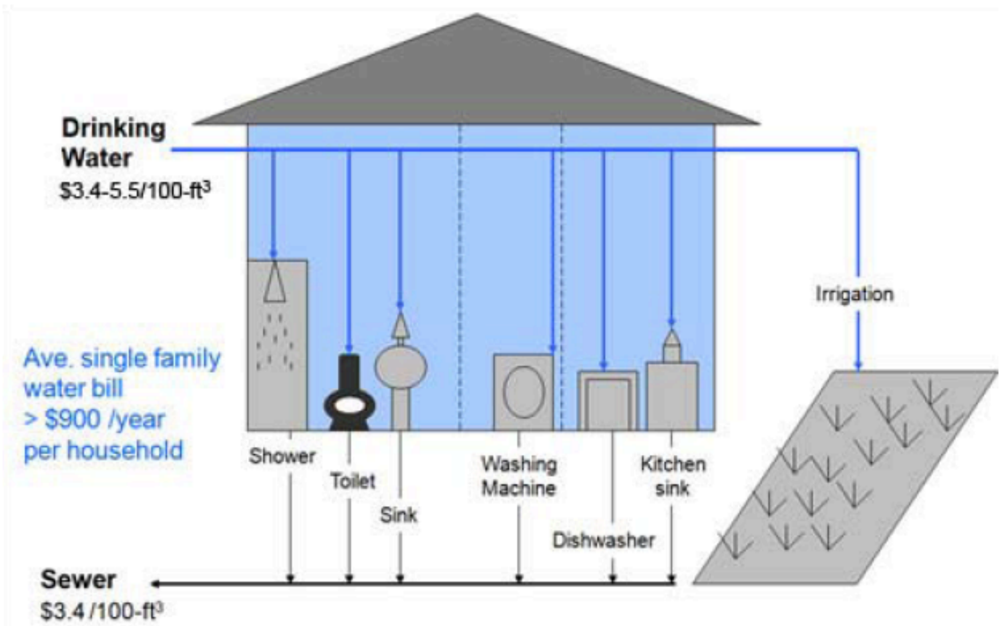

Figure 1: Typical Household Consumption of Water

This water is used once, the resulting greywater and black water is combined, and then all the sewage water is piped in a single domestic wastewater stream to an available wastewater treatment facility. Typically, the sewage water is treated to limit pollution and health risks, and then is returned to the environment. As such, most greywater ends up as effluent in river basins, eliminating any potential for reuse.

Alberta's existing water management and treatment system does not use water, energy and resources efficiently because it does not appropriately match water quality to water need. If water quality was appropriately allocated to water need, greywater could replace potable water in some household non-potable applications (e.g., toilet flushing and landscaping). These practices represent one of the most promising untapped opportunities to better use and manage existing water supplies. The impact of its implementation can illustrated by the following example.

Alberta's population is expected to increase at 1.3% annually for the next twenty years - an increase of 50,000 people a year. This increase in population will have a large impact on the demand for water in Alberta. Currently, an estimated 258,000 cubic meters of municipal (residential) greywater is produced every day in Alberta, and an estimated 161,000 cubic meters of municipal (residential) toilet water is flushed each day in Alberta. If greywater was reused strictly for toilet flushing in municipal homes, Alberta would conserve an estimated 59 million cubic metres of water a year, or up to 25 percent of all residential water consumption (source: WaterSMART).

Alberta is faced with an ever-increasing demand for water resources from all sectors: industry, agriculture and municipalities. If we are to remain nationally and globally competitive in these sectors, we must direct our focus towards creating sustainable economic and environmental plans to manage these water demands. As our water supplies are relatively fixed, the recovery and reuse of wastewater ("reclaimed water") must become an integral part of these plans. The conservation of water resources through better use and reuse of our current water supply will ultimately provide water for other economically and environmentally beneficial applications.

3.3 Concerns Regarding the Implementation of Greywater Reuse

Using available technology, the practice of water reuse is safe and is allowed in several countries around the world. For example, recycled greywater from showers and bathtubs can be used for flushing toilets in most European and Australian jurisdictions, as well as a few United States jurisdictions (Florida, California) that have adopted the International Plumbing Code. Many examples exist in Europe, the Caribbean and other parts of the world that prove the viability of greywater as means of meeting increasing water demands. The use of greywater for indoor applications shows that when treatment or filtration systems are designed and implemented properly, the public health concerns with using different water qualities can be fully addressed, and need not be a limiting factor.

Despite the significant benefits for water conservation, and technology that protects public health, research indicates that greywater reuse is rarely practiced and almost never encouraged or permitted in Canada and the majority of U.S. jurisdictions (CWWA Report on Rainwater Harvesting and Greywater Reuse for Potable and Non-Potable Uses, 2002).

In the United States, the primary concerns regarding greywater reuse are as follows (Sheikh, *Whitepaper on Greywater,* 2010):

- Public health concerns related to the potential for cross-connection with either a potable or reclaimed water system;
- Fear of any health problems potentially caused by the poor microbial quality of greywater becoming associated with high-quality recycled water in the public's mind;
- Reduction of flow of raw material, as a result of diversion of greywater, into wastewater treatment plants (WWTPs), impairing the reliable production of recycled water;
- Public, media, and elected officials' confusion of greywater and recycled water and their respective qualities;
- Reduction in the carrying capacity of sewers for solids as a result of reduced flow into the sewer;
- Increase in the salinity of recycled water as a result of diversion of the lower-salinity bathwater, shower water, and lavatory wastewaters from the sewer; and
- Concerns by residential users about ongoing maintenance and repairs for greywater systems.

Some relatively high fecal coli form counts in greywater have been reported in the United States, ranging from thousands to millions of CFU/100 mL. The potential for high numbers of bacteria in greywater has been reported as a reason that many public health officials oppose widespread residential reuse of untreated or lightly treated greywater, without stringent regulatory control.

There are two primary areas of concern expressed by residential users interested in installing a greywater reuse system:

- **Potential additional costs associated with energy consumption.** These treatment systems require the use of electricity to move or pump the treated water throughout the home. The average electronic control pressure pump used in these applications is a one-horse power pump that requires 110-220 volts to run. This is equivalent to the energy needed to power two to four standard light bulbs.

- **Quality of the treated greywater.** It is inevitable that water allocated for non-contact uses (irrigation, toilets) is never really non-contact. Young children or animals can become exposed to this water and therefore it must not contain any harmful bacteria or contaminants. Greywater must be held to a certain level or standard, as the reused greywater for outdoor use (irrigation, car washing) will eventually be discharged into locally sensitive receiving watersheds.

3.4 Regulation of Greywater Use

In Alberta, recycled water cannot be used within buildings, but can be used for irrigation purposes. However, irrigation use is effectively prohibited in metropolitan residential areas due to regulations that require a minimum of 60 meters clearance between inhabited buildings and the reclaimed water. The introduction of recycled greywater use into all residential communities will require a broader approach and new legislation, codes, guidelines and standards.

The Government of Alberta established the *Alberta Reclaimed Water Working Group,* which included participants from four sectors of government: Alberta Environment; Alberta Health and Wellness and the Alberta Health Services Board; Alberta Municipal Affairs; and, Alberta Transportation. The group was tasked with developing the framework to facilitate safe use of reclaimed water for domestic applications. The focus of the framework included approved uses for reclaimed water, water quality or technical standards and guidelines, and a management system for approvals, reporting and monitoring. Further development of this reclamation framework will be vital in order to introduce greywater use throughout the province, and in producing a market for greywater technology in Alberta.

Regulations, standards and guidelines will only make sense if they tie into existing Alberta policies and actions committed to protecting the environment, enhancing economic prosperity, and improving the health and lifestyle of our communities. In this respect, Alberta's *Water for Life* strategy, which commits the province to improving overall efficiency and productivity of water use by 30% from 2005 to 2015, is an excellent opportunity upon which to advance a new framework that will support the efficient recycling and reuse of greywater.

4.0 Addressable Market Opportunities

4.1 Uses of Greywater in North America and Abroad

Greywater reuse has become an important opportunity for water conservation throughout the world (see Sections 3.3 and 4.1). The majority of information regarding greywater in North America is available to the public on the websites of environmental groups that advocate water recycling, as well as suppliers of technology and equipment for greywater reuse. There are few North American scientific studies or peer-reviewed research results regarding actual volumes of greywater diverted and used.

The current leader in greywater reuse technology is Australia. The government of Australia has overseen the development of a variety of technologies and policies that are based on the demand and supply of water in each region of the country.

To better understand current practices for greywater reuse in North America and elsewhere, the Canadian Water and Wastewater Association (CWWA), on behalf of Canada Mortgage and Housing Corporation, undertook to review practices involving water reuse in residential and other buildings (CWWA Report on Rainwater Harvesting and Greywater Reuse for Potable and Non-Potable Uses, 2002). This work included looking at regulations and standards governing non-potable water. CWWA distributed a questionnaire to all Canadian provincial and territorial drinking water and plumbing regulators, to the same regulators in all U.S. state and federal jurisdictions and to a wide range of CWWA contacts in other countries. The Association received a total of 48 responses: 6 from Canadian jurisdictions; 8 from U.S. jurisdictions; and 34 from other contacts. Responses came from regulatory bodies, water utilities and water districts.

The CWWA researched information using the Internet, and met with several European suppliers of agricultural harvesting equipment and town engineers in Belgium, where harvesting is required by state law, and CWWA also spoke with officials of France's Ministry of Health.

Jurisdictions reported a variety of uses and applications for greywater, as shown in Table 3. In addition to the uses identified in Table 3, other greywater reuses include:

- Crop irrigation;
- Ornamental lakes and streams;
- Industrial construction;
- Dust control;
- Street washing / snow melting; and,
- Sale to other agencies.

Uses	Rainwater				Grey Water			
	CAN.	U.S.	Other	Total	CAN.	U.S.	Other	Total
Potable water uses		1	6	7		1	1	2
Sanitary use (toilet flushing)	1	1	17	19	—	2	10	12
Laundry	1	1	7	9	—	1	—	1
Bathing/showering	1	1	8	10	—	1	—	1
Garden irrigation	4	1	19	24	—	2	12	14
Animal husbandry	1	1	5	6	—	1	2	3
Industrial	1	1	4	5	1	2	1	4
Groundwater recharge	1	1	4	5	—	1	1	2
Golf course irrigation	—	1	—	1	1	1	—	2
Vehicle washing	—	—	—	—	—	—	1	1
Helicopter washing	—	—	—	—	—	—	1	1
Firefighting	—	—	—	—	—	—	1	1

Table 3: Primary Uses of Rainwater and Greywater in Canada and Other Countries
(source: CWWA Report on Rainwater Harvesting and Greywater Reuse for Potable and Non-Potable Uses, 2002)

4.2 Potential Uses of Greywater in Alberta

In Alberta, garden irrigation, sanitary use (toilet flushing) and heat reclamation are likely to be the three most popular uses of greywater in all sectors (residential, commercial, industrial). These three uses hold the most immediate potential for market growth and adoption of greywater systems.

- **Irrigation (outdoor use)**

  Some relatively 'clean' greywater may be applied directly from the sink to the garden or container field, receiving further treatment from soil life and plant roots. Greywater used for irrigation must be free from bleaches, bath salts, artificial dyes, cleansers, products containing boron (which is toxic to plants at high levels), and sodium-based laundry and dishwasher detergents (which can inhibit seed-germination and destroy the structure of clay soils). This greywater can, however, contain some soap residues, as long as they are from all-natural, biodegradable soaps whose ingredients do not harm plants.

  Some Alberta residents have already begun to purchase and install greywater reuse systems within their homes for irrigation purposes (source: Brac Systems).

- **Toilet Water (indoor use)**

  Recycled greywater from showers and bathtubs is used for flushing toilets in European, Australian and United States jurisdictions that have adopted the International Plumbing Code.

  The danger of biological contamination in these systems is avoided by using:
  - a cleaning tank, to eliminate floating and sinking items;
  - an intelligent control mechanism that flushes stored water before it can become potentially hazardous (this can lessen the requirement for more advanced filtration and chemical treatment).

  According to Environment Canada, approximately 65% of indoor home water use occurs in our bathrooms, and toilets are the single greatest water user. As indicated in Section 3.3, if Alberta allowed greywater recycling for use in toilet flushing, we could conserve approximately 25% of all residential water consumption.

- **Heat Reclamation (indoor use)**

  One of the main challenges for adoption of greywater systems in Alberta is the use and reuse of water in our cold climate. Alberta winters create problems with reclaimed water storage and use, particularly in the case of outside storage and the elimination of irrigation in winter months. These systems can overcome this challenge by allowing for indoor storage and overflow releases that provide for water discharge when water reaches a certain level in the storage tank.

  In the case of indoor storage, devices are currently available that capture heat from residential and industrial greywater through a process called greywater heat recovery (also known as drain water heat recovery, or hot water heat recycling). In this process, rather than flowing directly into a water heating device, incoming cold water first flows through a heat exchanger, where it is pre-warmed - by heat from greywater flowing out. To appreciate the benefits of this system, consider the following example: typical heat exchange systems receiving greywater from a shower can recover up to 60% of heat that would otherwise go to waste.

- **Commercial and Institutional Buildings**

  Commercial and institutional buildings represent a promising market opportunity. These facilities not only accumulate large volumes of greywater, but present multiple reuse opportunities including heat, toilet flushing, irrigation, and cooling systems. Internationally, there is growing evidence of commercial and institutional buildings becoming a big market for water and other reuse systems.

  An additional benefit is that young children or animals are less likely to be present in a commercial and institutional building, and as a result, less likely to become exposed to any potential bacteria or contaminants associated with greywater.

4.3 Competition / Alternatives to Greywater Reuse

Rainwater is one of the primary alternatives for household, commercial and industrial greywater. In Canada rainwater harvesting is becoming more widely used in residential, agricultural, industrial and institutional sectors, however, it is considered a ‘minor’ source when compared to greywater (Sheikh, *Whitepaper on Greywater,* 2010).

4.4 Greywater Reuse: Success and Sustainability

Climate change, water shortages, droughts, and awareness of water scarcity are becoming more popular in the media reporting and public discussion. As such, cost effective and environmentally friendly measures that reduce water demand and use – including greywater reuse and recycling – will undoubtedly be viewed positively. In fact, research suggests greywater reuse is already viewed more favourably than more sophisticated water reuse projects proposed around the world, including Southern California, Florida, and Australia in recent years (Sheikh, *Whitepaper on Greywater,* 2010).

Some of the major benefits of greywater reuse and recycling that will contribute to the adoption and success of greywater systems include:

- **Cost-Effectiveness and Ease of Implementation:** Greywater reuse systems are generally small, individual, and not subject to the lengthy environmental review processes that much larger municipal wastewater reuse systems must undergo. While the cost of these systems vary over a wide range, the most elementary systems, with do-it-yourself kits and components purchased from hardware stores, can cost as little as $1,000. Easy, quick and inexpensive implementation can further incent homeowners already intent on adopting environmentally sustainable practices to invest in greywater systems.

- **Water Savings Potential:** Greywater systems provide a wide range of water cost savings to purchasers and users.

- **Costs Avoided by the Community:** The community and municipality benefits from reduced demand on its water supplies, and from a reduction of wastewater flow into treatment plants (and associated treatment and chemical costs). In fact, there are infrastructure savings on both the upstream (fresh water) and the downstream (wastewater) facilities.

- **Reduced Energy Use and Carbon Footprint:** Since greywater systems bypass traditional centralized wastewater treatment systems, they can potentially reduce the amount of energy needed for operating those facilities. On a smaller scale, the use of hot water heat recycling can result in additional energy savings for both residences and businesses. The carbon footprint of greywater systems is also much smaller than that of centralized systems.

- **Cost-Effectiveness for Society:** Since the user bears the full costs of constructing, operating and maintaining their individual greywater system, the burden of wastewater management for that system is not assumed by the community. With minimal or no cost, society reaps the cumulative benefit of avoided costs of conveyance, treatment, and redistribution that comes from the collective implementation of greywater reuse systems.

4.5 Product Positioning

Greywater treatment systems can be positioned within the Environmental Products and Services sector. Their value add results from saving both users and municipalities water and energy costs over the life of the greywater system investment.

4.6 Market Channels

The near-term opportunities for market channels into Alberta would likely involve leveraging existing manufacturing, wholesale and distribution suppliers and channels already engaged in other provinces and countries (franchises, licensee, etc). Once local expertise and markets are more fully developed, there is the opportunity to expand these sales channels and markets.

4.7 Target Market, Market Size, and Market Growth Potential

The primary target market for greywater reuse systems in Alberta is:

1) Residential homes in remote and rural locations whose cost of water as a percentage of household expenses is relatively higher than urban households; and
2) environmentally conscious consumers who want to adopt more sustainable water use practices.

Appendix 1 provides a forecast of the estimated addressable market (including size and growth potential) for a variety of greywater re-use systems, from 2012-2020. This forecast is based on a range of sales estimates, starting with entry-level systems (e.g., sand-filter), and moving up to more advanced and expensive systems (e.g., aerobic biological treatment). The forecast assumes a five percent penetration or adoption rate of greywater re-use systems in new home starts.

The following assumptions have been made in developing the detailed forecast:

1) New Alberta regulations will allow for more widespread greywater use in both rural and urban residential applications throughout the province, effective 2012.
2) The greatest near-term opportunity for installation of greywater systems will be in new home starts as opposed to existing homes, as the cost to install systems in new homes will be less than retrofitting existing homes.
3) Water users who live in rural and remote areas generally pay significantly more for water than urban municipal users. These rural users are more incented to conserve, and thus will be more inclined to purchase greywater systems.
4) There is a growing number of environmentally conscious consumers who want to adopt more sustainable water practices.
5) Only five percent of all new home construction in Alberta will install greywater systems.
6) The relatively low cost of water in large urban municipalities may discourage some of these users from installing greywater systems. Urban residents in Alberta pay some of the lowest rates for water in the world, averaging twelve cents per 10-minute shower (source: WaterSMART).
7) The estimated cost per system per household (including installation) will range from $1,500 for entry-level systems to $6,500 for advanced systems. This cost will remain relatively stable during the forecast period. Ongoing maintenance costs are not included in the forecast.

Based on these assumptions, the addressable market opportunity for greywater systems in Alberta ranges from $1.6 million per year for entry-level systems, to as much as $7.2 million for advanced systems in 2012. In 2020, the comparable estimates are $2.1 million per year for entry-level systems and $9.1 million for advanced systems.

5.0 Technology Review and Assessment

5.1 Greywater Processes and Technologies

Greywater and other wastewater recycling technology are a form of “appropriate technology”. The term “appropriate technology” has been used in developed nations to describe the use of technology and engineering that results in less negative impacts on the environment and society. At present, the majority of greywater recycling systems work in two ways:

- Recycle water, without purifying it;
- Recycle water, while purifying or decontaminating it.

Water recycling without purification can be used for some agricultural applications (e.g., tree nurseries), and in households for applications where potable water is not required (e.g., landscape irrigation and toilet flushing). In this case, greywater must be fairly clean to begin with.

Typical residential greywater reuse systems capture water that has been used for applications that do not allow the water to come into contact with high levels of contamination (e.g., sewage or food waste) or non-degradable chemicals such as non-natural soaps or detergents.

There are numerous systems and technologies for filtering greywater to purify or decontaminate it. These systems fall into two categories: those based on “soft” processes, and those based on “hard” or direct processes. Soft processes include natural biological principles such as:

- Mechanical systems: e.g., sand filtration, lava filter systems and systems based on UV radiation;
- Biological systems: e.g., treatment ponds, constructed wetlands, living walls;
- Bio-reactors or compact systems: e.g., activated sludge systems, biorotors, aerobic and anaerobic biofilters, submerged aerated filters.

Hard or direct processes include distillation (evaporation) and mechanical processes such as "Membrane Filtration" (e.g., "Ultra Filtration" and "Reverse Osmosis"). These systems are typically used in non-residential applications and are capable of treating high volumes of greywater to create potable or near-potable water.

Table 3 lists the most effective and up-to-date technologies offered in the grey water recycling market.

Table 4: Greywater Recycling Technologies
(source: Pacific-Institute)

TREATMENT	COST	DESCRIPTION	PROS	CONS
Sand Filter	$1,500	Beds of sand or in some cases coarse bark or mulch which trap and adsorb contaminants as greywater flows through.	Simple operation, low maintenance, low operation costs.	High capital cost, reduces pathogens but does not eliminate them, subject to clogging and flooding if overloaded.
Disinfection	$2,500	Chlorine, ozone, or ultraviolet light can all be used to disinfect greywater.	Highly effective in killing bacteria if properly designed and operated, low operator skill requirement.	Chlorine and ozone can create toxic by products, ozone and ultraviolet can be adversely affected by variations in organic content of greywater.
Activated Carbon Filter	$4,500	Activated carbon has been treated with oxygen to open up millions of tiny pores between the carbon atoms. This results in highly porous surfaces with areas of 300- 2,000 square meters per gram. These filters thus are widely used to adsorb odorous or colored substances from gases or liquids.	Simple operation, activated carbon is particularly good at trapping organic chemicals, as well as inorganic compounds like chlorine.	High capital cost, many other chemicals are not attracted to carbon at all -- sodium, nitrates, etc. This means that an activated carbon filter will only remove certain impurities. It also means that, once all of the bonding sites are filled, an activated carbon filter stops working.

Aerobic Biological Treatment	$6,500	Air is bubbled to transfer oxygen from the air into the greywater. Bacteria present consume the dissolved oxygen and digest the organic contaminants, reducing the concentration of contaminants.	High degree of operations flexibility to accommodate greywater of varying qualities and quantities, allows treated water to be stored indefinitely.	High capital cost, high operating cost, complex operational requirements, does not remove all pathogens.
Membrane Bioreactor	$3,500	Uses aerobic biological treatment and filtration together to encourage consumption of organic contaminants and filtration of all pathogens.	Highly effective if designed and operated properly, high degree of operations flexibility to accommodate greywater of varying qualities and quantities, allows treated water to be stored indefinitely.	High capital cost, high operating cost, complex operational requirements.

5.2 Greywater Reuse and Recycling Systems

Greywater systems range from simple low-cost devices that divert greywater to direct reuse, such as in toilets or outdoor landscaping, to more complex treatment processes incorporating sedimentation tanks, bioreactors, filters, pumps, and disinfection (NovaTec Consultants). Some greywater systems are home-built, do-it-yourself piping and storage systems, but there are also a variety of commercial systems available that filter water to remove hair, lint, and debris, and remove pollutants, bacteria, salts, pharmaceuticals, and even viruses.

Table 5: Residential Greywater Reuse Systems by Brand

Company	Treatment Technology	Cost (hardware only)	Description
WaterSavor Aqus (Australia)	Sink-to-toilet	$200 to $300	Simple process of filtering sink water once before sending the filtered water to the toilet tank
Brac System (Canada)	Chemical Disinfection	$2,000 to $4,000	Use of chlorine, bleach, or peroxide to treat water, the process allows for storage and removes any odours from the water
Pontos AquaCycle System (Germany)	Membrane Bioreactor (MBR)	$7,000 to $10,000	Complex process involving three stages of treatment, beginning with filtration, biological treatment, and finally UV sterilization
Nubian System (Australia)	Membrane Bioreactor (MBR)	$7,000 to $9,000	Complex process involving three stages of treatment, beginning with filtration, biological treatment, and finally UV sterilization

The four most popular residential greywater systems currently available in Canada are listed in Table 5. It should be noted that the prices of systems listed in this table do not include installation and on-going maintenance. These systems are described in more detail in the following sections.

Each system, with the exception of the WaterSavor Aqus, requires the restructuring of plumbing for retrofitting within the home. A new system of pipes (also referred to as purple pipes) must be installed to avoid contamination of potable water entering the home and to maintain the separation of greywater from black water. In existing residential properties this involves a substantial amount of labor to reset the existing plumbing infrastructure. For residential homes in new developments, the process requires an additional 2-3 days of labor to install the purple plumbing and greywater treatment system.

- **WaterSavor Aqus System (Australia)**

  This system uses the most basic greywater reuse application. It filters the greywater from a sink once, before it is sent directly to an adjacent toilet water tank. The maintenance involved in this system is simple and only requires changing the filter every few months.

  Tucked inside the vanity below the sink, the AQUS® reservoir works with standard lavatory pipes and holds up to 5 ½ gallons of water from the sink. Inside the toilet tank, the AQUS® fill control unit keeps potable water from filling the tank by holding the fill valve in the off position. This allows water (held in the reservoir under the sink) to fill the toilet tank. A water hose connects the reservoir to the fill control unit. The system uses gravity, water pressure and a small electrical pump to move water from the vanity to the toilet. A filter keeps hair and other solids from entering the toilet. Disinfection tablets control bacteria and other contaminants. Reused water in the toilet is not harmful to people or pets. AQUS® comes with all required parts, and typically takes about two hours to install.

  WaterSaver Technologies, LLC, is an Australian company. The company's website claims it seeks to develop earth friendly and environmentally friendly items for eco sensitive consumers.

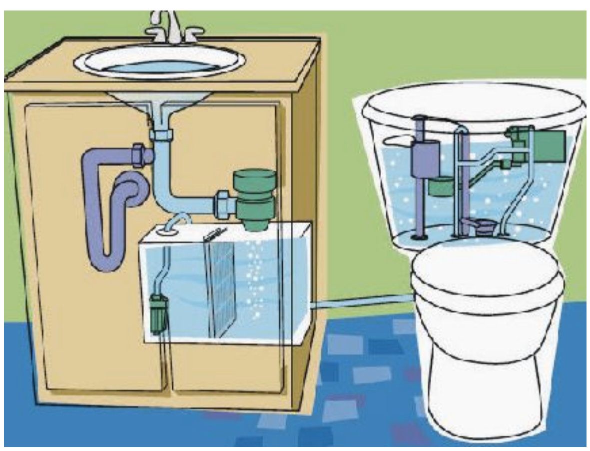

Figure 2: WaterSavor Aqus Greywater System (Australia)

- **Pontos AquaCycle System (Germany)**

  This system is expensive to purchase and install, and requires a relatively large amount of space to operate. However, it is one of the most efficient and detailed treatment systems currently available, and can even produce potable water. Steps in the filtration process are as follows:

  1. Pre-filtration – Any coarse particles in the incoming shower and bath water (e.g. hair and fluff) are filtered out. Residues flow into the drainage system. The filter is automatically backwashed.

2. Two-fold biological treatment – In the first stage of biological treatment microorganisms remove water contaminants by supplying atmospheric oxygen. The substrate in the containers (foam cubes) provides the microorganisms with the surfaces they need to settle on. The system pumps the water to a second tank during the second stage of biological treatment. Here the process is repeated. Sediments generated during the biological treatment process are automatically drained off into the drainage system at fixed regular intervals.

3. UV hygienization / sterilization – The water now flows through a UV lamp which performs sterilization. It is stored in the process water tank until it is reused. The quality of the purified water conforms to the hygienic requirements of the EU Bathing Water Directive 76/160/EC.

4. Pressure pump – The pressure booster system takes the treated water to the consumption points, for example to the toilet flushing system. It also supports the automatic filter backwash system.

5. Automatic drinking water top-up feed system – If there is not enough process water available, the automatic drinking water top-up feed system fills up the storage tank so that consumption points have a secure supply. Where there is a combination with rainwater, rainwater can be fed in initially instead of drinking water.

The Hansgrohe Group is a bathroom and sanitation company that employs more than 3,100 people globally. With ten production sites and subsidiaries in 37 countries, the Hansgrohe Group is among the few global players in the sanitation sector.

Figure 3. Pontos Aqua-Cycle System (Germany)

- **Nubian System (Australia)**

The Nubian System is an aboveground greywater treatment system capable of treating water for up to 12 people. Like the Pontos product, this system is efficient and detailed. Unlike the Pontos, the Nubian system is housed in lightweight, slim-line units that can be installed within or outside a building or residence, and installation can be completed in less than a day.

The Nubian treatment process is continuous and chemical free. The treated water is clear and there are no odors from the system, or the treated water (which can be stored indefinitely). Processing is automatic and no intervention by the owner of the system is required. The system treats greywater at the rate of one liter per minute and can process up to 1,200 liters per day. The Nubian system treats greywater in three steps:

- Solids separation removes lint and other coarse materials to prevent blockages and fouling of the system;
- Water flows down through a bed of proprietary media in the Processor unit. Contaminant removal is achieved through filtration, adsorption and biological treatment; and,
- Ultraviolet (UV) disinfection completes the treatment process before the treated water is stored for recycling.

Nubian Water Systems is an Australian company that manufactures wastewater and re-cycling products for the global market. Nubian also selects products for import and distribution in Australia.

Figure 4: Nubian System (Australia)

- **Brac Systems (Canada)**

Brac Systems Inc. has already sold more than 2,000 residential units within Canada.

Brac Systems offers a variety of greywater reuse system sizes – from 150 to 500 liters. For Example, the RGW-450 can treat and store up to 450 liters of greywater in a tank roughly the size of a hot water tank. The greywater enters the tank from above, and is filtered and treated with chlorine, bleach or peroxide. The treated water is then stored on the tank bellow the filter.

The chemical used (chlorine, bleach, peroxide) in the BRAC system depends on the regulations enforced in different regions. The maintenance required is minimal and simply involves changing the chlorine, bleach or peroxide tablet every other month.

Brac Systems Inc. is a Canadian company active in the development, production and sales of greywater recycling systems, rainwater harvesting solutions and related technologies. Brac Systems has developed a number of fully integrated systems for the recycling of water for residential and commercial markets. The Company is vertically integrated, covering all aspects from research and development to sales and installation, both directly and through its network of dealers. Founded in 2005, and headquartered in Quebec, the Company has generated sales in more than thirty countries worldwide.

Figure 5: Brac System RGW-150

5.3 Installation and Education

Even the best greywater reuse systems will not deliver to their maximum specifications if they are not installed or used properly.

The Plumbing Industry will need to develop courses and certification programs to ensure that plumbers and trades-people are properly qualified to install greywater treatment systems and purple pipes. Provincial regulatory and/or industry bodies will also need to provide certification courses and written materials that will help support both installers and owners understand and operate their greywater systems. Better knowledge by both the trades and users will result in more streamlined and optimal operation and maintenance of these systems.

NAIT has recently developed plans to build a new wastewater treatment facility called the Centre for Applied Technology (CAT). The Centre is the only one of its kind in Alberta, and will provide wastewater treatment operator training. CAT will play host to the latest in wastewater treatment technology and will teach students the steps required to install and maintain these systems. Wastewater will be collected and treated on site through a dedicated wastewater treatment system (purple pipes), and then will be treated and used for toilets and urinal flushing throughout the facility. This facility offers an excellent opportunity to showcase greywater reuse system installation and operation in practice.

5.4 Product Manufacturing and Development

Currently, no greywater systems are being manufactured in Alberta. The majority of greywater systems available for Albertans to purchase have been designed for warmer climates, and are primarily imported from other parts of Canada, Europe and Australia.

Currently, the best available technology has been designed for year-round indoor and outdoor use. This is not practical for Alberta, which faces 8 months (or more) of winter. Many of these systems will need to be modified in order to meet local cold climate requirements and environments. If a greywater reuse market is to become established in Alberta, it will require the formation of new private sector companies capable of integrating cold climate technologies into existing greywater reuse systems, and with access to production parts (purple pipe) that are also suited for cold climates. The main opportunity for Alberta businesses to succeed in the greywater reuse technology sector may reside in the development of cold climate technologies.

In the future, Alberta has the opportunity to become a global leader in greywater and wastewater reuse technology. Our wealth and diversity of natural resources, stable political structure, world-class advanced education and research institutes, positions Alberta to be a strong global supplier of these technologies. The province has a number of leading edge institutions that are actively working with entrepreneurs and corporations to develop innovative and efficient water related technologies. Among these institutions are Alberta Innovates Technology Futures, Calgary Technologies Inc., CETAC West, TEC Edmonton, and ABC Tech. The benefit of these efforts will come in the form of new jobs and businesses, more investment in the Province, and the draw of new knowledge and talent.

6.0 Implementation

6.1 Barriers to the Implementation of Greywater Systems

The following are considered to be the main barriers to effectively implementing greywater reuse systems in Alberta:

- Existing building codes and regulations currently prevent the more widespread adoption of greywater reuse.
- The cost of systems may be too high for some users to provide any economic benefit or payback.
- The cost of retrofitting existing buildings and homes may be too high – reducing potential market penetration.
- The cost of water remains relatively low in many communities and areas of Alberta, and as such, there can be little incentive to conserve.
- The benefits of greywater reuse are not widely known; little research or public awareness has been conducted on this opportunity.
- Greywater reuse systems are typically designed to operate year-round, and are not designed for cold climates, requiring system customization to accommodate Alberta climates.
- Some systems require a relatively large amount of space; households and commercial structures may not be able to accommodate the size and space requirements of these systems.
- There is currently no ‘made in Alberta’ solution for greywater reuse; cold climate technology development is in its infancy.

6.2 Overcoming the Barriers

The Water for Life Strategy has introduced the concept of water conservation to Albertans. Water quality and quantity has become the focus of public and environmental concerns. There has been an increase in water related media attention, and within the last few years there has also been a considerable amount of grassroots dialog in Alberta on the topic of water. The formation of watershed stewardship groups across the province has especially seen an increase in interest and growth in public participation. The members of these groups are often volunteers, and they include water experts, representatives from industry and government, and community stakeholders, all of whom are very concerned and very aware of the current status of water resources in Alberta. The question is: Will this growing interest in environmental stewardship and environmental practices translate into practice?

This paper has shown that greywater reuse holds the greatest untapped potential for water conservation in the province. So what steps can be taken to facilitate its implementation and build on the growing sense of environmental stewardship within the province?

Secure Buy-in from Community Leaders and Water Utilities: Most communities within the province have already instituted water conservation education programs and practices. Community leaders need to be incented to include greywater reuse in these programs and practices. Community and Utility websites in particular are an effective way to disseminate new information, as they have an established base of users that can be reached.

Develop Public Education Programs: Relatively little public information has been released regarding the benefits of greywater reuse. An education program should be developed by regulatory bodies and water utilities to increase public knowledge. Schools, industry organizations, environmental groups, and community watershed stewardship groups should also be both targeted and engaged to help spread the word.

Generate Excitement: It might be more appropriate to replace the current label, “reused” or “recycled” greywater, with a more appealing title such as ”refreshed” or “revitalized” water. This will improve perception and generate more excitement than using the more negatively perceived notion of something as being “reused” or “secondhand.”

Develop High Profile, Successful Pilot Projects: Nothing promotes a product better than showcasing its successful use (NAIT Centre for Applied Technology). A series of pilot projects should be undertaken and profiled to publicly demonstrate the economic and environmental benefits of greywater reuse in practice.

Encourage and Fund More Research: More research will increase knowledge about greywater reuse and greywater systems, and will allow the expansion of potential uses of greywater. As more uses and opportunities to conserve water and save money are discovered, adoption of the systems will in turn increase. Research will also provide data that can conclusively prove the benefits of greywater reuse.

Develop ‘Alberta-made’ Technologies and Systems: Developing technology and an industry within the province for greywater systems would reduce transportation costs, reduce customization costs, and would provide economic benefit to Alberta communities. These are all good incentives to buy and install locally developed and made systems.

Provide Rebates and other Monetary Incentives: Many residents may hesitate refurbishing the plumbing in their entire home, which could cost up to $10,000, just to save a few dollars on their monthly water bill. The introduction of rebate incentives could provide additional motivation. The government of Australia provides rebate incentives from $500 to $1,000 to residents that install greywater reuse technology in their homes. Considering entry-level systems cost approximately $1,500 installed, a rebate of $1,000 could be very attractive: the cost/benefit ratio of installing the system would be greatly improved. Similar incentives have proven successful in the introduction of energy efficient household appliances, and in the replacement of toilets with more water-efficient models in Alberta residential and commercial buildings.

Develop New Regulations: Regulations that support the more widespread reuse of greywater must be introduced. Current regulations are too restrictive to greywater reuse – particularly in urban dwellings.

7.0 Conclusions and Recommendations

Reusing greywater, either onsite or nearby, has the potential to:

- Reduce demand for fresh water.
- Lessen the impact from septic tank and treatment plant infrastructure.
- Extend the life and capacity of existing septic systems.
- Reduce energy use and chemical pollution from water transport and treatment.
- Lessen the requirement to expand water treatment and supply infrastructure.
- Provide topsoil nutrification.
- Facilitate groundwater recharge.
- Increase plant growth.
- Facilitate reclamation of nutrients to maintain soil fertility.
- Facilitate better quality of surface and ground water due to preservation by natural purification in the top layers of soil, versus when subjected to chemical water treatment processes.

8.0 Next Steps

While interest in the environment and water may be high – we still lack mechanisms to connect dollars with needs. As such, some of the most critical near term activities, in the next 12 months, should be focused on:

- Efforts to update provincial building codes and water regulations to support demonstration and pilot projects that expand greywater reuse in order to reduce potable water use in commercial and institutional buildings, and residential homes;

- Expanding discussions with municipalities and property developers on the benefits and use cases associated with greywater systems. Actively promote innovative greywater reuse projects, such as the NAIT Centre for Applied Technology;

- A detailed analysis of existing greywater systems and technologies, in particular with respect to their technical specifications and ability to efficiently operate in cold climates;

- Opportunities to expand and promote training and certification programs for trades;

These, and other key activities for catalyzing progress for Alberta's water industry, are opportunities that WaterSMART and many other organizations are committed to advancing.

APPENDIX 1

Forecast of the estimated addressable market for a variety of greywater re-use systems, from 2012-2020. See Section 4.7 - Target Market, Market Size, and Market Growth Potential for assumptions and details.

Treatment System	Estimated Cost per Greywater System (installed)	Year	Number of New Homes Built (% increase, annually)	Assumed % Penetration (adoption) of Systems	Total Addressable Market Value
			6%	5%	
Sand Filter	$1,500	2012	22,200	1,110	$1,665,000
	$1,500	2013	23,532	1,177	$1,764,900
	$1,500	2014	24,944	1,247	$1,870,794
	$1,500	2015	26,441	1,322	$1,983,042
	$1,500	2020	28,027	1,401	$2,102,024
Disinfection	$2,500	2012	22,200	1,110	$2,775,000
	$2,500	2013	23,532	1,177	$2,941,500
	$2,500	2014	24,944	1,247	$3,117,990
	$2,500	2015	26,441	1,322	$3,305,069
	$2,500	2020	28,027	1,401	$3,503,374
Membrane Bioreactor	$3,500	2012	22,200	1,110	$3,885,000
	$3,500	2013	23,532	1,177	$4,118,100
	$3,500	2014	24,944	1,247	$4,365,186
	$3,500	2015	26,441	1,322	$4,627,097
	$3,500	2020	28,027	1,401	$4,904,723
Activated Carbon Filter	$4,500	2012	22,200	1,110	$4,995,000
	$4,500	2013	23,532	1,177	$5,294,700
	$4,500	2014	24,944	1,247	$5,612,382
	$4,500	2015	26,441	1,322	$5,949,125
	$4,500	2020	28,027	1,401	$6,306,072
Aerobic Biological Treatment	$6,500	2012	22,200	1,110	$7,215,000
	$6,500	2013	23,532	1,177	$7,647,900
	$6,500	2014	24,944	1,247	$8,106,774
	$6,500	2015	26,441	1,322	$8,593,180
	$6,500	2020	28,027	1,401	$9,108,771