Water Reuse in Alberta

Overview of Water Reuse: Regulatory Framework and Case Studies

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1.0 Purpose

This document outlines the initial phase of a new plan to build multi-stakeholder support to modernize current Alberta legislation to permit the use of reclaimed water.

As the water supply in Alberta and across North America continues to tighten, recovering and reusing municipal wastewater (“reclaimed water”) for non-contact office, commercial, domestic and landscape purposes, will become an integral part of meeting water demands.

Although technology is available for safe wastewater reuse current Alberta provincial legislation:

- Prevents the reuse of reclaimed water for non-industrial applications inside buildings, specifically in toilets and urinals; and,
- Creates serious hurdles to the effective external reuse of reclaimed water, for example for watering lawns and gardens.

This legislation needs to be modernized to reflect the capability of current water treatment technology to safely treat wastewater for non-contact reuse applications.

2.0 Background: Water In Alberta

In 2004, the Alberta government published the *Water for Life* strategy, providing a framework to address water quantity and quality challenges in the province. Over the last several years, water has become an increasingly important issue to Albertans, and in fact the Alberta Government’s Task force on Sustainable Communities identified access to adequate supplies of clean water as the most significant economic development concern in 54 of the province’s rural communities.

In fact, water has become a critical economic and environmental issue for all Albertans, fueled by increasing demand and policy announcements such as the closure of the South Saskatchewan River Basin to the issuance of new water licenses, in August 2006. This moratorium on new water licenses, announced in the South Saskatchewan River Basin Report, has serious planning and development repercussions for municipalities, property developers and oilfield operators in southern Alberta. Recent water access and wastewater management issues in Balzac and Strathmore are just two examples of the future water challenges being faced by municipalities, industry and consumers.

Now that new water licenses are no longer available, additional demand must be met by reducing existing demand, reusing water, or buying unused water license allocations from others.

Some municipalities and developers are reducing water demand through water conservation measures such as water efficient appliances and low flow showerheads. However, significant opportunities still exist to meet this increasing demand for water by using reclaimed water to replace potable water supplies for many non-potable uses. This could reduce fresh water consumption per person by up to 30% to 40% with little or no change to lifestyle. Reclaimed water may also replace diversions from aquifers, rivers, or lakes.

Globally, successful projects exist for practically any type of reclaimed water use imaginable. Reclaimed water is used for non-potable (not for drinking) purposes, such as landscapes, public parks, and golf course irrigation. Other non-potable applications include agriculture, industrial cooling water, toilet flushing, dust control, commercial and construction activities, and creating wetlands and ponds.

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 many of the proven water recycling and reuse technologies and practices commonly in use throughout the world today.

3.0 Recycled Water 101 - Basics

Water produced by municipal structures can be divided into two categories:

- **Raw Water:** This is untreated water from a source such a river, lake, well, etc.

- **Potable Water (Drinking):** Water treated to a standard which is safe to drink.

Wastewater can be divided into two categories:

- **Black Water -** Any water contaminated by fecal matter and generally is the water from toilets and urinals. Any water which comes in contact with black water becomes black water.

- **Grey Water –** See definition below.

Recycled water can be divided into two categories:

- **Reclaimed Water** - is black water typically treated to a high level by a multiple barrier system, and just below the level of quality of potable water. It is typically done at a off site facility and pipes back to the dwelling in a piping system under pressure much as is potable water.

  Reclaimed water is highly engineered for safety and reliability so that the quality of reclaimed water is more predictable than many existing surface and groundwater sources. Reclaimed water is considered safe when appropriately used.

  Although reclaimed water is of very high quality, it is not typically used directly for drinking water. Reclaimed water planned for use in recharging aquifers or augmenting surface water usually receives adequate and reliable treatment before mixing with naturally occurring water and undergoing natural restoration processes. Some of this water eventually becomes part of our drinking water supplies.

- **Grey Water** - is water which is typically treated on site from sinks and laundry, etc, and contains minimal fecal matter. Grey water is wastewater from:

  - bathtubs
  - showers
  - bathroom sinks
  - washing machines
  - dishwashers and kitchen sinks
  - any source in your home, other than toilets.

  Grey water often makes up the largest portion of wastewater from a home, up to 40 gallons per person each day. Grey water can be used in place of fresh water to irrigate (below ground) the roots of trees, shrubs, and flowers. It's important to understand that grey water can contain harmful bacteria, viruses, and chemicals that pose a risk to public health and the environment if mishandled.

Contact vs. Non Contact Applications

Water uses can be divided into two categories:

- **Contact Applications -** Where people come in direct contact with the water such as in sinks, and showers.

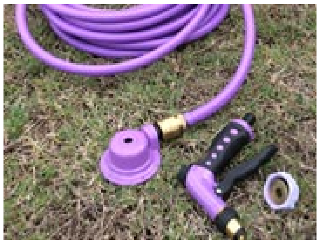
- **Non-Contact Applications** - Where there is no direct contact such as such as flushing toilets and urinals, and irrigation uses.

Currently in Alberta potable water is used for all contact and non-contact applications including lawn watering and toilet flushing. However, since there is no real requirement or need to use potable water for non-contact applications, there is a significant opportunity to use recycled water in these applications.

Some typical examples of “unrestricted” urban and recreational use includes:

- **Urban Use -** landscape irrigation of parks, playgrounds, schoolyards; fire protection; ornamental fountains and impoundments; vehicle washing; in-building uses including air conditioning and toilet flushing.

- **Recreational Use -** no limitations on body contact, including feed water for lakes and ponds used for swimming; snowmaking.



Some typical examples of “restricted” urban and recreational use includes:

- **Landscape irrigation -** golf courses, cemeteries, greenbelts and highway medians.

- **Restricted recreational use -** augmentation of ponds or lakes for fishing, boating, and other non-contact recreational activities; wetland restoration or enhancement (Exall, 2004).”

4.0 Water Recycling in Alberta and its Governance

Using modern technology, water reuse is safe and is allowed within other jurisdictions in Canada, the United States and around the world.

However, in Alberta, under current provincial regulations the use of reclaimed and/or grey water is not allowed within domestic structures, and the setbacks for external reuse are so large as to make it unpractical in most areas.

In order to update the applicable codes, some major technical and legislative changes need to be identified, and supported by a broad base of stakeholders, including corporations, industry associations, municipalities and cities, and NGO's with domain knowledge.

There is a sense of urgency in getting these actions underway, as a major component of the province's recycled water restrictions is under the jurisdiction of the Alberta Building Code, which is up for review and revision in 2010, and then afterwards, may not come up again for review until 2015.

Within Alberta recycled water cannot be used within buildings. Outside of buildings, recycled water can only be used for irrigation purposes. But irrigation use is effectively prohibited in residential areas through restrictions which require a minimum of 60 meters clearance between inhabited buildings and the reclaimed water. This restriction effectively limits the use of recycled water within residential areas.

Within Buildings
Water reuse within dwellings is governed by the *Alberta Building and Plumbing Code*, which states that "Every water distribution system must be connected to a public water main of a potable private water supply system." National Plumbing Code of Canada 2005 2.1.2.3 Water Distribution System

Outside Buildings
Water use outside of buildings is governed by the *Environmental Protection and Enhancement Act,* which prohibits the use of reclaimed water within 60 meter of an occupied building.

Further details on both these governance issues is provided in the Section "Existing Alberta Water Re-reuse Policy".

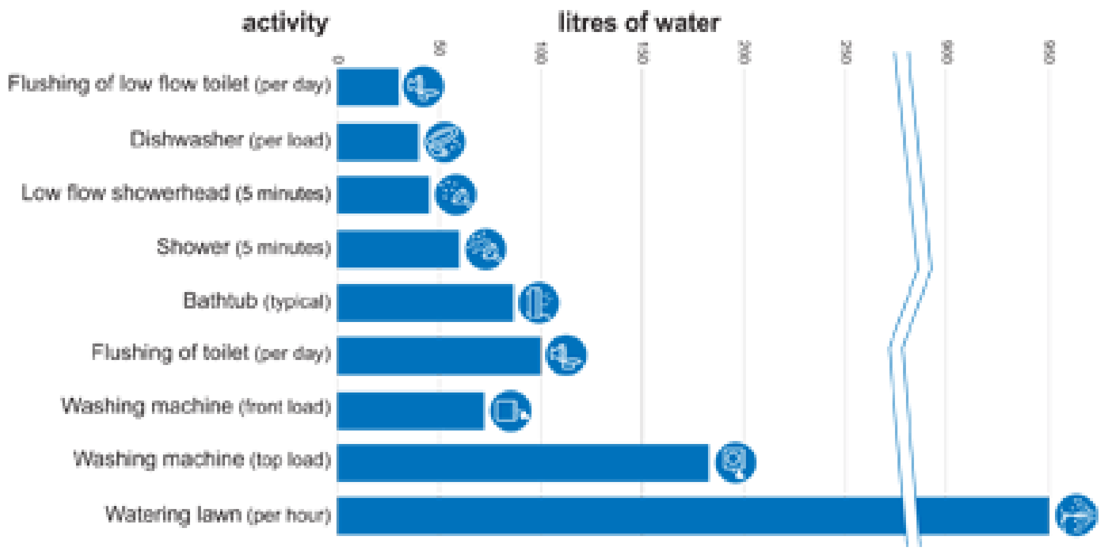
5.0 Charting a New Route

While municipalities currently account for about only 11% of provincial water allocations, Alberta's rapidly increasing economy and population will generate new and significant additional demand for water.

Globally, many communities are now stretching their existing water allocations through the use of grey and reclaimed water for a large variety of non-contact applications such as flushing toilets, watering lawns and fighting fires.

The increased use of reclaimed and grey water has the potential to reduce fresh water demand from households by as much as 30% to 40%, without effecting current consumption patterns, volumes or life styles. Put another way, an existing water license might be able to serve hundreds or even thousands of additional more homes, by more effectively managing a limited resource. Therefore, changes to the building codes to allow reuse are of growing interest to existing communities that are currently at the limit of their existing licenses, and especially to the developers of new communities.

Figure 1 – Domestic Household Water Demand



Although there are significant gains to be made from the use of reclaimed water into the household, it has the potential to introduce pathogens and chemicals and can also be a risk to health or environment. Thus, the introduction of these new practices and technologies must be approached carefully, and leverage the lessons and practices from nations such as Australia and the United States, which have been using reclaimed water for lawn watering, flushing toilets and fighting fires.

6.0 Existing Water Reuse Policy

6.1 National Level

According to Exall *et al*. (2004), no national guidelines exist for water reuse in Canada. However, three regulations at the national level were recognized in a CMHC study (1998) that would affect water reuse implementation[1]:

- The Guidelines for Canadian Drinking Water Quality (1996)
- The Guideline for Canadian Recreational Water Quality (1992)
- The National Plumbing Code of Canada (2005).

The study report notes that water quality guidelines (both for drinking and recreational water) may impede the implementation of on-site water re-use technology by imposing unrealistic or inappropriate quality standards (CMHC, 1998).

Since the 2004 Study, the 2005 Plumbing Code has been released and has not changed the guidelines for water use, but two additional document have been released for consultation and comment:

- Canadian Guidelines for Household Reclaimed Water for Use in Toilet and Urinal Flushing
- CSA B128.1-06 Design and Installation of Non-potable Water Systems Maintenance and Field Testing of Non-potable Water Systems

[1] Note that listed guidelines may have been amended since time of CMHC report release (1998) (i.e. National Plumbing Code (2005).

The Canadian Guidelines for Household Reclaimed Water for use in toilets and urinal flushing was released in July 2007 for consultation. The proposed guidelines suggest water quality guidelines for reuse and discuss the risks associated with on-site (grey water) and cluster systems (reclamation of black water). The water quality standards proposed appear to be in line with international standards.

The recently released Canadian Standards Association CSA B128.1-06 (July 2007) addresses the design and testing of non-potable water systems. Although not currently referenced by building or plumbing codes today, it is likely that this code will be a reference for development of any future codes.

6.2 Provincial Level: British Columbia

The *BC Municipal Sewage Regulation (Amended 2004)* provides for some strict rules for all uses of highly-treated wastewater. The list of applications includes outdoor uses such as agricultural and park irrigation and fire-fighting, and inside uses such as flushing toilets and urinals, primarily in commercial or office buildings. The BC regulation separates reclaimed wastewater into two categories: restricted and unrestricted access.

6.3 Provincial Level: Alberta

In Alberta, water reuse within structures, is governed by Municipal Affairs and Housing, through the 2007 Alberta Building Code. Water reuse outside of any structures, is governed by Alberta Environment.

Water reuse is also governed by the Ministry of Health. Both Municipal Affairs and Alberta Environment differ authority to Alberta Health in issues relating to matters of health. In fact, it maybe Alberta Health which could be the primary concern in efforts to change regulations for indoor and outdoor reuse applications.

6.3.1 Water Use: Within Structures (Alberta Building Codes)

Regulatory Structure

Water use within structures in Alberta is under the jurisdiction of Municipal Affairs, within the Safety Codes Act.

Municipal Affairs uses the combination of the Building and Plumbing Codes to regulate plumbing requirements, each adopted from the national Building Codes. As of September 2007, Alberta has adopted the new objectives-based building, fire and plumbing codes. The objectives-based codes are not expected to be updated before 2010, and then not again until 2015.

Building Code - As recommended by the Minister of Municipal Affairs and Housing, under the authority of the Safety Codes Act (Section 65) Alberta has adopted the 2006 Alberta Building Code. The new objectives based code became effective Sept 2, 2007.

Plumbing Code - As recommended by the Minister of Municipal Affairs and Housing, under the authority of the Safety Codes Act (Section 65) Alberta has adopted the new objective based National Plumbing Code of Canada 2005.

Mechanism of Regulation
The following outlines the basic mechanism of the governance of the plumbing within structures.

Alberta Building Code, 2007: Section	Implications
1.1.1.1 - Application of this Code States that the Alberta Building Code (ABC) applies to the building and construction of a variety of building conditions.	General
1.2 - Compliance with this Code 1.2.1.1 – States that compliance shall be achieved by: a) Complying with the applicable solution in Division B or b) Using alternatives solutions that will achieve a least a minimum level of performance required by division B in the areas defined by the objectives and functional statements attributes to the applicable accepted solutions (see Appendix A)	Allows for alternatives.
7 – Plumbing Services and Health 7.1.2 - Required Facilities • Compliance Allows for Alternate solutions (ABC Appendix A) • Alternate needs to comply with 1.1.2 of Dev B • 7.1.2.1 & 7.1.2.2 – States that Building and Dwelling Units shall be equipped with Plumbing facilities as required in 7.2	Allows for alternate solutions.
7.2 Plumbing Facilities 7.2.1.1 - States that every plumbing system and private sewage disposal system shall be designed and installed in conformance with the plumbing regulations made pursuant to the Safety Codes Act.	Safety Code refers to Plumbing code.
7.2.1.2 – Plumbing Systems and Fixtures 8.0 - States Non-Potable water shall not be connected to plumbing fixtures that provide water for human consumption, cooking, cleaning, showering or bathing.	The code does not state that non-potable water cannot be connected to toilets, urinals or for irrigation uses.

National Plumbing Code: Section	Implications
2.1.2.- Service Connections 2.1.2.1 Sanitary Drainage System 1) Every Sanitary drainage system shall be connected to a public sanitary sever, a public combined sewer or a private sewage disposal system.	By this statement grey water systems are prohibited as they would not be connected to any of the systems listed .
2.1.2.- Service Connections 2.1.2.3 Water Distribution System 1) Every water distribution system shall be connected to a public water main or a potable private water supply system.	By this statement reclaimed and grey water system are prohibited as they will not be connected to the public water system.

6.3.2 Water Use: Outside Structures (Alberta Environment):

Regulatory Structure:

Water use outside structures in Alberta is regulated by Alberta Environment under the Environmental Protection and Enhancement Act.

Mechanism of Regulation:

The following outlines the basic mechanism of the governance of the plumbing outside structures.

Alberta Environmental Protection and Enhancement Act R.S.A. 2000

Section	Implications
PART B4.1: OPERATIONAL REQUIREMENTS (b) a setback distance of at least 60 metres shall be provided between all irrigated land and all occupied dwellings; and (c) a setback distance of at least 30 metres shall be provided between all irrigated land and all watercourses, public roads, railway lines, or water wells.	b) by requiring a 60 metre setback all house yards are eliminated. c) by requiring a 30 metre setback all boulevards and fronts yards and many other areas is restricted.

Alberta Environmental Protection and Enhancement Act R.S.A. 2000

Section	**Implications**
PART B4.1.6 Treated wastewater irrigation shall not occur during the following periods, unless otherwise authorized in writing by the Director: (a) outside the growing season; (b) during and for 30 days prior to the harvesting of crops on the land irrigated or to be irrigated; (c) during and for 30 days prior to grazing by dairy cattle on the land irrigated or to be irrigated; and (d) during and for 7 days prior to pasturing by livestock other than dairy cattle on the land irrigated or to be irrigated.	These limitations apply to irrigation in agricultural settings. Additional clauses will be required for water of a higher quality suitable for use in communities where there is a chance of contact with people.
PART B5.1: LIMITS AND MONITORING REQUIREMENTS • Carbonaceous Biochemical Oxygen Demand <100 mg/L • Chemical Oxygen Demand <150 mg/L • Total Suspended Solids <100 mg/L • Electrical Conductivity <2.5 dS/m • Sodium Adsorption Ratio <9 • pH 6.5 to 8.5	The limits provided are quite lax, thus the strict requirements. If stricter requirements could be provided, many of theses could be significantly reduced.

7.0 Risks

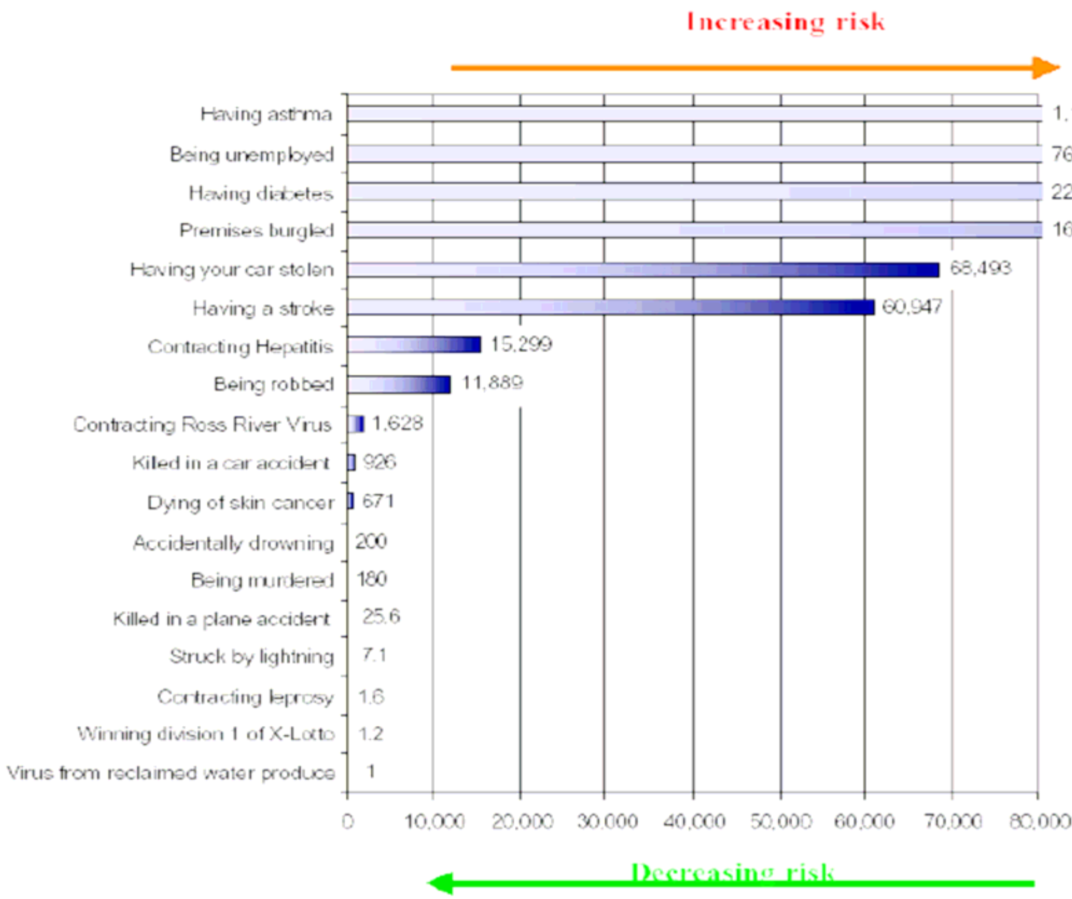
The following section examines some of the risks associated with the use of recycled water.

Although the risk of contracting a viral disease from contact with recycled wastewater is extremely minimal, the Australian Academy of Technological Sciences and Engineering (ATSE) found that:

"*The Australian community is far more sensitive to perceptions of even very small potential health risks which may flow from hazards implicit in using recycled water…than they are to other, much higher probability, risks over which they perceive they have more personal control."*

It can be assumed that the same perceptions would apply to the Canadian population. Although the risk of contacting a viral disease from contact with recycled wastewater can be shown to be small, there is a real need for education within the building industry, contractors and the general public.

The graphical analysis below compares the risk of contracting a viral disease from eating vegetables irrigated with reclaimed water meeting WHO standards (10-6 to 10-7) with other risks (source: Shuval et al 1997, pages 15-20). As mentioned above, the risks to human health and the environment depend on level of treatment and end use.



Comparisons of the number of people likely to experience various events over a year from each ten million Australians.

Research in Western Australia found that the public would be more accepting of assurances of safety where the issuer had been established for a number of years, had a good safety record and was not monetarily nor politically driven. Linked to this is the importance of trust in the technology which has been seen as an important element negatively impacting acceptance. Po *et al* (2004, p. 2) note that *"the public trusted the experts and government to make the right decision…"*.[2]

Health Canada is a widely trusted and accepted agency, and could fill this role in Canada. Health Canada's recently released Canadian Guidelines for Household Reclaimed Water (July, 2007) provides this type of assurance in the area of health risk. Concurrently, CSA International has developed standards for the design and installation requirements for such non-potable water systems: CSA Standard B128.1-06/B128.2-06.

8.0 Regulatory Changes: An Overview

Having established what the existing legislation, codes, guidelines and regulations are, the following section describes what changes would be required to regulate and further encourage recycled water use within Alberta, as a standard practice.

Utilities, which include potable water, sewage or telecom etc, are supported by legislation, codes, guidelines and standards. The introduction of recycled systems will require the same. Recycled water systems are much like potable water systems in that they are pressurized water systems, but due to the possibility of contamination, the introduction of recycled water into communities will require a broader approach and new legislation, codes, guidelines and standards.

California has progressively developed a set of Public Health laws related to recycled water that are summarised from the Health and Safety Code, the Water Code, and Titles 22 and 17 of the California Code of Regulations (State of California 2001) in a publication known as the Purple Book (DHS 2001). These have been widely adopted elsewhere as de facto standards, or have formed the basis of standards developed by other states and countries.

Among other aspects, the Purple Book provides that:

- Three public hearings are to be held for any recycling proposal.
- Wastewater treatment facilities shall provide for emergency storage capacity for 24 hours flow of untreated or partially treated wastewater, and a back-up power supply.
- There is to be no provision to by-pass the plant to the point of use.
- Multiple primary and secondary treatment units shall be fitted such that the plant can operate with one unit not in operation.
- Standards of water quality are set for various approved uses.
- Standards for disinfected secondary-treated water provide that the median concentration of total coliform bacteria does not exceed a most probable number (MPN) of 2.2 per 100ml over a seven-day analytical period, and that not more than one sample exceeds an MPN of 23 per 100ml in 30 days (aslightly lower standard is set for some non-contact uses).
- Standards for disinfected tertiary-treated water include chlorine residual standards, or with filtration processes, virus testing standards and that the median concentration of total coliform bacteria does not exceed an MPN of 2.2 per 100ml over a seven day analytical period, that not more than one sample exceeds an MPN of 23 per 100ml in 30 days and that no sample exceeds an MPN of 240 per 100ml.
- Turbidity standards must achieve an average of not more than 2 nephelometric turbidity units (NTU) for filter bed installations, (not more than 5% >2NTU for microfiltration/reverse osmosis systems) over a 24-hour period, and never exceeding 10 NTU (5NTU for microfiltration/reverse osmosis systems).
- Recycled water shall be in purple pipes or pipes wrapped with purple tape.
- Standards are set for dual potable/recycled reticulation systems.
- Backflow prevention devices shall be installed to protect the public water supply, the type to be a function of the assessed hazard.
- Systems shall be tested for any cross-connections every four years. Twenty cross connection incidents have been reported to California State Health since 1991(Safewaterreuse 2003).
- State, City or County agencies can require the use of recycled water for various purposes where it is available, does not cause any loss of water right and the connections comply with approved standards, (including use for domestic toilet and urinal flushing except in mental hospitals).

- There shall be no recycled water spray irrigation other than disinfected tertiary recycled water within 100 feet (30 m) of a residence or a place where public exposure could be similar to that of a park, playground or school yard.
- All areas where recycled water is used that are accessible to the public shall be signed "RECYCLED WATER – DO NOT DRINK".
- The price of recycled water shall be equal to or less than the retail price of potable water.

While California pioneered large scale recycling many other countries and jurisdictions have followed, and recycle wastewater today. The Table below (Exall et al., 2004) shows a comparison of general water reuse guidelines.

TABLE 1. Comparison of general characteristics of water reuse guidelines and regulations

Agency, state or province	*Number of reclaimed water quality classes*	*Coliform limit for unrestricted irrigation (per 100 mL)*	*Reference*
WHO guidelines	2	<200 FC	World Health Organisation (1989)
U.S. EPA guidelines	~3 (specific to application)	No detectable FC[a] (median), ≤ 14 FC (single sample)	U.S. EPA (1992)
California regulations	4	≤ 2.2 TC[b] (MPN[c]), ≤ 23 TC (single sample)	State of California (2001)
Florida regulations	Application specific	≤ 25 FC (in 70% of samples per month)	Crook (1998)
Arizona regulations	5	≤ 2.2 FC (median), ≤ 25 FC (single sample)	State of Arizona (2001)
Washington guidelines	4	≤ 2.2 TC (mean), ≤ 23 TC (single sample)	State of Washington (1997)
Texas regulations	2	≤ 20 FC (geometric mean), ≤ 75 FC (single sample)	State of Texas (1997)
South Australia guidelines	4	≤ 10 thermotolerant coliform organisms (median)	South Australia EPA (1999)
Alberta guidelines	2	≤ 200 FC (geometric mean), ≤ 1000 TC (geometric mean); golf courses and parks only	Alberta Environment (2000)
British Columbia guidelines	2	≤ 2.2 FC (median), ≤ 14 FC (single sample)	B.C. MELP (1999)

[a]FC; Fecal coliforms.
[b]TC; Total coliforms.
[c]MPN; Most probable number.

Please note that column three states "unrestricted irrigation", but Alberta's guidelines are for restricted use.

9.0 Regulatory Changes: In Alberta

Although there are many regulatory and policy components to the introduction of new water recycling standards and practices in communities in Alberta, two are critical and interlinked: water quality and set backs limits.

Currently in Alberta, Alberta Environment regulations reflect only one single category of recycled water, which is for the restricted use of recycled water for irrigation of remote areas and crops will little human contact, and for the restricted use of recycled water for parks and golf courses.

Application Water Quality Standards

The Table below compares Alberta's current standards with the standards proposed by Health Canada in their recently released Draft Canadian Guidelines for Household Reclaimed Water (July 2007), and the standards adopted for the Rouse Hill project, in Sydney Australia. From this table it is clear that an additional set of recycled water criteria will be required here in Alberta.

TREATED EFFLUENT QUALITY STANDARDS FOR WASTEWATER IRRIGATION

Parameter	**Unit**	**Current Alberta Standard**	**CND Guidelines**[3]		**Australia**	
			Median	Max	Guide	Typical
Total Coliform*	CFU/ 100mL	<1,000	--		<10	<1 in 100 ml
Fecal Coliform* (E-Coli)	CFU /100mL	<200	Not detected	≤200	<1	<1 in 1000 ml
CBOD	mg/L	<100 mg/L	≤10	≤20		
TSS	mg/L	<100 mg/L	≤10	≤20		
EC		<2.5 ds/m				
Turbidity (Alternate to TSS)	NTU		≤2	≤5	≤2	≤5
SAR		<9				
pH		6.5 to 9.5				
Total Chlorine Residual	mg/L	--	0.5		0.5	

* For golf courses and parks only.

[3] Canadian Guidelines for Household Reclaimed Water for Use in Toilet and Urinal Flushing

9.1 Management Model

In addition to amendments to existing water quality standards, there is also a need to create a number of new legislative Acts, regulations, codes and guidelines. The following section builds on an approach proposed by the US EPA's Decentralized Water Management program, and proposes an overarching management model grouped around three areas: **Administration, Installation, Operation and Compliance**.

The current status of each of these three components has been reviewed within the Alberta context, identifying its governing legislation, proposed changes, and a mechanism by which the change can be achieved.

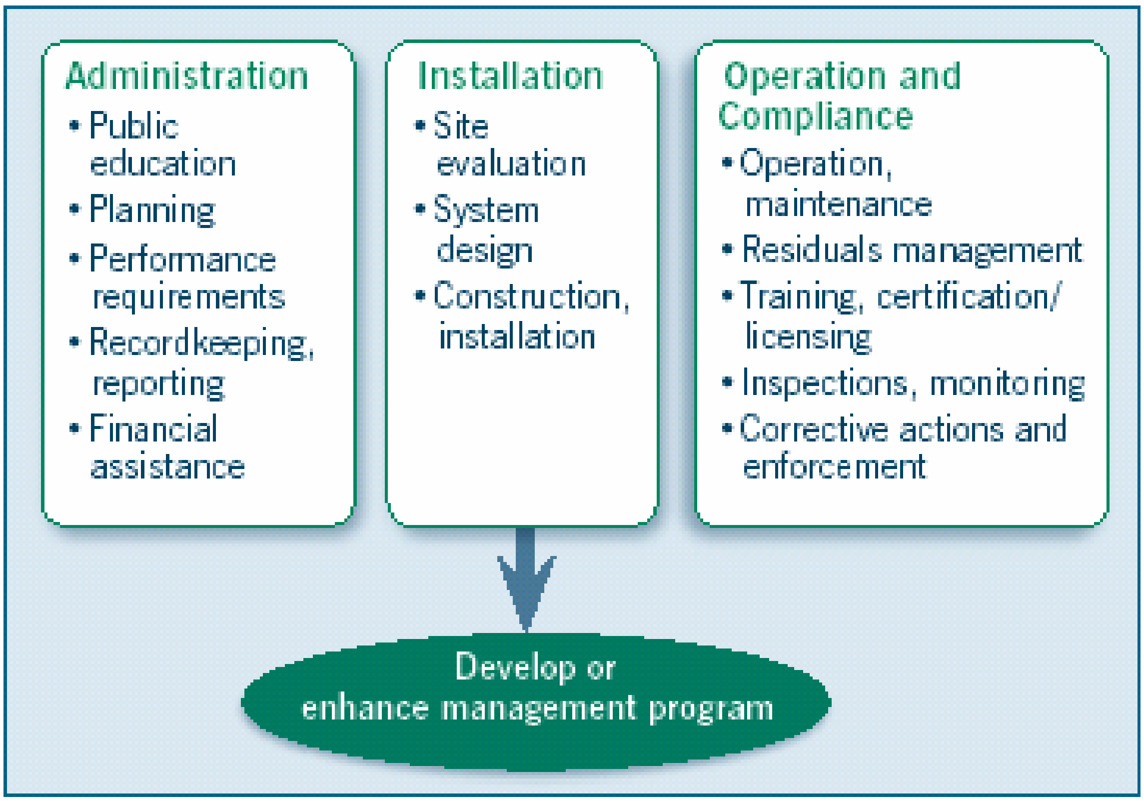


Figure 1: Decentralized reclaimed water management program elements (reproduced from U.S. EPA, 2005)

9.1.1 Administration

Public Education:
Required but not covered in this document.

Planning:
Required but not covered in this document.

Performance Requirements:
Performance requirements need to be established for:

Component	**Jurisdiction**	**Current Legislation**	**Proposed New and Amended Legislation**	**Mechanism of Change**
Recycled Water Quality (for use in Communities)	Alberta Environment (AENV)	AENV- Standards And Guidelines For Municipal Waterworks, Wastewater And Storm Drainage Systems (2006) (SGMWW)	Currently - Recognizes one quality of recycled water. Propose – 1. Establish two categories of recycled water, restricted and unrestricted urban access. 2. Initially existing water quality legislation for irrigation could be adopted for restricted access, and reviewed going forward. 3. Base water quality for unrestricted access upon standards proposed in Health Canada's - Canadian Guidelines for Household Reclaimed Water (Draft 2007-06).	AENV is open to changing policy. The technology department is responsible to make recommendations to the policy department based on new technology or practice. 1. Set up a meeting with both the technology and policy department to develop a joint plan to establish new standards.
Irrigation Setbacks	AENV	Alberta Environmental Protection and Enhancement Act (AEPA) (RSA 2000)	Current- Minimum setback based up low water quality. Proposed – 1. Removal of all set backs for water meeting unrestricted urban use quality restrictions. 2. Examine setbacks for restricted.	1. Meeting with AENV.

Administration (con't):

Performance requirements need to be established for:

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Design –Recycled Water Distribution Systems	AENV & Local Municipality	None	Current – AENV SGMWW set standards for potable and wastewater distribution systems. Proposed – Add reclaimed water system to the existing SGMWW. Equipment is similar to water distribution systems, and can for the most part be copied, but additional provisions will have to be made for purple pipe, separation and marking of recycled water.	1. Meeting with AENV.
Design -Building Recycled Water Systems	Municipal Affairs and Housing (AMAH)	Safety Codes Act → Building and Plumbing Codes	Current – the building and plumbing codes prohibit the use of recycled water within structures. Proposed - Modify codes to encourage the use of recycled water through: 1. The introduction of reclaimed water definition. 2. The removal of current restrictions. 3. Adopt CSA Standard B128.1-06/B128.2-06 -- CSA B128.1-06 Design and Installation of Non-potable water systems Maintenance and field testing of non-potable water systems, which covers many of the elements which need to be adopted 4. Have the CSA write new standards and references for recycled water systems materials.	The building codes and their interrelation to the CSA regulations is complex, and needs to be done by experts familiar with the standards and their cross references. Meet with the contributors to the code to enquire as to what can be done to encourage the effort and build public support to ensure adequate resources are available.

Administration (con't):

Performance requirements need to be established for:

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Materials – Distribution System	AENV	None	Current - No recycled water material standards. Proposed - 1. CSA to develop national material standards which and be adopted by the National Building and Plumbing Codes, which can then be adopted in whole, part or used as a template by the provinces. 2. CSA to develop national installation details which can be adopted individually by provinces.	1. Build public support base to raise the priority for development of new standards.
Materials – Within Buildings	AMAH		Current – No standards Proposed – 1. CSA to develop standards in advance for materials which can be referenced by the National Building and Plumbing Codes. 2. CSA to develop national installation details which can be adopted individually by provinces.	1. Build public support base to raise the priority for development of new standards. 2. Requires more research

Administration: (con't):

Record Keeping and Reporting:
Alberta Environment sets drinking water standards, approves waterworks systems, promotes best practices, trains and certifies operators, monitors performance, inspects facilities, and enforces both facility approvals and legislated requirements. The same standards and regulations must also be established for the management of recycled water. But in addition to testing at the treatment facility, other jurisdictions have also established testing within dwellings for cross connections.

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Water Quality	AENV	SGMWW	Current – No current regulations Proposed – 1. Within the SGMWW's developed regulations for recycled water quality monitoring within water treatment facilities and distribution systems.	Meeting with AENV to understand how to demonstrate the importance of the issue and assist making the resolution a priority.

9.1.2 Installation

Site Assessment
The use of recycled water can lead to the building of dissolved solids in the soil and not every area is suitable for the recycled water and the volume of water which can be applied by area varies

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Local Soil Suitability	AENV	SGMWW	Current – Regulations exist for soil suitability for restricted access. Proposed – 1. Develop soil suitability standards for unrestricted quality 2. Develops mechanism for developers to pre-determine entire development soil suitability.	Meeting with AENV.

Installation (con't)

System Design

Piping distribution and wastewater system designs (both community wide and within dwellings) need approvals prior to installation to ensure compliance with codes and regulations. The design of recycled water systems will have to be added to this approval process.

Component	**Jurisdiction**	**Current Legislation**	**Proposed New and Amended Legislation**	**Mechanism of Change**
Community Distribution System	Municipality	SGMWW	Current – None Proposed – 1. Modify SGMWW to expand municipalities responsibility to include recycled water systems into permit review process.	TBD
Household Plumbing systems	Municipality	Provincial Building and Plumbing Codes	Current – None Proposed – 1. Expand municipalities responsibility to include recycled water systems into permit review process.	TBD
Black Water Reclamation Technologies	AENV	SGMWW	Current – None Proposed – 1. Just as potable water treatment technologies must be validated, so must recycled water technologies. Requirements to do such must be included in the SGMWW	Meeting with AENV. Policy and technology departments.

Installation (con't)
System Design

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Grey Water Treatment Technologies	AMAH		Current – None Proposed – 1. As grey water technology is within buildings it falls outside the range of responsibility of AENV, but as it is a treatment technology much as a on site treatment technology it would be appropriate to maintain its regulation within AENV. 2. Discussions with CMHC have lead to the understanding that there is concern within regulators as to the publics ability to maintain individual systems. Further discussion is needed in this area. 3. The Arizona grey water code is refrenced by some as the guide to follow: R18-9-714. Type 1 - RECLAIMED WATER GENERAL PERMIT: GREY WATER	TBD

Construction/Installation

Upon Approval of designs and local ordinances municipalities issue construction permits.

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
During Construction	Municipality	?????	Current – TBD Proposed – TBD	TBD

9.1.3 Operation and Compliance

Operation and Maintenance

Component	**Jurisdiction**	**Current Legislation**	**Proposed New and Amended Legislation**	**Mechanism of Change**
Community Recycled Water System.	AENV	SGMWW	Current – No Current regulations Proposed 1. AENV needs to set introduce additional regulations for O&M as it has for potable water and wastewater.	Meeting with AENV.

Training, Certification and Licensing
As with the introduction of any new equipment or process training, certification and licensing will be required for those installing, permitting, installing and inspecting the recycled water systems.

Permitting

Component	**Jurisdiction**	**Current Legislation**	**Proposed New and Amended Legislation**	**Mechanism of Change**
Training	TBD	TBD	Current – No Current regulations Proposed – 1. Training must be provided for those who will be permitting recycles water systems, both at AENV and within the local municipalities.	TBD
Certification	TBD	TBD		TBD
Licensing	TBD	TBD		TBD

Operation and Compliance (con't)

Installers

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Permit Review	AENV	?????	Current – Proposed –	TBD
Certification				
Licensing				

Inspectors

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Permit	AENV	?????	Current – Proposed –	TBD
Certification				
Licensing				

Operation and Compliance (con't)

Inspection and Monitoring

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Post Construction (commissioning)	AENV	TBD	Current – Proposed –	Meeting with AENV to demonstrate the importance of the issue and assist making the resolution a priority.
Yearly	TBD	TBD	Current – Proposed –	
Upon Sale	TBD	TBD	Current – Proposed –	

Corrective Action and Enforcement

Component	Jurisdiction	Current Legislation	Proposed New and Amended Legislation	Mechanism of Change
Communal Reclaimed Water Treatment Plant and Distribution System	AENV	?????	Current – No Current regulations Proposed –	
Private Grey Water Recycling System	AENV	?????	Current – No Current regulations Proposed –	
Private Yards	Municipal			

10.0 Case Studies

A number of countries allow and encourage recycled water system and have regulations and guidelines for its reuse.

In Canada, British Columbia has had regulations since 2001, and has more facilities than any other jurisdiction in Canada. In the United States, California recycles massive quantities of water, as do a number of other states and the number are growing.

An excellent case study from Washington State is available from:

> Case Studies In Reclaimed Water Use: Creating new water supplies across Washington State
> Written by Katharine Cupps and Emily Morris (June 2005, Publication Number: 05-10-013)

Internationally Australia, due to necessity is quickly becoming the world leader in reuse applications and is now developing standards to enable the recycling of wastewater into the potable water system. Even Beijing, China will be implementing large scale water recycling. The Appendix provides further details on recycled water systems from around the world.

11.0 Wastewater Treatment Technologies

Recycled water can be produced on site, typically by grey water systems or community/ cluster wide by reclaimed water systems, which process back water. Reclaimed water systems are much larger than grey water systems and can employ common water treatment technologies, operated by trained professional. As such even though reclaimed water systems are processing black water with pathogen and contaminant levels multiple times higher than grey water systems are able to produce consistently high quality effluent. The bulk of this section is dedicated to reclaimed water technologies.

The other method of producing reclaimed water is through the on site recycling of grey water. These systems, even though they are treating a relatively high quality raw water, have a variety of other challenges due to the simpler treatment technologies, and often unskilled owner operators for whom operation of the system is only given a passingn thought.

In either case the treatment method used to produce recycled water should be suitable to reliably produce water of a standard that is fit for the purpose for which it is being provided, at a reasonable cost. Decisions about the best approach need to balance the environmental, social, safety and economic advantages and disadvantages.

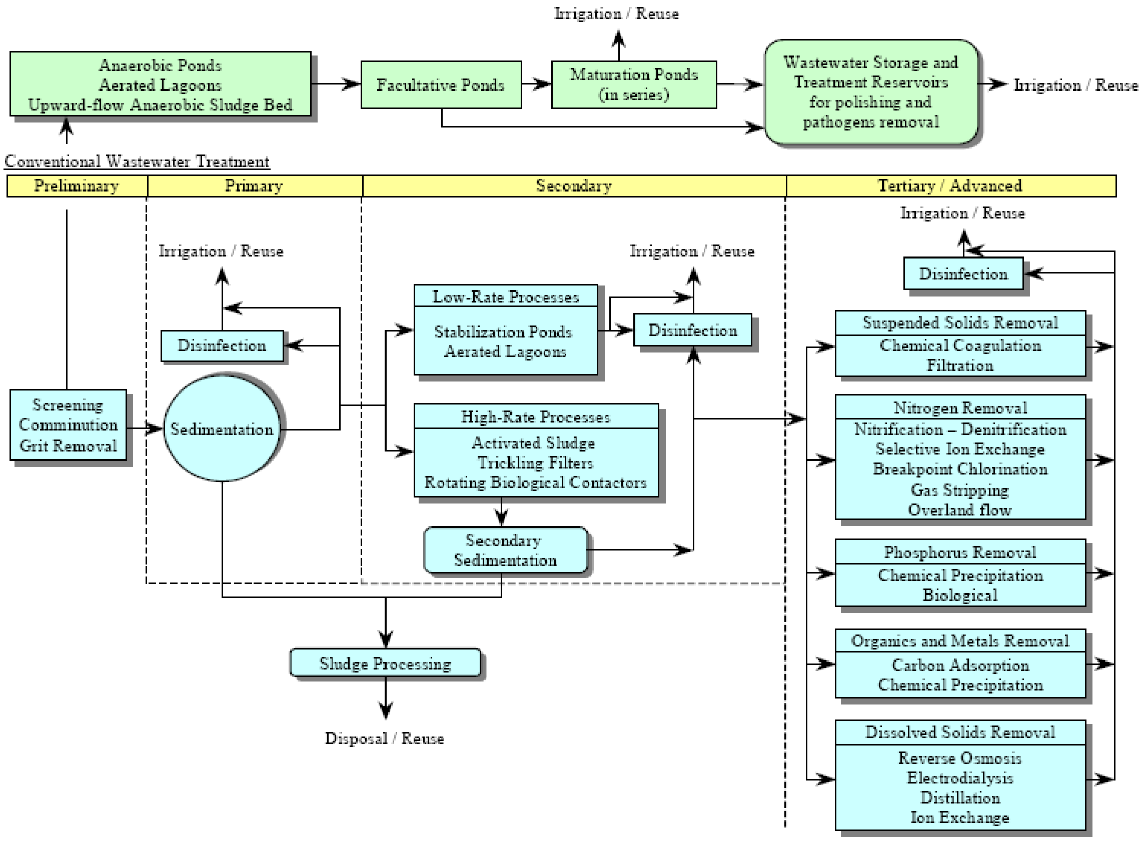
11.1 Reclaimed Wastewater Technologies

Treatment Processes

There are many treatment processes that can remove contaminants from sewage to varying degrees, depending on the intended final use of the recycled water. In recent years, other treatment options have also become available that can achieve high levels of removal of pathogens and other contaminants.

Options for components of the wastewater treatment process have been summarised by Asano (1999), and are reproduced in Figure XX, and greater detail on treatment processes are available in Appendix C.

Generalised wastewater treatment processes and operations, and effluent reuse schemes (Asano 1999, adapted from Asano, Smith and Tchobanoglous 1985).



11.2 Multiple Barrier Approach

A key element in the prevention of hazards in water recycling is the multiple barrier approach. This approach is typical and established in numerous jurisdiction including Australia under the Australian Drinking Water Guidelines (NHMRC & NRMMC 2004, which is readily applied to recycled water.

The application of the multiple barrier approach should embrace every stage in the production and use of recycled water.

This will include:

- source control
- treatment
- disinfection
- transport
- storage
- use (including both on-site and off-site health and environmental impacts).

This is because hazardous events can occur during each of these stages. In those cases where the supplier and user of recycled water are different entities, it may be necessary to prepare separate Recycled Water Management Plans.

11.3 On-site Residential/Greywater Reuse

Blackwater does contain harmful bacteria, viruses, and may contain chemicals that pose a risk to public health and the environment if mishandled. Greywater can also contain harmful bacteria, viruses, and chemicals that pose a risk to public health and the environment if mishandled.

Although raw grey water is of a higher quality than recycled black water, it is treated onsite by less sophisticated treatment technologies than black water, and typically by inexperienced owners, and as such the possibility of mishandling grey water is higher, as a result grey water is often only allowed for lawn watering and often only for subsurface applications.

Arizona, with its three tiered regulatory system (and water quality requirements rather than treatment technologies) is cited by some as a showcase example.

Grey water systems are small and there are a multitude of technology options. Thus, one alternative is validation of treatment technologies, in which the owner who wishes to install the technology must provide proof that it can meet the discharge quality requirements, and then upon installation must verify that the system is meeting standards.

12.0 Water Reuse: A WaterSMART and Bordeaux Initiative

Alberta WaterSMART (WaterSMART) is a not for profit society dedicated to the improvement of water management awareness, technologies and practices in Alberta. At WaterSMART, we are committed to improving water management through better technologies and practices. We are implementing a collaborative model in which our programs are supported through public and private partnerships, with participation from the public and private sectors, business and industry groups and associations, watershed stewardship groups, other environmental communities of interest and dedicated individuals.

WaterSMART is partnering with *Bordeaux Developments* on the Harmony development, a new and innovative community on 1,748 acres located west of Calgary. Harmony will be a thoughtfully planned, mixed-use family community that combines the timeless elements of what a caring community used to be with visionary practices in social, economic and environmental sustainability.

One of Harmony's distinguishing characteristics will be the depth and breadth of initiatives to maximize efficient energy and water use and optimize resource management so that the homes, community and surroundings remain clean and healthy. A third of the land will be reserved for green space, including the reintroduction of native plant species, and 17,000 trees where before there were five. Homes and businesses will incorporate state-of-the-art technologies that ensure a healthier lifestyle while saving energy and resources.

WaterSMART and Bordeaux's objective is to be the first development in Alberta to use reclaimed water for non-potable domestic purposes, and demonstrate that water sustainability is good business, in hopes the project will serve as an example that will inspire the future development of similar communities.

Water conservation is an integral part of the community's technical and architectural design, and the marketing of Harmony. A number of water conservation techniques, practices, and policies are being considered throughout the planning of Harmony to meet the sustainability and development objectives and to reduce capital and operational costs.

Primary among them is potable water use efficiency through full metering and appropriately structured water and wastewater rates to manage demand, high efficiency water fixtures (required through caveats on title), and the provision of alternatives to potable water for irrigation purposes (e.g. stormwater capture, reclaimed water).

Plan Moving Forward

Under development.

13.0 References

Alberta Environment. 2000. Guidelines for municipal wastewater irrigation. Edmonton, Alberta.

CMHC. 1998. Regulatory barriers to on-site water reuse: research highlights. Technical series 98-101.

Exall K., J. Marsalek and K. Schaefer. 2004. A review of water reuse and recycling, with reference to Canadian practice and potential: 1.incentives and implementation. Water Quality Research Journal of Canada 39:1-12

Exall, K. 2004. . A review of water reuse and recycling, with reference to Canadian practice and potential: 2. applications. Water Quality Research Journal of Canada 39: 13-28.

Government of Australia website,
http://www.aph.gov.au/senate/committee/ecita_ctte/completed_inquiries/2002-04/water/report/c03.pdf

Appendix A - Terminology

Blackwater
Blackwater is water that comes from toilets and is piped from homes via the wastewater system.

Class A+ Recycled Water
Class A+ recycled water is Queensland's highest class of recycled water for non-drinking purposes, as defined in the Queensland Water Recycling Guidelines. It is wastewater that has been highly filtered and disinfected through two different treatment plants. Treatment involves a complex process of ultra-filtration, ultra-violet disinfection and chlorination. Rigorous monitoring and testing regimes are in place to ensure its quality.

Class B Recycled Water
Class B recycled water is highly treated wastewater suitable for reuse. It has been used on the Gold Coast for many years to irrigate local sporting fields, parks and cane farms.

Detention Ponds / Water Infiltration Zones

These sand based ponds are used to capture stormwater in heavy rain flows and let it filter into surrounding soil over several days. Their presence reduces stormwater runoff that causes erosion of waterways after heavy rainfall.

Dual Reticulation
This term applies when recycled water and drinking water are delivered to a community through two separate water networks. In Pimpama Coomera, Class A+ recycled water will be delivered via a network purple water mains.

Greywater
Greywater is untreated water from kitchen sinks, bathrooms and laundry drains. It has not been cleaned or treated and is piped away from homes using wastewater systems.

Rainwater Tanks
On-site storage tanks used to collect and store rainfall runoff from roofs for beneficial use.

Reclaimed Water
Reclaimed water is treated effluent of a quality suitable for a specific reuse application.

Recycled Water Taps
These external taps have reverse threading and have 'warning – recycled water DO NOT DRINK' affixed above them. Like all recycled water pipes and fittings, they are purple in colour. The handles of these taps are removable to avoid accidental use by children.

Recycled Water Treatment Plant (RWTP)
The recycled water treatment plant is a facility that processes treated water from a wastewater treatment plant to a higher quality for reuse in the community. The Pimpama Recycled Water Treatment Plant will produce Class A+ recycled water.

Smart Sewers
Smart Sewers are wastewater pipes made with superior materials and construction practices that reduce the amount of stormwater and groundwater entering the wastewater system.

Stormwater
Stormwater is rainwater that drains from roofs and roads after storms. It flows directly to local waterways, and does not include wastewater.

Swales
Swales are 'V' shaped depressions planted with leafy vegetation that replace traditional kerbs and guttering alongside roads. They filter slow and filter the flow of stormwater and allow it to soak into local areas before it reaches our waterways.

Wastewater
Wastewater is used water from the community and/or industry.

Wastewater Treatment Plant (WWTP)
The wastewater treatment plant is a facility that treats wastewater to remove organic pollutants. Water that is passed through a wastewater treatment plant is known as Class B recycled water

Wastewater Reclamation
Wastewater reclamation involves the treatment to a predetermined water quality, which facilitates reuse.
.

Water Sensitive Urban Design (WSUD)
WSUD incorporates a range of landscaping initiatives designed to reduce the impact of stormwater from urban catchments. WSUD in Pimpama Coomera includes rainwater tanks, swales, infiltration zones and detention ponds.

Wastewater Reuse
Water reuse is the use of treated wastewater for beneficial purposes. Direct reuse refers to a system in which reclaimed water is transported to the point of reuse. Indirect reuse implies discharge of an effluent into receiving waters for assimilation and withdrawals downstream" (Exall *et al*., 2004).

APPENDIX A - Communities Using Recycled Water [4]

Recycled water is used around the world in residential developments, the following are a few examples.

Canada – British Columbia

Equilibrium Housing Pilot Demonstration Project – 12 across Canada

- Name: Echo Haven
- Location: Calgary, AB
- Community of 25 low-impact homes
- Project features include:
  - common shared amenities, equipment and renewable energy sources, incl. solar PV array and wind turbines
  - 100% storm water retention on site
  - greywater and balanced water strategies
  - zero ghg emissions for the entire community

- Development manager
  - David Spencer
  - Eco-Logic Land Corporation
  - 403-716-8206
  - dave.spencer@stantec.com

- source CMHC

Kingfisher Oceanside Inn

- Royston, BC
- All grey water and black water is treated and recycled for toilet and urinal flushing, and irrigation of the resort's gardens. Excess wastewater is discharged to a disposal field. The design capacity is 44, 500 L/day.
- Treatment includes a trap/lift station, aerobic bio-reactor, hollow fibre membrane filter, granulated activated carbon filter, UV, and storage.

- source CHMC

Sooke Harbour House

- Sooke, BC
- All grey water and black water is treated and recycled for toilet and urinal flushing, and excess renovated wastewater is used in a garden drip irrigation system. Design capacity is 22, 700 L/day.
- Treatment includes a trap/lift station, aerobic bio-reactor, hollow fibre membrane filter, granulated activated carbon filter, UV, and storage.

- source CHMC

Ministry of Social Services Building

- Sooke, BC
- All grey water and black water is treated and recycled for toilet flushing. Design capacity is 3,800 L/day.

-source CMHC

Quayside Village

- West Vancouver, BC
- 20-unit apartment building in which greywater will be reused for flushing toilets
- Treatment includes a settling tank, filtration tank, bio-filter, pre-ozonation, multi-stage sand filtration, and ozonation

[4] http://www.goldcoast.qld.gov.au/t_gcw.asp?PID=5894

British Columbia Permitted Uses and Standards for Reclaimed Water

Reclaimed Water Category and Permitted Uses (1)	Treatment Requirements (2)	Effluent Quality Requirements (3)	Monitoring Requirements (5)
UNRESTRICTED PUBLIC ACCESS			
URBAN - Parks (6) - Playgrounds - Cemeteries - Golf Courses (6) - Road Rights-of-Way - School Grounds (6) - Residential Lawns - Greenbelts - Vehicle and Driveway Washing - Landscaping around Buildings - Toilet Flushing - Outside Landscape Fountains - Outside Fire Protection - Street Cleanings AGRICULTURAL - Aquaculture - Food Crops Eaten Raw - Orchards and Vineyards - Pasture (no lag time for animal grazing) - Frost Protection (17), Crop Cooling and Chemical Spraying on crops eaten raw - Seed Crops RECREATIONAL (18) - Stream Augmentation - Impoundments for Boating and Fishing - Snow Making for Skiing and Snowboarding	Secondary (7) Chemical Addition (8) Filtration (4) Disinfection (9) Emergency Storage (2)	pH = 6 - 9 $\leq$ 10 mg/L BOD5 $\leq$ 2 NTU (10) number of fecal coliform organisms $\leq$ 2.2/100 mL (11) (12) General (13) (14) (15)	pH - weekly BOD - weekly Turbidity - continuous Coliform (16) - daily
RESTRICTED PUBLIC ACCESS			
AGRICULTURAL - Commercially processed food crops (19) - Fodder, Fibre - Pasture (20) - Silviculture - Nurseries - Sod Farms - Spring Frost Protection (17) - Chemical Spray - Trickle/Drip Irrigation of Orchards and Vineyards URBAN/RECREATIONAL (18) - Landscape Impoundments - Landscape Waterfalls - Snow Making not for Skiing and Snowboarding CONSTRUCTION - Soil Compaction - Dust Control - Aggregate Washing - Making Concrete - Equipment Washdown INDUSTRIAL (24) - Cooling Towers - Process Water - Stack Scrubbing - Boiler Feed ENVIRONMENTAL (18) - Wetlands (25)	Secondary (7) Disinfection (9)	pH = 6 - 9 $\leq$ 45 mg/L BOD5 $\leq$ 45 mg/L TSS (26) number of fecal coliform organisms $\leq$ 200/100 mL (11)(21)(22) General (14)(23)	pH - weekly BOD - weekly TSS - daily Coliform - weekly

United States: Communities Using Recycled Water

California, USA
Recycled water has been used for non-drinking purposes, such as toilet flushing, since 1991. Government has mandated the use of recycled water for all non-potable purposes in high rise buildings.

In communities where recycled water is available, California state law requires the installation of dual plumbing systems in new construction. To avoid confusion, the recycled water is carried in purple pipes. Cities and counties that currently do not have a recycled water treatment system can require dual plumbing systems in new construction and in buildings when they are substantially remodeled.

Florida, USA
Recycled water reuse is widespread in Florida. Currently more that 216,248 residences, 468 golf courses, 684 parks and 274 schools are using recycled water.

Virginia, USA
Recycled water has been discharged into the Occoquan Reservoir since 1978, which supplies drinking water for up to one million people. It is estimated that recycled water accounts for around 15 percent of the reservoir's volume. Water quality is monitored by an independent panel of review, and negative health effects have never been recorded.

Louisiana, USA
Louisiana's legislature has mandated a recycled water program that has prohibited the use of potable water for irrigation at parks, cemeteries, golf courses and landscaped areas.

Washington, USA
The Washington State Legislature enacted E2SSB 6117 (2007) with the Governor's Directive and ESHB 2884 (2006). Both bills amend Chapter 90.46 RCW - Reclaimed Water Use.

The 2006 law directed the Department of Ecology (Ecology) to develop and adopt rules on all aspects of reclaimed water use by December 31, 2010. The law also directs Ecology to coordinate with the Department of Health and form a rule-making advisory committee with a broad range of interested individuals.

In 2007, legislation reaffirmed the commitment to reclaimed water and recognized the importance of the following benefits of reclaimed water use:

- Consistent, reliable water supply as Washington faces climate change challenges
- Reduced discharge of treated wastewater into Puget Sound
- More water in our rivers and streams for salmon recovery
- More effective management of the Columbia River's water.

Some provisions of the new Washington State legislation include:

- Requiring reclaimed water use at state agencies where feasible
- Expanding the scope of the rule advisory committee to address, among other issues, organizational structure, staffing, removing barriers and creating incentives, and developing a long term funding strategy
- Increasing legislative reporting requirements

The Governor also directed Ecology to work with the legislative leadership to address water right impairment (vetoed Sec. 4) and related issues. The governor also directed Ecology to harmonize the implementation of the new reclaimed water planning requirements. The legislature also provided Capital

Budget funding of $5.5 million for initial feasibility and construction of reclaimed water facilities in Puget Sound.

Australia: Communities Using Recycled Water

Sydney, Australia
Recycled water has been successfully used for non-drinking purposes in the Rouse Hill area, in Sydney's north-west since 2001. More than 16,000 homes are connected to recycled water for toilet flushing and external uses, with the scheme reducing the community's demand for drinking water by 35 percent. Sydney Water has other similar schemes under construction in Sydney's south-west and western areas.
Gold Coast Australia

In Pimpama Coomera, Gold Coast City Council is implementing an award winning program that is designed to save up to 84 per cent of drinking water. The Master Plan
also aims to reduce the load on wastewater networks and treatment systems, reduce greenhouse gas emissions, reduce nutrient concentrations in stormwater runoff and lower the amount of recycled water released to local waterways.

Adelaide, Australia
Situated 12 kilometres from Adelaide, Mawson lakes is expected to house 10,000 residents by 2010. Mawson Lakes has successfully used recycled water for external uses since March 2005.

Melbourne, Australia
A new housing development named "Aurora", from the Urban and Regional Land Corporation will provide recycled water and water sensitive urban design to around 9000 homes. The recycled water is planned for external uses and toilet flushing.

Springfield, Queensland, Australia
A residential development with 18,000 home sites and a final population of 60,000 Water is used to irrigate ovals and grassed areas in the community. Home owners have the option of linking to the recycled water system for toilet flushing and external uses.

Other International: Communities Using Recycled Water

Singapore
Singapore is a small island with a very limited water catchment, forcing it to import half of its water from Malaysia. In 2003, after two years of testing, an expert panel concluded the Singaporean NEWater recycled water treatment plant could consistently and safely provide residents with recycled water for indirect potable reuse (ie drinking). Recycled water is added to drinking water reservoirs, where it is further treated before being piped to residents.

Beijing, China
Constructing a reclaimed wastewater system with a capacity of 255,000 m3/d. All Hotels with over 20,000m2/day, public buildings with over 30,000 m2 and residential area over 50,000 m2 require on site wastewater recycling.

United Kingdom
In the UK, private companies have long recognized the value of recycled water, recycled water programs are managed by private companies. Since 1997, recycled water has been added to Essex's Hanningfield reservoir, before being further treated and piped to residents for consumption.

Treatment Options for Recycled Water

The following describes treatment for both reclaimed and grey water.

CONVENTIONAL SEWAGE TREATMENT

The treatment method used to produce recycled water should be suitable to reliably produce water of a standard that is fit for the purpose for which it is being provided, at a reasonable cost. Decisions about the best approach need to balance the environmental, social and economic advantages and disadvantages.

There are many treatment processes that can remove contaminants from sewage to varying degrees, depending on the intended final use of the recycled water. Conventionally, sewage treatment has been categorized as primary, secondary or tertiary, to reflect the sequential nature of sewage treatment. In recent years, other treatment options have also become available that can achieve high levels of removal of pathogens and other contaminants (see section 6.2 of these guidelines).

In simple terms, primary treatment can be said to involve screening out of gross pollutants and sedimentation of coarse particles; secondary treatment removes organic matter and lighter solids by biological and mechanical treatment; and tertiary treatment removes suspended solids and nutrients via biological and/or chemical processes and/or filtration. Disinfection may be applied to either secondary or tertiary treated effluent. However, advances in wastewater treatment technology have meant that a simple distinction between these processes is not always useful.

Generally speaking, the greater the level of treatment applied to wastewater, the greater the reduction in levels of pollutants. Virtually any quality of source water can be treated to any final standard given the right level of treatment. However, recycled water should only be treated to a level that matches its intended use, to avoid unnecessary treatment costs. For example, a high degree of disinfection is not essential for irrigation of crops like sugar cane where there is substantial processing of the crop after harvesting.

ADVANCED RECYCLED WATER TREATMENT

There are a number of advanced treatment technologies that can improve the quality of recycled water. These start from conventional filtration technologies such as deep bed gravity filters with upstream coagulation/flocculation through to modern membrane technologies, electrostatic treatment, distillation, ultrasound and hybrid technologies.

Conventional media filtration

Conventional filtration generally involves adding a coagulant/flocculant to secondary treated effluent to aggregate suspended solids and colloidal particles into flocs so that they can be removed via filtration through a deep bed filter using sand or other media. When followed by heavy dosing with chlorine, this form of treatment can achieve significant reduction in pathogens. However, as it does not rely on a physical barrier to filter out pathogens, as membrane technology does, it cannot be guaranteed to consistently achieve the same level of pathogen reduction as membranes. The effectiveness of particle removal during media filtration greatly depends on the skill on the operator and requires continuous monitoring to detect when breakthrough of particles will occur so that backwashing of the media can be initiated.

Microfiltration

Microfiltration is the most commonly used type of membrane filtration, either alone or as a pre-treatment for reverse osmosis. Most microfiltration membranes have a pore size of 0.1 microns. Particles in this size range, such as bacteria, are retained and concentrated by the membrane. Microfiltration can be used to remove bacteria, protozoa and small suspended solids or to clarify liquids. When combined with post-filtration disinfection by UV, this is a very effective technology for virus removal, as it removes the particles that can shield viruses from UV radiation.

Ultrafiltration and nanofiltration
Ultrafiltration membranes have a pore size of 0.01 microns while nanofiltration membranes have a pore size of 0.001 microns. Molecules such as proteins and sugars are in this size range. Ultrafiltration or nanofiltration can be used to reduce the BOD of wastewater, separate oil from wastewater and remove natural and synthetic organics, disinfection by-products and multivalent inorganic substances (e.g. water softening by removing calcium and magnesium).

Reverse osmosis
Reverse osmosis is an extremely effective membrane-based water treatment technology that is usually applied after some form of particle filtration such as those mentioned above. It is capable of removing dissolved solids such as metal ions and salts and all micro-organisms. The pore size of reverse osmosis membranes is 0.0001 microns. Water that has been treated by reverse osmosis is so pure that it can dissolve mineral ions from pipes so it requires chemical treatment before being introduced into a distribution system.

The effectiveness of these membrane-based methods for removing contaminants depends on maintaining the filtration effectiveness and ensuring the quality of the input water. A drawback is that they can require an initially high capital outlay, have high running and maintenance costs and can produce a highly contaminated backwash. However, as technology advances, membrane filtration methods are becoming less expensive, more effective and more energy efficient.

Membrane bioreactors
Membrane bioreactors combine conventional biological treatment with membrane separation to produce very high quality recycled water. Treatment plants are very compact and have low requirements for operator attention compared with conventional sewage treatment plants.

Electrodialysis
Electrodialysis is a process that applies an electrical current to semipermeable membranes to remove impurities (e.g. metals or salts) from water.

Biologically activated carbon (BAC) filtration
Activated carbon is made by heating a carbon-based material such as wood, charcoal or coal to a high temperature in the presence of steam. This process removes non-carbon elements from the source material and creates a porous internal structure that provides a very large surface area. The surface of activated carbon is positively charged so any negatively charged particles in the water are attracted to it (that is they become adsorbed). Some carbon filters are designed so that bacteria are encouraged to grow on the surface of the carbon (biologically activated carbon or BAC). The bacteria growing on the carbon media will consume organic fractions adsorbed onto the carbon.

Filtration of recycled water through biologically activated carbon can remove many contaminants, including pesticides and herbicides, pharmaceuticals, disinfection by-products and cyanobacterial toxins. The effectiveness of activated carbon filters to adsorb organic chemicals can be enhanced by treating the water with ozonation to breakdown large organic compounds to smaller organic particles. Activated carbon filters are thermally regenerated by burning off the contaminants, after which they can be reused.

Ultrasound
When applied to wastewater treatment, ultrasound is generated by a transducer that converts electrical energy into high frequency vibration. This vibration then induces cavitation, in which air or vapour bubbles form due to a rapid reduction in pressure. At low ultrasound doses, bacterial flocs can be disaggregated by mechanical shear stresses. When the dose is increased, ultrasound cavitation breaks down the cell walls of micro-organisms, thereby achieving a measure of disinfection. Further disinfection by other methods like UV or chlorine dioxide is also facilitated.

Dissolved air flotation

Dissolved air flotation (DAF) involves injecting air into water, forming very small bubbles that attach to floc particles formed by addition of a chemical flocculant. Solids then float to the surface to be skimmed off. When combined with appropriate disinfection, DAF can produce high quality recycled water.

Ion exchange

Ion exchange is often used in industry to condition input water for industrial processes. It can also be used for treated effluent. It involves the replacement or exchange of specific ions in water for complementary ions to produce high purity industrial water. Ion exchange is not a typical sewage treatment process but rather it produces water of a specific quality suitable for a specific use. For example, sodium is exchanged with calcium so that calcium does not form scaling in heat exchangers.

Distillation

Distillation is the process of heating water to its boiling point, capturing and then condensing the steam to form pure distilled water. If the heat used for distillation is waste heat from some other process, this can be an efficient water purification process. Multi-effect and multistage flash distillation are thermally efficient processes that can produce pure water with very low salinity from recycled water or from salt water.

Reverse osmosis, thermal techniques (such as distillation) and electrodialysis are the most popular current technologies that can significantly reduce the salinity of water; however, they all produce significant saline waste streams.

Biofiltration through lagoons and wetlands

Wastewater has been treated through wetlands and lagoons for centuries. Wetlands remove pollutants through a combination of biological, chemical and physical processes. Wetlands can also be useful at the end of a secondary treatment process where they can reduce nutrients and other contaminants and also achieve some disinfection.

However, wetlands do need careful design and management to ensure their long-term effectiveness. Conventional biofiltration systems involve surface flow with visible water, while subsurface wetlands generally use emergent macrophytes growing in a saturated soil matrix. One of the key design features of biofiltration through lagoons or wetlands is the prevention of short-circuiting. The Queensland Government has published Guidelines for Using Free Water Surface Constructed Wetlands to Treat Municipal Sewage (DNR 2000b) that contain detailed advice on use of constructed wetlands for wastewater treatment.

DISINFECTION OF RECYCLED WATER

While most steps in sewage treatment can lead to some reduction in pathogenic organisms, specific disinfection steps are generally required to ensure that recycled water is fit for use. Among the disinfection options available for recycled water are chlorine (delivered as gaseous chlorine, liquid sodium hypochlorite or via anodic oxidation), chlorine dioxide, UV radiation, membrane filtration, pasteurisation (thermal disinfection) and advanced oxidation processes involving use of ozone, hydrogen peroxide or titanium dioxide in combination with UV. Each of these has advantages in different circumstances, and in many cases a combination of these approaches is best for recycled water.

All disinfection systems should be automated with alarms and automatic shut-off of the recycled water supply in case of failure. Effective maintenance and a quality assurance system would minimise the risk of treatment failure.

Chlorination

Chlorine is routinely added to drinking water supplies worldwide due to its disinfection capability and residual activity in water pipes. However, its use for disinfection of STP effluent gives rise to a number of problems.

The chlorine dose and contact time required to ensure adequate disinfection of STP effluent will depend on the characteristics of the effluent (e.g. pH, BOD and TSS), the chlorine demand (determined by the presence of organic matter, ammonia, iron and manganese) and the final uses of the recycled water (e.g. whether a residual is required). Also, there can be problems in measuring free versus available chlorine in STP effluent due to the formation of chloramines following the reaction of chlorine with ammonia in the effluent. This means that no single figure for free or total chlorine can be specified for chlorine disinfection of recycled water.

As with some other disinfectants, chlorine produces disinfection by-products in reaction with organic and inorganic substances usually present in STP effluent. The level of these by-products varies with the chlorine dose and the level of free chlorine in the water.

Also, chlorine is relatively ineffective at inactivating some pathogens, such as Cryptosporidium oocysts, and the residual chlorine can be toxic to sensitive organisms if it is released into the environment during final use of recycled water. When this potential for toxicity must be reduced, dechlorination may be required.

Ultraviolet radiation

Ultraviolet radiation is an effective disinfection process that does not produce by-products that may be toxic to humans or the receiving environment. UV dose is a product of UV intensity and exposure time and is expressed as milliwatt seconds per square centimetre (mW.s/cm^2). UV achieves disinfection by initiating a photochemical reaction that damages the DNA molecule within micro-organisms, so that cell division and consequently multiplication can no longer occur. The amount of cell damage depends on the dose of UV energy absorbed by the micro-organisms and their resistance to UV.

UV disinfection is only effective with recycled water that has low suspended solids, turbidity and colour. A chemical residual, such as chlorine, may be required after UV disinfection to limit bacterial regrowth within the distribution system.

Oxidation processes

There are many oxidation processes that can be used for treatment and disinfection of recycled water, the more common of which use ozone, chlorine dioxide or hydrogen peroxide. The most commonly used is ozonation. In a typical arrangement, ozone gas is generated on-site by passing an electric current through oxygen. This ozone is then passed through the recycled water where it oxidises organic matter, including micro-organisms, and achieves high removal of both pathogens and organic matter. A disadvantage of ozonation is that it produces small quantities of disinfection by-products that may be hazardous to human health when ingested or inhaled in sufficient quantities. In addition ozone gas is extremely toxic so ozone generating facilities must be managed in accordance with appropriate workplace health and safety provisions.

If ozone-treated recycled water has a significant amount of residence time in pipes, it is also likely to require a chlorine residual to prevent microbial regrowth.

Disinfection and pH

Where disinfection relies on some form of chemical treatment, as with chlorine or ozonation, attention should be paid to the pH of the recycled water. The ideal pH range varies for different forms of chemical disinfection. Further information on pH and disinfection can be found in the Information Sheets published in Part IV of the Australian Drinking Water Guidelines (NHMRC & NRMMC 2004).